LATE CRETACEOUS STRATIGRAPHY, SEDIMENTOLOGY, AND
MACROPALEONTOLOGY OF SEYMOUR ISLAND,
ANTARCTIC PENINSULA
VOLUME I

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
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* * * * *

The Ohio State University
1984

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Advisor
Department of Geology
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To my wife Laura,

and

to the memory (?) of my friend

Marcelo Bonet
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CHAPTER I

INTRODUCTION

Seymour Island (Isla Vicecomodoro Marambio in the Argentine literature) is located on the northeastern tip of the Antarctic Peninsula at latitude 64°15'S and longitude 56°45'W (Fig. 1), and has the only fossiliferous outcrops of latest Cretaceous age on the entire Antarctic continent. Seymour Island, which belongs to the group of islands that surround James Ross Island, has a relatively undeformed and continuously exposed marine sequence. These deposits contain a sedimentary record from the latest Campanian through the earliest Tertiary. The abundance and preservation of the fauna rank among the best in the world and are probably unmatched in any other locality from the Southern Hemisphere. The fauna has close affinities with others of similar age from southern South America and New Zealand. This fact provides a unique opportunity to examine the Late Cretaceous molluscan distribution around the now scattered component pieces of Gondwana and to establish correlations between these areas prior to the final breakup of the supercontinent.

Because of the continuous exposure and abundant macrofossils, the stratigraphic and paleoecologic study of this fauna provides information on the evolution of shallow water communities, fluctuations in sea level
during the latest Cretaceous in Antarctica, and serves as a possible model for other shallow water marine sequences.

Seymour Island contains some of the finest examples of distribution of macrofauna below the Cretaceous/Tertiary boundary anywhere in the world. The presence of an abundant ammonite fauna provides the opportunity to study the taxonomic diversity and relations of this group just prior to its demise at the end of the Mesozoic. In addition to the important paleontological, paleobiogeographical and evolutionary aspects of the record on Seymour Island, the sedimentary facies and rocks in this area are suitably located to provide insight into the late Cretaceous-early Tertiary tectonic history of the Antarctic Peninsula.

Most of the research conducted on the island before the 1970's was concentrated on building up large fossil collections irrespective of their stratigraphic position. This problem was partially solved during the middle 1970's, particularly by researchers from the Instituto Antartico Argentino. They provided the first modern geological map of the island as well as a stratigraphic section through the Cretaceous (Fig. 2). However, this section did not include the total thickness of the sediments of this age cropping out on the island, and should be regarded as a preliminary investigation. Until this study, there had been no detailed stratigraphic and paleontologic work in the Cretaceous portion of this unique sequence.
Figure 1-- Map showing the location of Seymour Island.
The objectives of this research are:

- Preparation of a detailed geological map of the Cretaceous-Early Tertiary portion of the island.

- Measurement and description of detailed sections, with emphasis on the distribution of facies and petrography of the rocks.

- Paleontological description of different macrofaunal assemblages, placing particular emphasis on their stratigraphic distribution.

- Establishment of a biostratigraphic zonation of the sequence, and, in turn, a precise age for the sediments.

- Correlation of these sediments with similar strata cropping out on the nearby Snow Hill, Vega and James Ross islands.

- Correlation with other known faunal assemblages of the Southern Hemisphere, particularly southern South America, on the basis of the ammonite faunas present in these areas.

- Establishment of the distribution of ammonite faunas around the Southern Hemisphere during late Cretaceous time, in order to provide data on the paleobiogeographic evolution of this biota.

- Investigation of the sedimentology and petrography of these sedimentary rocks in order to determine the environments in which they were deposited and the sources from which they were derived.

- Investigation of the distribution of fossils and variations in sedimentary environments adjacent to and at the Cretaceous/Tertiary boundary, in order to determine trends in the disappearance of different taxa.
In order to meet the objectives of this study, the following methodology was used:

1) Photointerpretation of the area, trying to establish different units with particular geomorphologic expressions. This information was used to determine the best areas for measurement of geologic sections and to provide a geological framework for investigation during field work. The photos used had a scale of 1:26,000, and were taken by the British Antarctic Survey in 1979. Geologic data were later transferred onto a controlled drainage map prepared by Henry Brecher of Ohio State University.

2) Fieldwork. Two field seasons were spent in the Seymour Island region. The first, during the austral summer of 1982, lasted from February 19 to March 11. Transport to the island from South America was provided by the icebreaker, US Coast Guard "Glacier". Logistic support within the field area was provided by ship-based Coast Guard helicopters. Besides the planned activities on Seymour, good weather condition made it possible to visit Snow Hill, Vega and James Ross islands. Four sections were measured (Fig. 2)(A, B, part of D, E, and part of F) on Seymour, one on Snow Hill Island, one on Vega Island, and another at The Naze (James Ross Island). Individual stations (260 in all) were located on aerial photographs; sediments and macrofossils were collected at each station. Crossbedding directions were also measured in the upper levels of the Seymour Island sequence and some marker units
Figure 2-- Simplified geologic map of Seymour Island showing location of measured sections.
were traced laterally across the island.

For the second field season (from December 11 1983 to January 10, 1984), transportation to the Peninsula was provided by the icebreaker US Coast Guard "Westwind". On this occasion, the objectives were to test the validity of the stratigraphic and biostratigraphic divisions developed on the basis of the data collected during the first expedition. An additional 156 stations were sampled for macropaleontologic and lithologic studies. New sections (C, upper part of D and upper part of F) (Fig. 2) were measured in the southern portion of the island, as well as a short one in the Cape Wiman area. In this last locality, crossbedding orientations were also measured.

In order to compare the Cretaceous sequence of Seymour Island to that of southern South America, two field seasons were spent in southern Chile (February 1982 (eight days), and February 1983 (20 days)). Several localities were visited, and four sections measured, in the Ultima Esperanza region.

3) Paleontological identification and description of macrofossils (Annelids, Bivalves, Gastropods and Ammonites).

4) Visits to museums and institutions. In order to compare the fauna of Seymour Island with other Antarctic collections or related faunas, the following institutions were visited: U.S.A.: American Museum of Natural History, New York; Argentina: Museo de La Plata,
Universidad Nacional de Buenos Aires, CIRGEO, and Instituto Antartico Argentino; Chile: Empresa Nacional de Petroleo (ENAP), Punta Arenas; Universidad Nacional de Concepcion; Museo de Nacional de Historia Natural, Santiago; England: British Museum (Natural History), London; British Antarctic Survey, Cambridge; Sweden: Naturhistoriska Riksmuseet, Stockholm.

5) Sedimentological analysis. This includes grain size analysis, sedimentary petrography, and megascoponic description of the sediments.

6) Age determinations on glauconites in order to provide absolute age control on the unfossiliferous part of the sequence.
CHAPTER II

REGIONAL GEOLOGY

The Antarctic Peninsula is a narrow, arcuate strip of land, approximately 1500 km long, bordered on both flanks by a series of islands. Geologically, it has been considered as the continuation of the Andean chain (Andersson, 1906; Dalziel and Elliot, 1972, 1973, among others) (Fig. 3). Outcrops at these isolated latitudes are very much restricted to cliffs, coastal areas, and other snow-free areas. The geologic understanding of this area is the product of many years of institutional and personal efforts comprising a wide range of international participation, notably by the British Antarctic Survey, the Instituto Antartico Argentino, the Instituto Antartico Chileno, and, more recently, several U.S institutions, all building on the work of the Swedish South Polar Expedition. Structural and stratigraphic complexities add additional difficulties to the enormous task of mapping this area, and the lack of fossiliferous occurrences in several lithotectonic units within the Peninsula has led to the correlation of isolated outcrops on the basis of lithologic character alone.

The Antarctic Peninsula was an active magmatic arc during the Mesozoic, with well defined fore-arc basins on the Pacific side and back-arc basins on the Weddell Sea side. Fore-arc basins developed
Figure 3—Simplified geologic map of the Antarctic Peninsula. (Modified after Dalziel and Elliot, 1973).
during late Jurassic and early Cretaceous time in the southern peninsula, together with a related back-arc basin (Suarez, 1976; Suarez and Pettigrew, 1976; Thomson, 1982b; Elliot, 1983, among others). However, fore-arc sediments were also deposited in the northern peninsula (South Shetland Islands) at this time. During the late Cretaceous, a sequence similar to a foreland basin but lacking the thrusting and folding, developed to the east of the Peninsula in the back-arc terrain (Elliot, 1983). Alternatively, this basin, which is floored by continental basement (Hamer and Moyes, 1982) might represent a retroarc-basin in the sense of Dickinson (1974a,b), but lacking the typical fold and thrust belt.

The core of the Peninsula is composed of Carboniferous to Triassic shale, siltstone, and sandstone of the Trinity Peninsula Group (Hyden and Tanner, 1981), intruded by Mesozoic to Tertiary plutons with Andean affinities. An associated volcanic component is present in the form of widespread outcrops of mostly silicic volcanic rocks (Antarctic Peninsula Volcanic Group). Thick sequences of volcanioclastic sediments, formed by the stripping of this deformed cordilleran belt, were deposited in basins located on either flank of the arc during the course of a late Mesozoic–Early Cenozoic sedimentary cycle. A brief description of the general stratigraphy of the peninsula follows, placing particular emphasis on the Mesozoic.

**Basement**

The most extensive basement outcrops consist largely of quartzose
graywacke and shale with minor components such as conglomerate, conglomeratic mudstone, and greenschist (cf. Adie, 1957; Aitkenhead, 1965; Elliot, 1965, 1966; Fleet, 1968). The maximum thickness reported for this folded sequence is 13,715 m (Aitkenhead, 1965), and its age (based on plant fragments recovered at Hope Bay, northern Trinity Peninsula) is no older than Carboniferous (Adie, 1957). However, deformed sediments as young as Triassic are included in this unit (cf. Edwards, 1982; Thomson, 1982b). The Trinity Peninsula Group locally attained a sub-greenschist facies of metamorphism, and it was deformed during the course of the Gondwanian orogeny (Dalziel and Elliot, 1973; Elliot, 1975).

**Jurassic (mostly continental deposits and volcanics)**

The Carboniferous-Triassic rocks are disconformably overlain by Upper Jurassic sedimentary and volcanic rocks. The contact between these two units is present, but poorly exposed, at Hope Bay (Bibby, 1966; Elliot and Gracanin, 1983). The lowermost beds of this lithotectonic unit are formed of coarse conglomerates constituting alluvial fan deposits. Extensive outcrops of such rocks also occur on the South Orkney Islands (Elliot and Wells, 1982), and other occurrences are reported from Joinville Island (Elliot, 1967), Botany Bay (Camp Hill)(Farquharson, 1982b), and Longing Gap and Tower Peak (Aitkenhead, 1965). Plant material interbedded in this sequence has been interpreted as middle Jurassic by Halle (1913), but Stipanicic and Bonetti (1970) argued that this assemblage might be better placed in the latest Jurassic or in the lower Cretaceous.
In the southeastern peninsula, a deformed sequence of marine shale, siltstone, sandstone and conglomerate is interbedded with volcanic rocks (Latady Formation) (Laudon et al., 1983). This sequence crops out for more than 600 km along the Orville, Lassiter and southern Black Coasts.

The conglomerates and continental plant-bearing sequences are followed by the widespread occurrence of mainly andesitic to rhyolitic lavas and pyroclastic rocks of the Antarctic Peninsula Volcanic Group (Thomson, 1982b). These rocks possibly represent the remnant of an active volcanic arc associated with subduction to the west (Elliot, 1983). In the central and eastern portions of the Antarctic Peninsula, these volcanic sequences were deposited in a continental environment, but they are interbedded with shallow marine sediments in the western coast (cf. Thomson, 1982b).

Until recently, the Antarctic Peninsula Volcanic Group was assumed to have been deposited everywhere during the late Jurassic, but recent paleontologic, petrologic and radiometric evidence suggest an age ranging from early Jurassic to early Tertiary (Thomson et al., 1983). According to Farquharson (1983a,b), the volcanic rocks were erupted no earlier than the latest Jurassic or during the early Cretaceous in the northern Antarctic Peninsula. Farquharson (1983a,b) concluded that there was not an extensive emergent volcanic arc in northern Graham Land during the Late Jurassic.
Upper Jurassic-Lower Cretaceous mostly marine sediments

Following and partially coeval with the widespread "late Jurassic" calc-alkaline volcanic activity, marine sediments were deposited in different parts of the Peninsula. In northern Graham Land, the Ameghino Formation (Medina and Ramos, 1981)(=Nordenskjold Formation of Farquharson, 1982a) comprises a sequence of mudstone and ash-fall tuffs, with abundant radiolaria forming well-bedded cherts. This sequence, up to 550m thick (Farquharson, 1983a), is exposed on the eastern side of Northern Graham Land (Joinville Island; northern Dundee Island; Longing Gap; Sobral Peninsula; and Cape Fairweather) (Figs. 3, 4). The presence of fine laminations and the related absence of bioturbation, the absence of bottom dwelling macrofauna, the lateral continuity of individual beds, and the abundance of radiolaria, were interpreted by Farquharson (1982a, 1983a,b) as evidence for deposition under quiet water and anoxic conditions. The presence of this sequence in the James Ross Basin is indirectly represented in the form of blocks of shale with late Jurassic-early Cretaceous ammonites and belemnites found at Brandy Bay (Olivero et al., 1980) (Fig. 4).

According to Farquharson (1982a, 1983a,b), these sediments are the fossil record of a paleo-upwelling zone of high productivity, and could be correlated with other well-bedded black shales of the South Atlantic and southern South America. The presence of an upwelling zone in the eastern Antarctic Peninsula during the late Jurassic requires the absence of an emerged arc in this area (cf. Farquharson, 1983a,b). This is difficult to reconcile with the probable age of the Hope Bay plants
(cf. Stipanicic and Bonetti, 1970; Baldoni, 1977), the presence of plant material in the Ameghino Formation at Longing Gap (Medina and Ramos, 1981), and the abundance of fragments of petrified wood in the Sobral Peninsula (Farquharson, 1983a). This, together with the presence of several clastic intervals at the last locality, strongly indicates proximity to land.

Poorly preserved ammonites and inoceramid bivalves indicate a Kimmeridgian to Tithonian age for the Ameghino Formation (Medina and Ramos, 1981; Medina et al., 1981; Crame, 1982; Farquharson, 1983a). Possibly contemporaneous with this sequence is a Tithonian-Valanginian shale and volcaniclastic sandstone assemblage that crops out on Byers Peninsula (Livingston Island, South Shetlands). These beds, which contain a bivalve-ammonite fauna, pass upward into marine, and then terrestrial, volcanic rocks (Tavera, 1970; Covacevich, 1976). Also on the western coast of the Peninsula, volcanogenic marine rocks with upper Jurassic fossils occur on Low Island (South Shetland Islands)(Smellie, 1980), and Adelaide Island (Thomson, 1972).

Farther south, at Alexander Island (Fig. 3), a thick sedimentary sequence (approx. 5000m), mostly of shallow marine origin, was deposited in a fore-arc or intra-arc setting from the Kimmeridgian to the Albian (Thomson, 1982b; Elliot, 1983). These sediments have been included in the Fossil Bluff Formation (Taylor et al., 1979; Thomson, 1982b). The lower part of this fore-arc sequence is predominantly volcanic, and passes up into conglomerate, sandstone, and shale with an abundant
Figure 4.-- Geologic map of the James Ross Island Area. (Modified after maps of the British Antarctic Survey).
volcanic component (Thomson, 1982b).

The general depositional environment of this sequence ranges from shallow marine-deltaic in the lower portion to continental in the highest beds (Horne, 1969). Sedimentation was strongly influenced by large deltas and contemporaneous subaerial volcanism (Horne, 1969; Thomson, 1982b). A comparable marine sequence was found at Carse Point (Palmer Land) on the Peninsula itself (Thomson, 1982b).

Lower Cretaceous marine sediments deposited in a back-arc setting are found to the east of the Peninsula. The southernmost exposure occurs at Crabeater Point (Bowman Coast) in isolated outcrops of deformed calcareous shale, mudstone, and conglomerate, bearing a poorly preserved marine fauna of possibly lower Cretaceous affinities (Thomson, 1967; Taylor et al., 1979). Further north, at Pedersen Nunatak and Sobral Peninsula (Fig. 3), a thick sequence (up to 425m in the Sobral Peninsula) of graded conglomerate interbedded with sandstone and pebbly sandstone has poorly preserved fragments of plants similar to Zamites (Elliot, 1966). The clasts in the conglomerates are lithologically identical to, and suggest derivation from, the Antarctic Peninsula Volcanic Group (Elliot, 1966). According to Elliot (1966), the presence of plant remains indicate a lacustrine environment for at least a portion of these sediments. A very similar conglomeratic sequence is found at Pedersen Nunatak (Elliot, 1966). Del Valle and Medina (1980) suggested that these conglomerates were deposited in a fluvial environment of high energy and that they were later reworked seaward and
finally deposited in submarine fans. Poorly preserved ammonites of the family Neocomitidae help to date the sequence as early Cretaceous (Hauterivian-Valanginian?) (Medina et al., 1981; Del Valle et al., 1983). However, Farquharson (1983b), on the basis of undescribed calcareous nanofossils indicates a Turonian-Maastrichtian age for the same sequence.

A late early Cretaceous sedimentary cycle was apparently widespread in the northern Antarctic Peninsula, but it is mostly present as exotic blocks and boulders in the upper Cretaceous beds of the James Ross Basin (Bibby, 1966). However, these beds have recently been found in situ in two localities. At the first one, Cape Welchness (Dundee Island) (Fig. 4), Ramos et al. (1978) described a volcaniclastic sequence with Inoceramus concentricus Parkinson; Aucellina sp.; Hamitoides? sp., and Turrilitidae gen. et sp. indet. Crame (1979) also reported the presence of Inoceramus concentricus from this locality, indicating a middle to late Albian age. The second locality was recently discovered on James Ross Island, in sediments that had previously been considered as late Cretaceous in age (Medina et al., 1982; Crame, 1983a,b). A sequence of mudstone, shale, bioturbated siltstone and coarse-breccia conglomerates was found on Kotick Point (Fig. 4). Fossils in this unit include Rotularia "callosa" Stoliczka, Aucellina radiostriata Bonarelli; Sphaera? striata Richter, the ammonites Silesites desmoceratoides Stolley; Acanthohoplites sp.; Belemnoptysis sp.; Gaudryceratinae gen. et sp. indet., together with the fossil plant Prilophyllum sp. (Medina et al., 1982). Beyond this material Crame
recognize here an *Inoceramus* of the *I. neocomiensis* group. This assemblage, which is very similar to a fauna from Alexander I Island (Cox, 1953), Falkland Plateau (Jones and Plafker, 1976), Lago San Martín (Bonarelli and Nagera, 1921), South Georgia (Wilckens, 1947), and Tierra del Fuego (Camacho, 1949; Macellari, 1979), has been considered to indicate an Aptian-Albian age. Medina et al. (1982) measured 290 m of sediments in this locality, but Crame (1983a), who includes here also the Upper Kotick Formation and at least a part of the Stoneley Point Conglomerates (Bibby, 1966), estimates a thickness of 1500 m for the sequence. Large allochthonous blocks, several tens of meters in length, mostly of acidic volcanic rocks, are found interbedded with the shales (A. Crame and J. Ineson, personal comm., 1983).

**Upper Cretaceous**

Upper Cretaceous marine sediments have only been found on the east flank of the Peninsula. These sediments, which have a strong volcaniclastic component, were deposited in a back-arc basin. The Upper Cretaceous marine sediments were probably deposited along the entire eastern margin of the Peninsula, but record of this sedimentary cycle is preserved only at Cape Marsh (Robertson Island), Cape Longing, and in the James Ross Basin (Fig. 4). According to magnetotelluric investigations (Del Valle et al., 1980), this sequence is approximately twice as thick in the James Ross Basin as it is in the other two localities (6000 m vs. 3000 m).

A shallow water sequence, composed of loosely cemented siltstone
and fine sandstone, is exposed at Cape Marsh (Robertson Island) (Fig. 3). It contains sparse fossil invertebrates, including Rotularia shackletoni (Wilckens), Nucula sp., Linotrigonia (Oistotrigonia) antarctica (Wilckens), Taloma globus Medina and del Valle, and Gaudryceras sp., indicative of a late Cretaceous age (possibly Campanian) (Fleet, 1966; Medina and Del Valle, 1980). Stromatolites have also been found at this outcrop (F. Medina, personal communication, 1983).

Upper Cretaceous marine sediments have been found in two localities at Cape Longing (Medina et al., 1981) (Fig. 4). The southern locality has a 170 m thick sequence composed of fine conglomerates and medium to coarse sand, with intercalations of crossbedded tuffs. Fossils found in this locality include plant remains, as well as gastropods and abundant Inoceramus. Crame (1981) considered these specimens as members of the I. lamarcki group, which have a lower to middle Turonian age. The second locality, farther to the north, contains finer grained sandstone and fine grained rocks, with a prominent tuffaceous intercalation composed almost exclusively of glass shards (Medina et al., 1981).

Because of its relevance to the present study, the thick and fossiliferous sedimentary sequence of the James Ross Basin will be described in more detail below.

**Andean Intrusions**

The Antarctic Peninsula includes extensive outcrops of calc-alkaline plutonic rocks. These rocks range in composition from
gabbro to granite. According to Adie (1955), quartz diorite is the most common rock type of the Andean igneous complex in the peninsula. Dalziel and Elliot (1973) maintain that rocks of more acidic composition are also important.

Geochronological data indicate that the locus of magmatism migrated westward as well as northwards during the late Mesozoic (Saunders et al., 1982). The peak of Andean plutonism is inferred to be at 90-110 my. Two other grouping of ages can be recognized: an older group (155-185 my) restricted to the east coast, and a younger group (45-60 my) confined to the northern part of the west coast of the peninsula. Plutons of intermediate ages are found throughout the Peninsula (Saunders et al., 1982).

**Cenozoic sediments and volcanics**

Paleocene to Oligocene marine and possibly fluvial sediments are well exposed on Seymour Island (Trautman, 1976; Elliot and Trautman, 1982). Other Tertiary sediments are found on King George Island (South Shetlands). Here, outcrops of the Miocene (but possibly older) Cape Melville Formation consist of approximately 200 m of glaciomarine gray-green to brownish-black shale and silty shale with minor fine grained sandstone intercalations (Birkenmajer, et al., 1983). Particularly interesting is the occurrence of reworked belemnites and Cretaceous calcareous nannofossils, thought to have been transported by ice, together with "in situ" Tertiary fossils (Birkenmajer et al., 1983).
Tertiary to Pleistocene volcanism was important in the northern Peninsula. Alkalic olivine basalt lavas, agglomerates, and palagonitic tuffs of the James Ross Island Volcanic Group are found in the James Ross Basin (Nelson, 1966). These yielded radiometric ages of 6 to 1 m.y. (Rex, 1976). Other outcrops of the James Ross Volcanic Group are found on several islands immediately north and east of James Ross Island, on Tabarin Peninsula, and on several islands in the Antarctic Sound. Comparable volcanic rocks are found to the south, at the Seal Nunataks (Nelson, 1966). Extensive volcanic activity is recorded in the South Shetland Islands (cf. Dalziel and Elliot, 1973; Dupre, 1982). This includes subduction related lower Tertiary rocks and marginal basin rocks of late Cenozoic age.

JAMES ROSS BASIN

The James Ross Basin contains the thickest sedimentary sequence in the back-arc basin that was formed on the eastern flank of the Antarctic Peninsula (Figs. 4, 5, 6). The basin developed on folded and eroded rocks of the Trinity Peninsula Group. The precise timing of the early stages of sedimentation is still unclear. Due to the lack of exposure and uncertain lateral relations, the base of the sequence could be formed by either Mesozoic alluvial fan conglomerates (i.e. Elliot and Gracanin, 1983), or shales of the Ameghino Formation, or both. The key may lie in the precise dating of the Hope Bay plant-bearing horizons as well as the overlying volcanic rocks. If the plant horizons are late Jurassic-early Cretaceous in age (Baldoni, 1977) and the overlying
Figure 5-- Stratigraphic column of the James Ross Island Basin.
volcanic rocks are as young as early Cretaceous (Farquharson, 1983a; Thomson et al., 1983), then the conglomerates may be younger than the black shales of the Ameghino Formation which have been dated paleontologically as Kimmeridgian to Tithonian (i.e. Farquharson, 1983a). However, the presence of Neocomian, together with Upper Jurassic molluscs in blocks of shale in the Stoneley Point-Hidden Lake formations at Brandy Bay (James Ross Island) (Olivero et al. 1980), indicates that the Ameghino Formation might also overlap the "late Jurassic" plant-bearing horizons, and eventually the Antarctic Peninsula Volcanic Group (APVG). The lateral extent of the APVG, and its continuation beneath the James Ross Basin are debatable. Correlation of these volcanic rocks with the Le Maire Formation of Tierra del Fuego (Borrello, 1969)(=Serie Tobifera of Chilean authors; and Complejo El Quemado of Riccardi, 1971), would imply that these "Jurassic" volcanic rocks had an extensive lateral development, including the more offshore portion of the James Ross Basin. The volcanic rocks in southern South America have been ascribed to the formation of an extensive rift zone and related diapirism in the upper mantle beneath (Bruhn et al., 1978), and the APVG might represent the same event in the Peninsula. If this were not the case, the possible lateral extent of the volcanic sequence would be restricted to the environs of the center of eruption.

Following the upper Jurassic-lower Cretaceous sedimentary rocks are conglomerates and shales forming the lowermost units of the James Ross Island sequence. These include the Lagrelius Point Conglomerates, the Lower Kotick Point Formation, and possibly also the Upper Kotick Point
Figure 6-- Idealized cross-section of the James Ross Basin.
Formation (Bibby, 1966; Medina et al., 1982; Crame, 1983a,b); total thickness is approximately 746 m (Fig. 5). This fundamentally conglomeratic sequence contains clasts of metamorphic and volcanic rocks (Medina et al., 1982). The Cretaceous beds in the James Ross Basin usually dip towards the east with inclinations of up to 20–25° in the west, but become more horizontal to the east, where dips of 5–6° are common.

The above sedimentary cycle is overlain by conglomerates, sandstones and siltstones of the Stoneley Point Conglomerates and the Hidden Lake Formation (Bibby, 1966). The conglomerates contain numerous angular fragments of green shale and sandstone, some of them more than 1 m in length (Bibby, 1966; Malagnino et al., 1979). The tuffaceous content increases upward in the section, and the most abundant autochthonous fossils of these beds are coquina pockets composed exclusively of the bivalve *Inoceramus*. Crame (1983b) included these specimens in the *I. neocaledonicus* group, which has a Coniacian to Campanian age. The overlying Hidden Lake Formation consists of shales and sandstones, but Malagnino et al. (1979) failed to find definite lithologic criteria for distinguishing between these two formations. The thickness of these two formations in Brandy Bay was found to be 690 m (Malagnino et al., 1979).

Over 200 specimens of benthic foraminifera were described from Brandy Bay by Macfadyen (1966), who assigned a late Cretaceous age to the assemblage. Only five species of ammonites were found in the Hidden
Lake Formation (Desmophyllites sp.; Tetragonites (Saghalinites) cf. cala (Forbes); Gaudryceras varagurense (Kossmat), and Submortoniceras chicoense (Trask)). Only the last mentioned is diagnostic, and is given an age of early Lower Campanian (Howarth, 1966). Examination of the original material, preserved at the British Museum of Natural History (London), as well as additional specimens stored at the British Antarctic Survey, indicate to the author the necessity of restudying this material. Riccardi (1982) described Baculites delvallei and Jimboiceras (?) antarcticum from glacial drift on top of the mesa of Seymour Island. These specimens were interpreted by Riccardi to be diagnostic of a late Santonian–early Campanian age, indicating that sediments of this age should be present somewhere in the Basin. In conclusion, the presence of sediments older than Campanian in the later Cretaceous cycle is to be expected.

The Hidden Lake Formation is overlain by the Lopez de Bertodano Formation (Rinaldi et al., 1978; Rinaldi, 1982)(=Snow Hill Island Beds +Older Seymour Island Beds of Andersson, 1906; =Snow Hill Island Series of Bibby, 1966). This monotonous and very fossiliferous sequence is composed of dark brown–green, loosely cemented siltstone and sandstone with more calcareous and resistant intercalations. The Lopez de Bertodano Formation crops out at isolated exposures on James Ross Island (Brandy Bay, Lachman Crags, The Naze, Dagger Peak, and Cape Hamilton), Vega Island (Cape Lamb), Humps Island, Cockburn Island, Snow Hill, and Seymour islands (Bibby, 1966). Because bedding is very difficult to distinguish in some of the these outcrops, estimation of total thickness
**Figure 7**—Summary of the development of the stratigraphic nomenclature and assigned ages of sedimentary units exposed in the James Ross Island Region. Modifications in the older formations of the Marambio Group, after Crame, 1983a,b; Malagnino et al., 1983; and Medina et al., 1982.
depends on the interpretation of the structure, and this, in turn, must rely on the age relations of the fossil assemblages (mostly ammonites) found at these localities. Three alternative interpretations are possible: a) A continuous homoclinal sequence dipping more or less constantly to the east, thus showing a continuous younging of the beds in that direction. Total thickness in this case would be around 7000 m (i.e. Olivero, 1981; Rinaldi, 1982); b) A homoclinal sequence that is repeated by faulting (faults covered by ice); c) A folded sequence, such that some localities to the west could be younger than other localities further east. Total estimated thickness in this case is 3580 m. (Bibby, 1966). The data for folding presented by Bibby (1966) are the presence of west dipping beds at Humps Island, horizontal, or nearly horizontal beds nearby, at The Naze, and the repetition of the Humps Island faunal assemblage in southwestern Vega Island (cf. geologic map of Bibby, 1966). Bibby (1966) oriented fold axes at N 25° with a synclinal axis slightly east of The Naze and separated approximately 15 km from the anticlinal axis to the southeast. Based on the presence of different ammonite faunas, the minimum proven thickness of this formation is: Brandy Bay (560 m)(Malagnino, et al., 1979); Snow Hill Island (approx. 400 m) (Olivero, 1975); Seymour Island (1190 m) (Macellari and Huber, 1982), to which we have to add an estimated 600 m of covered section between exposed sections, giving a total minimum figure of 2800 m. Other localities (i.e. The Naze, Cape Lamb, Cape Hamilton, Humps Islet) have faunas similar to those of Snow Hill Island and could represent exposures of the same sediments (Fig. 5). As will be discussed in a later chapter, Bibby's interpretation is preferred here.
The type section of the Lopez de Bertodano Formation, the principal lithostratigraphic unit studied in this work, is located at Lopez de Bertodano Bay on Seymour Island (Fig. 2). It has been assigned an Upper Albian to Campanian (Kilian and Reboul, 1909), Campanian to possibly Maastrichtian (Spath, 1953), lower to upper Campanian (Howarth, 1958, 1966, Olivero, 1981); and lower Campanian to uppermost Maastrichtian age (Huber et al., 1983; Macellari and Zinsmeister, 1983; Macellari, in press), but here it is considered to also include lowermost Tertiary sediments (Fig. 7). The macrofauna in this unit is very abundant, diverse and well preserved, and indicates deposition in a shallow marine environment. Macropods found here include annelids, corals, echinoderms, decapods, bivalves, brachiopods, cephalopods, corals, scaphopods, marine reptiles, shark vertebrae and teeth, as well as abundant fossil wood, which is usually bored by pholadid bivalves. The microfossils are also very abundant, particularly foraminifera, diatoms, and to a lesser extent, calcareous nannoplankton (Huber et al., 1983).

On Seymour Island, the Lopez de Bertodano Formation is followed by the slightly more sandy, but equally friable, Sobral and Cross Valley formations of possibly Paleocene age. Rinaldi (1982) included all the Cretaceous formations cropping out in the James Ross Island area together with the Sobral Formation into the Marambio Group (Fig. 7). However, the lower two or three units (Lagrelius Point Conglomerate, Lower Kotick Point Formation, and possibly the Upper Kotick Point Formation) should be separated from the Marambio Group because they are bounded at the top by an angular unconformity (Medina et al., 1982).
Although a minor disconformity separates the Lopez de Bertodano Formation from the Sobral Formation, similarities in their respective faunas indicate only a minor time break. Because these two formations together with the overlying Cross Valley Formation, were deposited during the same marine cycle, it is advisable to include them all in the Marambio Group. Thus redefined, the Marambio Group represents a late Cretaceous to Paleocene marine cycle that includes the Stoneley Point Conglomerate, the Hidden Lake, the Lopez de Bertodano, the Sobral, and the Cross Valley formations (Figs. 5, 6, 7).

The Sobral and Cross Valley formations, which will be discussed in more detail later, represent approximately 350 m of shallow marine to possibly fluvial sediments indicative of the last stages of the regression that commenced during the late Cretaceous and terminated during the Paleocene.

Other sediments in the James Ross Basin include the Eocene-Oligocene La Meseta Formation siltstones and sandstones (Elliot et al., 1975; Trautman, 1976) that disconformably overlie older sediments. Previous accounts suggested a thickness of 450 m of La Meseta Formation sediments (Elliot and Trautman, 1982), but a more recent survey indicated the presence of an additional 300 m of section at the base of the formation (Zinsmeister and Devries, 1982). Possibly unconformable above this formation follows the thick volcanic sequence of the James Ross Volcanic Group (Nelson, 1966). Contact between the two units has not been observed on Seymour Island. At nearby Cockburn Island, the
James Ross Island Volcanic Group was deposited on top of a deeply sculptured topography, excavated within sediments possibly correlative with those of the La Meseta Formation (Zinsmeister and Webb, 1982). The youngest marine unit found in the basin (but also present at other localities in Antarctica) is the Pliocene Pecten Conglomerate which probably represents a Pliocene interglacial interval (Hennig, 1911, P. Webb, pers. comm., 1984). Here the macrofauna is almost exclusively composed of the large pectinid *Myochlamys anderssoni* Hennig. A cover of glacial debris and boulders is found scattered throughout the basin, forming in some instances thick accumulations (i.e. Rabassa, 1982).
CHAPTER III

SEYMOUR ISLAND

Although discovered in 1843 by James Clark Ross, interest in the geology of this snow-free island did not develop until the recovery of fossil plants and invertebrates by C.A. Larsen in December of 1892. The description of these fossils, the first ever found in Antarctica, strongly influenced the decision of the leader of the Swedish South Polar Expedition, O. Nordenskjold, to winter over in the vicinity of this island (Andersson, 1906; Nordenskjold, 1905, 1913). The extensive collection of the Swedish Expedition was described in a series of monographs and provided a wealth of information on a previously unknown part of the world. The presence of fossil plant material on the Antarctic continent proper was very surprising because such presence indicated that climatic conditions in the past were different from those prevailing in Antarctica today. Additionally, the Cretaceous ammonites, described by Kilian and Reboul (1909), strongly influenced Haug (1909) in postulating the presence of a world-wide Cretaceous transgression (cf. Spath, 1953).

Brief visits to Seymour Island by a Falkland Islands Dependencies Survey party (now British Antarctic Survey) in 1953 and 1954 resulted in the recovery of ammonite material described by Howarth (1958). However,
no extensive studies were conducted until 1973-74, when the Instituto Antartico Argentino initiated a mapping project on the island. The task was greatly aided by the presence of the newly established (1969) Argentine Base Vicecomodoro Marambio. Latter, this effort was joined by members of the Institute of Polar Studies (Ohio State University, USA), whose objective was to study the Tertiary strata of the island (Elliot et al., 1975).

The results of the Argentine survey were published by Rinaldi et al. in 1978. These investigators divided the Cretaceous sequence of Seymour Island into the Lopez de Bertodano and the overlying Sobral formations. The age of these formations was postulated to range from the late Campanian to the Maastrichtian (Rinaldi et al., 1978).

PHYSIOGRAPHY

Seymour Island, which is approximately 20 km long (NE-SW) and 8 km wide (between Cape Bodman and Penguin Point), has a maximum altitude of 200 m at a point close to the Argentine Base. It is physiographically divisible into three main areas: a) An area in the north, which has steep relief and is capped by an extensive mesa. Only Tertiary sediments occur here. b) A zone of low relief, in the center of the island (Cross Valley), with a badland topography developed on soft sediments of the Tertiary La Meseta and Cross Valley Formations. c) A sector to the south of Cross Valley with a relatively low, complex relief, developed on Cretaceous sediments of the Lopez de Bertodano
Formation, as well as younger sediments of the Sobral and Cross Valley formations. The research reported here concentrated on this last physiographic zone, which, therefore, will be described in more detail.

The physiographic development of this zone is affected by two important factors: lithology and recent uplift. The alternation of friable sandy siltstone with more cemented sandy and calcareous horizons dipping homoclinally 8°-10° to the southeast gives a cuesta-like topography. This is particularly true towards the southeast, in the Sobral and Cross Valley formations. A similar control of the topography is observed near Cape Wiman (Cabo Gorochategui on Argentine maps) at the northern tip of the island, where an extended cuesta is also present. However, relief in the Lopez de Bertodano Formation is highly irregular and controlled by the alternation of softer and more resistant beds. Because these resistant beds are only a few meters thick at the most, a cuesta-like topography rarely develops here. The alternation of soft and more resistant beds is particularly noticeable on the southern portion of the island near Cape Lamb and along the coast between Cape Lamb and Penguin Point (Fig. 9). This character disappears towards the north in the Cape Bodman-Lopez de Bertodano Bay area, where the relief is complex. The most conspicuous depression controlled by this geology is the Quebrada Larga (Fig. 8), a valley that extends along strike throughout most of the island, and that was previously interpreted by Rinaldi et al. (1978) as being structurally controlled.

The Cretaceous portion of the island is cut by several Pliocene
basaltic dikes oriented ENE-WSW (cf. Rinaldi et al., 1978). The most prominent (Filo Negro) (Fig. 8) forms an elongate and steep hill which divides this portion of the island into two parts.

The coastal areas in most of this sector are abrupt and formed by vertical cliffs, clearly indicating the recent uplift of the area. An exception to this is the coast between Cape Lamb and Cape Bodman where an extensive low "glacis" developed on soft muds of the Unit 3 of the Lopez de Bertodano Formation (Fig. 9). Other low coasts are found in the Lopez de Bertodano Bay close to Cross Valley where a series of terraces have developed along faulted Cretaceous and Tertiary sediments (Fig. 9). The coast between Penguin Point and Penguin Bay is relatively low because it is developed in the back portion of the cuesta formed by the Cross Valley Formation.

DRAINAGE

The recent uplift of the island (Andersson, 1906; Zinsmeister, 1980; Malagnino, et al., 1979, 1983; Elliot, 1981; Corte, 1982) has a strong influence on the drainage pattern of the island. Four major watersheds are observed in the area of study (Fig. 8). The drainage system has not yet fully equilibrated to the recent uplift, as shown by numerous examples of capture observed. The predominant pattern is dendritic with a high density of drainage. A rectangular pattern can also be observed. Streams developed along fracture zones tend to have a WSW-ENE orientation. Streams controlled by differences in competence of
Figure 8-- Drainage map of Seymour Island. Numbers refer to different watersheds.
the beds are aligned along strike (almost N-S).

At least two and possibly three levels of fluvial terraces were observed near Station 56 (Fig. 9), also pointing to the recent uplift of the area. The present discharge of the rivers is generally very small. They run intermittently, carrying a large amount of suspended load, when the temperature rises above freezing point during the summer. According to Corte (1982), the high density of drainage is due, among other factors, to the presence of the permafrost level at a few centimeters depth. This acts as an impermeable barrier to the infiltration of water, thus increasing the amount of water available for hydraulic erosion. The water table is controlled directly by the depth of the permafrost, which is approximately 60 cm. Floodplains are covered by fine-grained sediments, which when wet, as is usually the case, form a very soft substrate. Local accumulations of "dirty" ice are common, particularly on the lee (NW) slopes. This, according to Corte (1982), together with the increased runoff by melting on north facing slopes caused by increased solar radiation, causes steeper relief on NE-facing slopes.

The presence of a glacial influence is suggested in the cirque-like shape of some valleys (i.e., valleys of stations 54-59) (Fig. 9) near the south coast. Likewise, the entire island is covered with scattered small granitic and metamorphic pebbles (5-10 cm), the remnants of a previous geomorphologic cycle.
The geology of the Cretaceous-Paleocene portion of the island (excluding the Cross Valley area) was mapped at a 1:25,000 scale by means of photo-interpretation and subsequent field control (Fig. 9). Because of the lack of vegetation and snow cover, it was relatively easy to trace geomorphological units laterally. Most of the effort was concentrated in the diamond-shaped southern portion of the island; a small amount of time was spent in the Cape Wiman area. The following lithostratigraphic units were distinguished here:

a) **Lopez de Bertodano Formation.** This formation crops out in a large diamond-shaped area in the south of the island. Ten individual units have been distinguished within this formation. Because they have an almost uniform lithology, the units described and mapped here are not distinctive enough to warrant member status. The contacts have been drawn at distinctive beds that are easy to trace laterally on the aerial photographs. Exceptions to this are the mudstone units found in the lower part of the sequence and in the southwestern portion of the island. These stand out clearly as lighter-colored units in the photographs. Another exception is the cuesta-like topography defined by the cemented sandstones of Unit 1, only found on Cape Lamb, and which correlate with other cliff-forming sediments on nearby Snow Hill Island.
Figure 9. - Geologic map of Seymour Island. (See 1:25,000 scale map at the back)
b) Sobral Formation. The contact between this unit and the underlying, more friable Lopez de Bertodano Formation is well defined by a break in topography. This formation crops out extensively in the southeastern portion of the island, and was divided into two informal units: Unit 1 (older) and Unit 2 (younger). Sediments lithologically similar to those of Unit 2 are also exposed on the Cape Wiman area.

c) Cross Valley Formation. The contact with the underlying Sobral Formation is traced at a distinctive break in topography where a cuesta-forming unit having a more grainy textural pattern overlies the Unit 2 of the Sobral Formation. This same criterion can be applied in the Cape Wiman area. This difference in textural pattern in the aerial photographs coincides with a lithologic change that will be discussed later. The Cross Valley Formation was previously recognized as cropping out along the entire length of the Cross Valley, but its type section was defined in the southeastern part of the valley (Sections 12 and 13 of Elliot and Trautman, 1982). Trautman (1976), and Elliot and Trautman (1982) considered the sediments exposed in the Cape Wiman area as possibly equivalent with the Cross Valley Formation. Palynological studies indicated an early Tertiary age for samples thought to have been collected in the Cross Valley Formation type section (Cranwell 1959), but later this age was reinterpreted as Maastrichtian-Paleocene by the same author (Cranwell, 1969). Hall (1977), in the study of dinoflagellates from the section S-11 (located in what is now considered to be the Sobral Formation) indicated a Paleocene age for these
Figure 10-- Panoramic view of a portion of the area studied on Seymour Island showing contacts between the different lithostratigraphic units. Klb: Lopez de Bertodano Formation; Tps: Sobral Formation; Tpcv: Cross Valley Formation; Telm: La Meseta Formation; g: glauconitic bed; Q: Quaternary.
sediments. However, samples analyzed by Hall (1977) from the Cross Valley area (S-13) gave inconclusive evidence of the age of the beds. Wrenn (1982), after a study of the dinoflagellates, concluded that the Cape Wiman section was early late Paleocene in age. However the samples from the type area gave an inconclusive age because some yielded a Paleocene and others an Eocene age. Wrenn (1982) suggested the possibility that individual samples were collected from a number of fault blocks, some Eocene and others Paleocene. A slightly older age was proposed by Palmarczuk (1982) (Danian) for the Cape Wiman sediments, on the basis of a dinocyst study.

The lithologic similarity between the sediments of the type section of the Cross Valley Formation, and those exposed in the Cape Wiman area, led Zinsmeister (1982a) to believe in the possible equivalence of these two outcrops. More recent paleontologic dating suggest that these lithologically similar outcrops (Cross Valley and Cape Wiman (in part)) are contemporaneous, and thus they can be considered as isolated outcrops of the same formation.

Due to the lack of detailed stratigraphic work, the presence of the Cross Valley Formation was not previously recognized south of the type area. The possibility of the presence of the Cross Valley Formation along the Penguin Point-Penguin Bay coast was mentioned by Macellari and Huber (1982), and by Macellari and Zinsmeister (1983), on the basis of lithologic similarity to the type section. This similarity is also observed in thin section, being characteristic the abundance of
andesitic volcanic fragments. Abundance of fossil wood as well as the presence of yellowish stained (limonitic) intervals, and pebbly sandstones are additional characteristics in common with the type section. Glauconite dates presented in this work from Penguin Point, (Station 83, Appendix B) yielded an early late Paleocene age (55±0.4 m.a.) which is very much in agreement with the accepted age of the Cross Valley Formation, at least in the Cape Wiman area, where it is less disturbed tectonically. It is concluded therefore that outcrops comprising the youngest portion of the homoclinal sequence in the south of Seymour Island belong to the Cross Valley Formation.

d) Dikes. The Pliocene dikes, which are restricted to the southern part of the island, form elongated steep relief, which is very easy to distinguish on the aerial photographs.

e) Quaternary. Quaternary sediments have been mapped under three different categories: a) Glacial deposits. These have only been found on top of the mesa, containing large boulders of metamorphic, granitic, and sedimentary rocks (Elliot, 1981; Malagnino et al., 1981). b) Marine Terraces. Only found to the south east of the Lopez de Bertodano Bay (previously described by Zinsmeister, 1980) and on the coast north of Fossil Bay. c) Alluvial sediments. They are found in the floodplain of major streams.
Figure 11-- Contact between the López de Bertodano and Sobral formations. A change from a massive sandy silt with scattered concretions to a well-laminated mudstone is clearly displayed.
CONTACTS

a) **Lower contact of the Lopez de Bertodano Formation in Seymour Island.** Slightly older as well as comparable age sediments to those of the lower part of the Seymour Island section, crop out on the nearby Snow Hill Island. Even though separated by a narrow waterway (only approximately 3 m deep), it is possible to recognize units 1 to 3 or their lateral equivalents, on Snow Hill. The physical correlation was also verified by the serpulid zonation of Macellari (1984). However, on Snow Hill Island, at least 200 m of sediments lie beneath those equivalent to the lowest Seymour Island strata.

b) **Upper contact of the Lopez de Bertodano Formation.** The contact between the Lopez de Bertodano and Sobral formations was previously believed to be conformable (Rinaldi et al., 1978; Zinsmeister, 1982a; Macellari and Huber, 1982). However, during the course of the second field season additional sections were measured between the datum represented by the last ammonite occurrence in the island and the base of the Sobral Formation. This work proved that although beds above and below the contact dip at approximately the same angle, the contact itself is highly irregular on a regional scale. Clearly, the Sobral Formation was deposited in extensive channels cut into the top of the Lopez de Bertodano Formation (Figs. 10,11,12). Further evidence for this, lies in the presence of small pebbles ("5mm) of the Lopez de Bertodano Formation in the base of the Sobral Formation, near stations
Figure 12-- Panorama showing the contact between the Lopez de Bertodano (Klb) and the Sobral (Ks) formations (dotted line). Observe the presence of large scale channels near to the base of the Sobral Formation (solid lines).
c) **Contact of the Sobral and Cross Valley Formations.** No clear indication of the lower contact of the Cross Valley Formation was found by Elliot and Trautman (1982), because the base of this formation is not well exposed in the type section. Elliot and Trautman (1982) found this formation in fault contact with the other sedimentary units exposed in the island. These authors believed that the Cross Valley extended along the entire length of the Cross Valley, and was separated from the Lopez de Bertodano and the La Meseta formations by possible faults on both sides of the valley. Stratigraphic relationships in the Cross Valley area are obscured by complicated tectonics involving minor fault blocks. However, in the two places where the contact is clearly exposed (southern part of the island, and Cape Wiman) this formation follows conformably on top of the Sobral Formation (Fig. 10). The upper contact of the Cross Valley Formation has not been observed, because in all cases it is truncated by faulting or erosion. However, on the basis of regional observations, it should lie with angular unconformity beneath the La Meseta Formation.

d) **Contact between the La Meseta and the underlying sediments.** La Meseta Formation was found resting on an angular unconformity on top of units 8, 9 and 10 of the Lopez de Bertodano Formation (Figs. 10,13,16). This contact is recognizable in isolated outcrops along the southern portion of the Cross Valley. Particularly clear is the contact near Lopez de Bertodano Bay (Station 192) and to the east, close to Station
Figure 13-- Unconformable contact between the La Meseta (Telm) and the Lopez de Bertodano (Klb) formations (near to Station 375).

Figure 14-- Fault contact between the Cross Valley (Técv) and the La Meseta (Telm) formations. Cape Wiman area.
Figure 15-- Breccia found at the fault contact between the La Meseta (Telm) and the Cross Valley (Tpcv) formations, Cape Wiman area, Station 3.

Figure 16-- Contact between the La Meseta (Telm) and the Lopez de Bertodano (Klb) formations, showing the presence of large allochthonous blocks (B) in the former, derived from the underlying Cretaceous-Paleocene sequence. The elongated, well-bedded block is approximately 4m. long. (Station 354).
375 (Fig. 9). This contact is complicated by faulting. The contact between the La Meseta and the Sobral and Cross Valley formations at Cape Wiman, is delineated by a normal fault dipping approximately 45° to the south (Figs. 9, 14). A breccia was observed at the contact zone (Fig. 15). This contact, however, is interpreted by Zinsmeister and Saddler (pers. comm., 1984) as one of the borders of a steep channel where the La Meseta Formation was deposited. The explanation of an erosional contact in not entirely incompatible to that of a fault contact; the channel could have developed along a pre-existing fault. Possible evidence for this stems from the fact that both flanks that bound the outcrop of the La Meseta Formation to the south and north, are parallel and very straight.

Significant relief existed on the edge of the La Meseta basin which most likely was fault bounded. This is evidenced in the presence at the base of the La Meseta Formation, of large blocks of Cretaceous sediments (up to four m. in length)(Station 354), together with a glauconitic pebbly sandstone (very similar to, and probably derived from the Cross Valley Formation)(Fig. 16). Some of the basal units of the La Meseta Formation prograded to the south on top of this fault but only for a short distance (Fig. 9).

e) Dikes. The diabasic dikes, oriented approximately N 90°, cut across the Cretaceous–Paleocene sequence. They have been dated by the K/Ar method and give a Pliocene age (6.8 ± 0.5 m.a.)(Rinaldi et al., 1978).
The Cretaceous-Paleocene sequence dips homoclinally 8 to 10° to the ESE in the southern portion of the island, but is slightly less steeply dipping in the Cape Wiman area (5-6°). La Meseta Formation is striking almost normal to the previous sequence, and these beds generally tend to dip away from the Cretaceous-Paleocene sequence (Rinaldi, et al., 1978; De Vries, pers. comm., 1984). At Station 192, beds of this formation dip 15° to the northeast, becoming almost horizontal beneath the center of the mesa, but dip to the southwest in the northern portion of the island, producing a synclinal pattern.

Faults generally show minor displacements (with the exception of the faults bounding the La Meseta Formation), and are normal. An east-west trend is the dominant alignment in the Cretaceous-Paleocene portion of the island. This trend controls the emplacement of the Pliocene dikes and hence is no younger than the dikes. The tectonic pattern of the areas where the La Meseta Formation is cropping out, has not been studied in detail here. However the two faults that bound the exposures of this formation are parallel and oriented ENE-WSW. Both are normal faults, dip approximately 45 to 50°, and form an extended graben. If the presence of these faults controlled the sedimentation of the La Meseta Formation, then this ENE-WSW trend should be older than the E-W trend that is present elsewhere.

The tectonic events that affected the island can be summarized as
follows:

1) Homoclinal tilting of the Cretaceous-Paleocene sequence sometime between the late Paleocene and the early Eocene.

2) Possible development of ENE-WSW normal faulting that controlled (?) the sedimentation of the La Meseta Formation. These faults, which are almost perpendicular to the axis of folding of the Cretaceous sequence, could have developed as an extensional feature produced by compression parallel to the axis of regional strain, and thus at essentially the same time as the folding.

3) Normal faulting (E-W), possibly associated with the intrusion of the diabasic dikes during the Pliocene (but also could be older).
CHAPTER IV

STRATIGRAPHY OF THE LOPEZ DE BERTODANO, SOBRAL, AND CROSS VALLEY FORMATIONS

INTRODUCTION

A total of six sections were measured through the Cretaceous-Lower Tertiary sequence of Seymour Island (Fig. 17, Appendix A). This sequence is divided into three formations and several minor units, most of which can be traced throughout the island. Sections in the Lopez de Bertodano Formation are correlated on the basis of the last ammonite occurrence. This "datum" is parallel to the upper units of this formation, and as will be discussed later, it is considered to coincide with the Cretaceous/Tertiary boundary. Correlation of individual units was made on the basis of lithology and lateral tracing of individual beds on aerial photographs. From older to younger, it is possible to recognize: Lopez de Bertodano, Sobral, and Cross Valley formations.

LOPEZ DE BERTODANO FORMATION

This formation, defined by Rinaldi et al. (1978), has a monotonous lithology composed of sandy siltstones with intercalations of more indurated calcareous horizons. It increases in thickness from north to
Figure 17-- Correlation of sections measured in the Cretaceous-Paleocene sequence of Seymour Island. See figs. 2, and 9 for location of sections. (See envelope at the back for detailed sections).
south (Fig. 17). Maximum thickness was found in Section A (1190 m), and the minimum thickness in Section F (920 m). This is due to the preservation of older strata in the southwest portion of the island, as well as to a greater rate of sedimentation. Grain size and mud percentages remain fairly constant, but there is an increase upward in glauconite as well as the volcanic component.

Individual beds are difficult to trace laterally, but several units of particular geomorphological expression, and or lithologic identity, can be traced laterally on aerial photographs, and can be recognized in the field. The poorly indurated strata of the Lopez de Bertodano Formation are divided into 10 units. The macrofauna is abundant, and allows the clustering of the 10 units into two informal, larger units. Units 1 to 6 are grouped into the Rotularia units which are virtually devoid of macrofauna with the exception of abundant specimens of the annelid Rotularia. Units 7 to 10 are combined into the Molluscan units, on the basis of the widespread occurrence of bivalves, gastropods, and ammonites. Based on the macrofaunal content and the glauconite ages, the age of this formation on Seymour Island is considered to range from the upper Campanian to the lowermost Tertiary, consisting mostly of Maastrichtian age strata.

Rotularia Units (1 to 6)

The lowermost beds on Seymour Island form a distinctive lithologic sequence composed of friable silty mudstone and sandy siltstone,
Figure 18-- Correlation of sections in the Rotularia Units. A decrease in thickness, particularly due to the disappearance of the mudstone facies, is observed from section A to F.
predominantly gray in color, usually strongly bioturbated, and interbedded with fine grained gray sandstone. Concretions are sparse and increase in abundance towards the top (Fig. 18).

The maximum thickness found of the Rotularia units, which continue laterally into Snow Hill Island, occurs in Section A (635 m), on the southwest portion of the island. The lowermost portion of this sequence is not exposed in either sections D or F, but a rapid decrease in thickness of the upper beds is observed in a northeasterly direction.

Units 1 to 6 are characterized by the conspicuous presence of the annelid worm tube Rotularia (Fig. 19), and the almost total absence, or alternatively, lack of preservation, of most of the macrofauna which is so abundant in the overlying beds. Also characteristic of these beds is the presence of an almost exclusively agglutinated foraminifera fauna (Huber, 1984). Other important fossil constituents of these units are echinoderms, solitary corals, and fragments of fossil wood. Plesiosaur bones (Gasparini and Del Valle, in press) as well as poorly preserved internal moulds of bivalves, gastropods and ammonites are present.

The Rotularia units show rapid lateral changes in lithology. This feature is in marked contrast with the upper 600 m of the Lopez de Bertodano Formation, where sedimentation was more homogeneous throughout the portion of the basin exposed on Seymour Island. Among the lateral changes observed here is a decrease in thickness towards the northeast, mostly the consequence of the pinching out of gray mudstone units in
Figure 19-- Rotularia "in situ", in a friable clayey sandy siltstone. (Diameter of specimens is approximately 1.5 cm.)

Figure 20-- Outcrop of well-bedded sandstone of Unit 1 in the southwestern end of Seymour Island (Stations 1-5). Snow Hill Island is observed on the background.
that direction. Another lateral difference is the decrease in the amount of fine sand in the same direction, in such a way that in section F the sandstone beds form discrete packages among a predominantly clayey sandy siltstone sequence. Fossils, even though very sparse, become slightly better preserved in this direction. Six lithologic units have been distinguished, from base to top:

Unit 1: It is exposed only in Section A and has a total thickness of 59 m (Figs. 9, 18). It is composed of well lithified, moderately well-bedded fine grained, well sorted, angular, greenish to greyish sandstone in beds 20 cm to 1 m thick with irregular tops and bottoms (Figs. 20, 21). The sandstone beds are separated by thin siltstone-shale intercalations. Round to subround concretions up to 30 cm in diameter and having a yellowish patina are found here. Sandstones have a calcareous cement, and bioturbation is very common. At the base of the section (Station 1) there are common small (approx. 2 mm in diameter), randomly oriented tubes with the appearance of feeding traces of polychaete worms (Fig. 116). Horizontal tubes are more common towards the top of this Unit (Figs. 22, 23). Fossils are very sparse and poorly preserved. These include: Rotularia (Austral ROTULARIA) fallax (rare); Gunnarites cf. kalika; Linotrigonia (Oistotrigonia) sp.; Gastropoda sp. indet.; and fossil wood. All fossils are preserved as internal moulds. Morphologically this unit presents a prominent cuesta topography.

Unit 2: Also found exclusively in the first section, Unit 2 has a
Figure 21-- Close-up view of Fig. 20. Hammer on left for scale.

Figure 22-- Horizontal burrows in sandstone of Unit 1. These burrows are also common throughout units 1 to 5 (Station 5).
Figure 23-- Horizontal burrows (arrow) in a calcareous fine grained sandstone. (Bag is approximately 20 cm. wide). Station 390, Unit 5.

Figure 24-- Massive clayey silt intercalated with slightly more indurated (calcareous), and better bedded silty sandstone. Station 7, Unit 2.
thickness of 56 m. It is composed of greenish gray to tan, very fine
grounded sandstone intercalated with friable siltstone (Fig. 24).
Laminations are preserved in some portions of the clayey siltstone.
Sandstone beds are approximately 50 cm. thick, with packages of
approximately 12 m of siltstone in between. Fossils are also sparse and
poorly preserved as internal moulds. These include *Nordenskjoldia* sp.;
bivalve sp. indet.; corals; ammonite sp. indet.; fossil wood. This unit
gives rise to a low "soft" relief, somewhat serrated due to the presence
of the more resistant sandstone beds.

**Unit 3:** Unit 3 is found in sections A and D, and has a maximum
thickness of 110 m. Lithologically it consists of friable sandy muddy
siltstone, massive in appearance and with colors ranging from gray to
olive green. A grain size analysis of this unit yielded: sand 28%,
silt 46%, and clay 26%, (total mud: 72%). Particular horizons seem to
have an even larger mud content. Rounded, calcareous, reddish
concretions (10-15 cm in diam.) are common. The only fossil found here
is *R. (Australrotularia) fallax*, which is moderately abundant. This unit
forms a typical badland topography, with low relief.

**Unit 4:** This unit comprises different lithologic types, some of
which could be traced from section A to D. Its lower boundary is
defined by a break in topography, and is easy to delineate in aerial
photographs. In this unit, as well as in the overlying units 5 and 6,
intervals of muddy siltstone, similar to those of Unit 3, are
intercalated with other lithologies. These intervals disappear rapidly
in a northeasterly direction.

The most conspicuous feature of this unit is the presence of large (up to 1.5 m in diameter) rounded, calcareous concretions that preserve the original bedding planes of the rock (Figs. 26, 27). In general the lithology is composed of a gray sandy siltstone which is interrupted by layers of 0.3–0.5 m thick of gray, moderately bedded, more resistant, calcareous sandstone (Figs. 28, 30). The sandstone generally shows a basal, erosional contact, and commonly has small solitary corals on the bedding planes. Small round concretions are occasionally present. Some levels are strongly bioturbated. Mud intraclasts have been found at Station 22 (Fig. 31) and this was also reported by Gasparini et al. (in press) from the same area.

With the exception of Rotularia, fossils are poorly preserved. Fossils recovered here include: corals; R.(Austrorotularia) tenuilaevis, ammonite sp. indet.; gastropoda sp. indet.; the decapod Hoploparia stockesi, abundant echinoderm spines, vertebrae of marine reptiles, and fossil wood. A size analysis of a representative sample of this unit yielded 64% of mud (18% clay) (Sample 22).

Unit 5: The boundaries of this unit can be traced in aerial photographs, however, there is a marked facies change from one end of the island to the other (Figs. 9, 18). Section A contains the gray massive clayey sandy silt beds which pinch out rapidly to the northeast. These muddy units have concave bases and flat tops. On top of these are
Figure 25-- Panorama looking north, showing the contact between mudstones of Unit 3 and the more resistant beds of Unit 4. Cliff on the background is Cape Bodman.

Figure 26-- Well-bedded sandy siltstone with large, rounded, calcareous concretions that preserve the original bedding. Person in the background for scale. Station 20, Unit 4.
Figure 27-- Same as Fig. 26, showing large concretions "in situ". Station 110, Unit 4.

Figure 28-- Massive gray sandy silt with irregular concretions. Station 19, Unit 4.
Figure 29-- Panorama showing the typical low relief developed in the Rotularia Units. Irregular mounds on the surface are formed by more resistant calcareous concretions that preserve the original bedding, and which correlate with those of Figs. 26 and 27.
Figure 30-- Plasser bedded mudstone overlain by a fine grained calcareous sandstone. Note the irregular contact between the two lithologies. Station 21, Unit 4.

Figure 31-- Mud intraclasts in a sandy siltstone, Station 22, Unit 4. Tag is approximately 10 cm. wide.
found well laminated shales, siltstones and sandstones in beds 1 to 1.5 cm thick, occasionally flaser-bedded and gray greenish in color (Figs. 32, 33). This well laminated bed can be traced to the top of Unit 5 in Section D, but disappears completely further to the northeast. Intercalations of well lithified sandstone up to 3m thick are also observed. These usually contain small solitary corals on the bedding planes (Figs. 34, 35). In Section F and in the lower part of Section D, the predominant lithology is a massive gray sandy siltstone with well-bedded, fine-grained, calcareous sandstone intercalations 20-25 m apart, and approximately 0.2-0.4 m thick. Strongly bioturbated concretionary levels are common (Fig. 37). Fossils are better preserved and more diverse in Section F. A Rotularia-solitary coral—echinoderm spine association generally dominates. Fossils found in this unit include:

ANNELOIDES:
R. (Australrotularia) tenuilaeviis (A,F)

BIVALVIA:
Panope clausa (A,F)
Pinna sp. (F)

AMMENOIDA:
Maorites tuberculatus (F)

Marine reptiles (F)

GASTROPODA:
Eunaticina arctowskiana (F)
Perissoptera sp. (D,F)
Cryptorhynchus philippiana (F)
Taloma charcotlanus (F)

Corals (D,F)

Echinoderm spines (A,F)

Fossil wood (F).

(letters in brackets indicate the section in which the fossil was found).

A grain size analysis of Sample 28a indicated 74% of mud with 21% of clay. The thickness of this unit ranges from 82 m (Section A) to 96 m (Section D) to 160 m (Section F).
Figure 32-- Contact between well-bedded brownish clayey sandy silt and massive, gray sandy silt (below). Unipod is 1.5m high. Station 28, Unit 5.

Figure 33-- Close-up view of Fig. 32.
Figure 34-- Massive sandy silt (A), followed by more indurated and better bedded sandy siltstone (B), and by a calcareous concretionary horizon (C) on top. Station 418, Unit 5.

Figure 35-- Same as Fig. 34, showing the lateral continuity of levels A, B, and C. Station 418, Unit 5.
Figure 36—Strata of Unit 5 in the vicinity of Cape Bodman. Lithology composed of apparently massive gray sandy silt with sporadic intercalations of more indurated fine, calcareous sandstone. D: basaltic dike. Cockburn Island can be observed in the background. Stations 413-416.
Figure 37-- Strongly bioturbated concretionary level. Station 91, Unit 4.

Figure 38-- Panoramic view of the upper part of the Rotularia Units in the south-west portion of the island. Note the abundance of round concretions on the surface. Snow Hill Island is observed on the background.
Unit 6: With the exception of one level of massive gray mudstone present only in Section A, this unit is uniformly distributed throughout the island. The dominant lithology is a dark, apparently massive sandy siltstone with abundant red-weathering concretions, between 10–30 cm in diameter (Fig. 38). Minor fine-grained calcareous sandstone intercalations are also observed. Concretions with calcareous tubes 5-8 mm in diameter and 10-15 cm long are common.

Grain size analysis of Unit 6 indicate a mud percentage from 71.5 to 97% with up to 21.5% of clay. Fossils are sparse but somewhat more abundant than in the underlying unit. Rotularias are extremely abundant at several levels. The most common association is that of Rotularia and echinoderm spines. Fossils found here include:

**ANNELOIDA**
- **R. (Australorotularia) tenuilaevis** (A, D, F)
- **R. (Rotularia) shackletoni** (F)

**BIVALVIA**
- Pycnodonte seymourianus (A)
- Eriphyla drygalskiana (D)
- Nucula suboblonga (F)
- Cucullaea antarctica (F)
- Linotrigonia (Distotrigonia) sp. (D, F)
- Panope clausa (D)
- Thracia sp. (A)

**AMMONOIDEA**
- Diplomoceras lambi (A, D)
- Maorites seymourianus (F)

**GASTROPODA**
- Cassidaria mirabilis (A, D)
- Cryptorhitis philippiana (F)
- Eunaticina arctowski (A)
- Taloma charcotianus (D)

Corals (A, D)
echinoderm spines (F)
marine reptiles (A)

Molluscan Units (units 7 to 10)
Figure 39— Correlation of sections measured in the Molluscan Units.
A thick sedimentary package of generally monotonous sandy siltstone that contains a very abundant and well preserved molluscan fauna, overlies the Rotularia units (Fig. 39).

Unit 7: This unit has an almost uniform thickness of 250m. The dominant lithology is a dark gray, friable silty sandstone with minor fine sandstone intercalations. Flaser-bedding is present in some intervals as is bioturbation. The lower 130m of the unit in Section A carries abundant small round concretions. However, this concretionary interval is much thicker in Section F where concretions are large and irregular at the base, but become progressively smaller up section. Intercalations of thin (approximately 40-50cm), gray, well-bedded calcareous sandstone are more abundant in Section A (Figs. 41,42,43,44).

Fossils are very abundant and well preserved at the base of the unit, but become less common towards the top. Bivalve molluscs generally have the two valves articulated, and many are still in life position, indicating no, or very little, post-mortem reworking of the material. Fossils found in this unit include:

ANNELOIDA
R. (Rotularia) shackletoni
R. (Austrorotularia) tenuilaevis
R. (Austrorotularia) zinsmeisteri

CEPHALOPODA
Maorites seymourianus (A,D,F)
Kossmaticeras (Natalites)? wedellensis (A,D,F)
Kitchinites darwini (A,D,F)
Diplomoceras lambi (A,D,F)
Grossouvrites gemmatus (A,D,F)
Pachydiscus ootacodensis (D)
Eutrephoceras simile (A,D,F)
BIVALVIA
Nucula suboblonga (A,D,F)
Linotrigonia pygosceltium (A,D,F)
Laevitrignia ecplecta (A,D,F)
Nordenskjoeldia nordskjoldi (D,F)
Indogrammatodon cf. iormandi (A)
Cucullaea antarctica (A,D,F)
Pinna anderssoni (A,D,F)
Acesta snowhillensis (F)
Limatula antarctica (F)
Eriphyla drygalskiana (A)
Lucina? scotti (D)
Lahilla larseni (F)
Thyasira townsendi (A)
Thracia sp. (A)
Solemya rossiana (A)
Panope clausa (A,D,F)
Goniomya hyliformis (A,D,F)
Pycnodonte cf. vesiculosa (A,D)
Pycnodonte seymourianus (A,D,F)

GASTROPODA
Perissoptera sp. (A,D,F)
Cassidaria mirabilis (A,D)
Cryptorhitis philippiana (ab.) (A,D,F)
Eunaticina arctowskiana (ab.) (A,D,F)
Amberleya spinigera (ab.) (A,D,F)
Pleurotomaria larseni (A,D,F)
Taloma charcotianus (F)
Cerithium sp.

Fossil wood, echinoderm spines, shark vertebrae, corals, marine reptile bones, and the decapod Callianasa meridionalis, are also present in this unit. Mud content in this unit ranges from 67 (Station 45) to 68% (Station 38), and the clay percentage from 17 (Station 45) to 12% (Station 38).

Unit 8: The base of Unit 8 is uniform throughout the island. It consist of 6 to 15 m of massive, relatively well cemented gray silty sandstone. The sandstone, in beds approximately 1m thick, appears massive and or stratified (Figs. 45,46,47). In Section D the same beds
Figure 40-- Massive sandy silt, typical of the Molluscan Units. Station 362, Unit 9.

Figure 41-- Same as Fig. 40, Station 368, Unit 9, showing the intercalation of a slightly darker bed.
Figure 42-- Massive sandy siltstone with scattered irregular concretions. Molluscan units.

Figure 43-- Massive gray sandy siltstone with a concretion containing a specimen of Grossouvreites gemmatus (Huppo). Station 326, Unit 9.
exhibit some minor clay layers and evidence of strong bioturbation. Horizontal and oblique burrows are common. Fossils are well preserved, but are relatively rare, usually small, and not very diverse. This unit, with the exception of some localities in Section D, shows a marked decline in the diversity of the macrofauna. Solitary corals are abundant. In contrast, the foraminiferal fauna shows a large peak in diversity (Huber, 1984). Above this, there are better bedded sandy siltstones that are intercalated with massive gray silty sandstones and brownish to yellowish sandy silt with levels of calcareous fine sandstone. Concretionary horizons are more common towards the top of the unit with concretions ranging from irregular to round. Concretions at some levels are bioturbated and burrowed. Two glauconitic intervals, 40-50 cm thick, are present in Section A. The fossils found in this unit are:

ANWELIDA
R. (Australrotrula) sp.
R. (Rotularia) shackletoni

GASTROPODA
Perissoptera nordenskjoldi (A,C,D,F)
Amberleya spinigera (A,C,D)
Eunaticina arctowskiana (F)
Cassidaria mirabilis (C,D,F)
Cryptorhysis philippiana (C)
Taloma charcotianus (D)

AMMONOIDEA
Grossouwritites gemmatus (A,D)
Maorites densicostatus (C,D)
Maorites suturalis (D)
Kitchinities laurae (D)
Pachydiscus ricardi (D)
Anagaudryceras cf. mikobokense (D)

scaphopods

BIVALVIA
Mucula suboblonga (A)
Cucullaea antarctica (C,D,F)
Pulvinitesantarcticus (D)
Laevitrigonia eclecta (C,D,F)
Linotrigonia pygoscellum (C,D)
Lahilla larseni (A)
Panope clausa (A,F)
Goniomya hyriformis

corals
echinoderm spines
fossil wood
Figure 44-- Massive gray sandy siltstone with intercalations of darker horizons. On top follows a glauconite-rich bed. Note the presence of loose material partially covering the outcrop due to solifluxion. (Unit 9)

Figure 45-- Thickly bedded silty sandstone forming the base of Unit 8. Station 182.
Figure 46-- Same as Fig. 45. Note randomly oriented burrows. Station 154, Unit 8.

Figure 47-- Massive silty sandstone with a gastropod (*Amberleya spinigera*) "in situ". Unit 8.
The increase in both grain size and sand percentage is clearly shown in the grain size analysis with values of 41 to 63% of sand. The thickness of this unit varies from 100 to 110m.

Unit 9: This unit has an almost uniform thickness. It displays an increase in the glauconite content of the sediment, which results in a more greenish coloration of the rock (Figs. 39,48). The glauconitic sediments occur lowest in the section in the southwest (section A), and at progressively higher levels over the rest of the island. The macrofauna is again very abundant and diverse (Figs. 49,50,51,52,53). At the top of this unit, and approximately coincident with the Pachydiscus ultimus Zone, there is a level with abundant bioturbation and macrofauna. The oyster Pycnodonte cf. vesiculosa (Forbes) is especially common. These last beds are informally called here Pycnodonte Beds, and will be discussed independently. Unit 9 is approximately 150 m thick and is present in all five of the sections measured through the top of the Lopez de Bertodano Formation. In Section A, the lithology is composed of yellowish to tan colored and occasionally gray sandy silt, intercalated with several concretionary levels. Upward, glauconitic intervals become more abundant in intervals approximately 0.5 m thick, and are intercalated with several gray sandstone beds. A level with large round concretions is found just beneath the Pycnodonte Beds (Fig. 54).

In Section C, the dominant lithology is a gray sandy siltstone, well-bedded at the base, and more massive towards the top. Concretions
Figure 48. Panoramic view of Unit 9 (Lopez de Bertodano Formation). Several of the darker horizons are rich in glauconite. D: Basaltic dike (Filó Negro). (Stations 336-340).
Figure 49-- Massive, gray sandy siltstone with numerous specimens of *Ditrupa* sp. (calcereous worm tube). *Ditrupa* sp. is generally found in narrowly defined horizons.

Figure 50-- Large specimen of the heteromorph ammonite *Diplomoceras lambi* Spath. (Scale in cm.).
Figure 51-- *Pachydiscus riccardi* n.sp. preserved in a large concretion. Unit 9.

Figure 52-- Well preserved specimen of *Maurites densicostatus* Kilian and Rebull. Large burrows are observed in the concretionary horizon on the background. Station 341, Unit 9.
become abundant upwards, some of them up to 0.4-0.5 m. in diameter, with numerous large burrows (Fig. 55). These sediments are followed by the Pycnodonte Beds.

In Section D, there is a 4-5m thick glauconitic silty sandstone at the base of Unit 9. This grades upward into a gray massive sandy siltstone, which contains horizons with small annelid tubes (Ditrupa sp.), and bivalves (Fig. 49). Numerous elongated concretions (which possibly represent burrows of this shape) are found at the top. This is followed by the Pycnodonte Beds and above this, 36 m of gray massive sandy siltstone with small round to irregular concretions. This 36m section is possibly not represented in the other sections (Fig. 39).

In Section F, the lithology is composed of dark gray massive sandy siltstone with intercalations of calcareous sandstones and one glauconitic bed one meter thick.

Fossils found in Unit 9 (excluding the Pycnodontes Beds) include:

**ANNELIDA**
R. (Rotularia) shackletoni (A, C, F)
R. (Australrotularia) zinsmeisteri (A)
R. (Australrotularia) sp. (C, F)
Ditrupa sp.

**CEPHALOPODA**
Maorites densicostatus (A, C, D, F)
Maorites tenuicostatus (A, C, F)
Maorites suturalis (A, C, D, F)
Grossouwrites gemmatus (A, C, D, F)
Diplomoceras lambi (A, C, D, F)
Kitchinites laurae (C, D, F)
Pachydiscus riccardi (A, C, D, F)
Anagaudryceras cf. mikobokense (C, D)
Vertebrites sp. (D)
Pseudophyllites loryi (F)
Eutrephoceras simile (D, F)

BIVALVIA
Linotrigonia pyoscelium (D)
Laevitrigonia ecplecta (C, D, F)
Cucullaea antarctica (C, D, F)
Pinna anderssoni (C, D, F)
Pulvinites antarcticus (C)
Phelopteria sp. (D)
Entolium sp. (D, F)
Acosta snowhillensis (D)
Limatula antarctica (D, F)
Eriphyla drygalskiana (D)
Lucina? scotti (D)
Lahilla larseni (C, D, F)
Cyclorhisma incognita (C, D)
Thyasira townsendi (D)
Soledmya rossiana (D)
Panope clausa (D, F)
Conomya hyriiformis (D)
Pycnodonte cf. vesiculosa (D, F)
unident. small bivalves (D, F)

GASTROPODA
Perissoptera nordenskjoldi (A, C, D, F)
Cassidaria mirabilis (C, D, F)
Cryptorhytis philippiana (D, F)
Amberleya spinigera (C, D, F)
Pleurotomaria larseniana (A, D, F)
Taioma charcotianus (C, D, F)
Cerithium sp. (D)
Eunaticina arctowskiana (F)

In addition, the following were found: echinoderm spines, marine reptile bones, shark vertebrae, the decapods Hoploparia stockesi and Callianassa meridionalis; Brachiopoda sp. indet., corals, and fossil wood, usually bored by pholadid bivalves.

The macrofossils are well preserved and are found in most cases "in situ" with bivalves still articulated. The thickness of this unit up to the Pycnodonte Beds ranges from 70 to 120 m. Large concretions containing numerous juvenile ammonites, particularly of Maorites
Figure 53-- Large specimen of Anazaudryceras cf. mikobokense Collignon. Station 333, Unit 9.

Figure 54-- Large round concretions in Unit 9 (Station 66).
Figure 55-- Gray sandstone with conspicuous bioturbation displaying meniscus structure. Station 331, Unit 9.

Figure 56-- Calcareous concretion with very abundant juvenile specimens of *Maorites* densicostatus. Station 377, Unit 9.
densicostatus, M. tenuicostatus, M. suturalis, and to a lesser extent
Grossouwrites gemmatus, are also common here (Figs. 56,57). A coquina,
with intraformational conglomerate and a reworked fauna was found at
locality N-83. A grain size analysis on Sample 60 yielded 35% of sand
and 21% of clay.

**Pycnodonte Beds:** This sub-unit which has well defined lithologic
characteristics, does not have a defined lower boundary and for this
reason it has not been considered independently (Fig. 39). It coincides
approximately with the *Pachydiscus ultimus* Zone, and is 40 to 50 m
thick. Characteristics shown by these beds include the very abundant
bivalve *Pycnodonte* cf. *vesiculosa* (Fig. 58), and extremely abundant
bioturbation similar to *Planolites* (cf. Pemberton and Frey, 1982) that
is preserved in large (up to 1 m) concretionary horizons (Figs.
52,59,60). The lithology consists of massive gray sandy siltstones and
glaucnonic beds, which are more common in Section F. Small irregular
concretions are also present. Fossils found in the *Pycnodonte* Beds
include:

**ANNElIDA**
R.(Rotularia) shackletoni
R.(Australorotularia) sp. (A,C,D,E,F)
Ditrupa sp.

**CEPHALOPODA**
Maorites densicostatus (C,D,F)
Maorites tenuicostatus (A)
Maorites suturalis (D)
Grossouwrites gemmatus (C,D,F)
Diplomoceras lambi (C,D,F)
Kitchinities sp.(D)
Pachydiscus riccardi (C,D)
Pachydiscus ultimus (A,C,D,E,F)
Anagaudryceras cf. mikobokense (D,F)
Zelandites sp. (D)
Figure 57-- Large concentration of juvenile specimens of *Maorites* sp. Note that all specimens lie with their plane of symmetry parallel to the bedding plane. (Station 331, Unit 9).

Figure 58-- *Pycnodonte* Beds. Note the large number of specimens of *Pycnodonte cf. vesiculosa* on the surface, as well as abundant bioturbated concretions. (Station 399).
Figure 59-- Strongly bioturbated concretions. Note conspicuous tubes extending from a more expanded chamber (Pycnodonte Beds, Station St. 6).

Figure 60-- Abundant trace fossils similar to Planolites. Pycnodonte Beds, Station 342.
Pseudophyllites loryi (C)
Eutrephoceras similis (C,D)

BIVALVIA
Pinna anderssoni (C,D)
Laevitrigonia egelecta (C,D,F)
Cucullaea antarctica (C,D)
Pinna anderssoni (C,D,F)
Pulvinites antarcticus (C)
Acesta cf. snowhillensis (C,D,F)
Limaflata antarctica (C,D)
Lahilla larseni (C,D,F)
Cyclorhismina incognita (C)
Panope clausa (C,D)
Goniomya hyriiformis (C,D)
Pycnodonte cf. vesiculosia (A,C,D,E,F)

GASTROPODA
Perissoperta nordenskjoldi (D,F)
Cassidaria mirabilis (D)
Cryptorhytis philippiana (C,D,F)
Amberleya spinigera (C,D,F)
Taloma charcotianus (C,D,F)
Cerithium sp.
Eunaticina arctowskiana (C)

In addition, the following also are present: echinoderm spines, marine reptile bones, Hoploparia stockesi (Decapod)(very abundant in section F), corals, crinoid fragments, bored fossil wood and coalified wood.

There is a sharp decline in macrofaunal diversity at the top of Unit 9, coincident with the total disappearance of the cephalopods. This level is considered to coincide with the Cretaceous-Tertiary boundary. Grain size analysis shows a range in mud percentage from 52 to 64%.

Unit 10: This unit represents the uppermost beds of the Lopez de Bertodano Formation, and is directly overlain by the Sobral Formation.
Figure 61-- Strongly bored log. Borings produced by Teredo-type bivalves. (Station St. 5, Unit 9).

Figure 62-- Massive silty sand with irregular calcareous concretions, and the bivalve Lahilla larseni (Sharma and Newton). (Station 119, Unit 10).
The unit displays a marked decrease in macrofaunal diversity, which is restricted to few species of bivalves and gastropods. The most typical element here is the venerid bivalve *Lahilla larseni* (Sharman and Newton) which occurs in large concentrations, commonly associated with the winged gastropod *Perissoptera nordenskjoldi* (Wilckens). Bored fossil wood is particularly abundant. The thickness of the unit is directly controlled by the degree of erosion associated with the lower unit of the overlying Sobral Formation. Glaucconite is common, particularly in Section A. The rock is a green to greenish-brown sandy siltstone becoming progressively more sandy upwards. Large round concretions are usually found at the top of the unit, and concretionary horizons and irregular concretions are also common (Fig. 62). Fossils found in Unit 10 include:

**ANNELIDA**

*R. (Austrorotularia)*sp.

**BIVALVIA**

*Nucula suboblonga* (C,D)  
*Cucullaea elliottii* (A,C,D,E,F)  
*Lahilla larseni* (A,C,D,E,F)

**GASTROPODA**

*Perissoptera nordenskjoldi* (A,C,D,F)  
*Pleurotomaria larseniana* (A)  
*Austrosphaera patagonica* (C)

Echinoderm spines  
Bored fossil wood (abundant)

*present only at the base of the unit.

**SOBRAL FORMATION**

The Sobral Formation rests disconformably on the Lopez de Bertodano Formation. These beds are approximately equivalent to the "couches a *Lahilla luisa* Wilckens sans ammonites" of Kilian and Reboul (1909). They were included in the "Older Seymour Island Beds" of Anderson (1906)
Figure 63—Correlation of sections measured in the Sobral and Cross Valley formations.
and in the "Snow Hill Island Series" of Bibby (1966), together with the Lopez de Bertodano Formation (Fig. 7). Rinaldi et al. (1978) considered these beds an independent lithostratigraphic unit, and this interpretation was followed by Rinaldi (1982); Zinsmeister (1982a); Macellari and Huber (1982), and Macellari and Zinsmeister (1983). The lower contact was not clearly defined by Rinaldi et al. (1978) and its upper boundary was not defined.

A revision of the contacts of the Sobral Formation is formally proposed here. The lower contact of this formation is defined as the base of a very distinctive and laterally continuous 15-20m thick dark brown, well-laminated to flaser-bedded silty mudstone which displays numerous channels on varying scales (Figs. 9,10,11,12,64). This unit has been called informally the "brown chocolate layer", and makes a distinctive break in the topography, which is easily traceable in aerial photographs. The top of the formation is defined as the base of a distinctive glauconitic horizon that is the first conspicuously cross-bedded unit found on ascending stratigraphically (Figs. 10,71,72). This horizon also coincides with a marked break in the topography.

With the boundaries of the formation as defined here, the thickness of the Sobral is 168m. in Section A and 178m. in Section E. Lithologically and morphologically, two units can be distinguished (Fig. 63):

Unit 1: Unit 1 forms a comparatively strong relief due to the presence of more resistant beds that produce steep cuesta-like topography. The thickness of this unit is 110 m. in Section A and 119 m
Figure 64-- Base of the Sobral Formation. BC: "Brown chocolate layer". Note the presence of small channels. G: Glaucnite-rich bed. (Stations 120-122).

Figure 65-- Unit 1 of the Sobral Formation showing several glauconitic (darker) horizons. (Photo taken near to Station 74).
Figure 66-- "Brown chocolate layer" showing flaser bedding and irregular channels with a higher sand content (lighter areas). Soft sediment deformation is observed at the base of the channel. (Station 122).

Figure 67-- "Brown chocolate layer" with a more sand-rich (lighter color) channel. Burrows disturb the fine lamination of the sediment. (Station 122)
in Section E (Fig. 63). It is composed mostly by a silty sandstone with sporadic intercalations of massive sandstone and conspicuous glauconitic horizons (Fig. 65). The lower bed or "brown chocolate layer" is a uniform and continuous unit of well-laminated to flaser-bedded siltstone with localized more sandy channels. Some show soft-sediment deformation at the base (Figs. 66, 67). Some channels are cut by large vertical burrows. The channels are usually 1-3 m wide and almost coalesce at certain intervals. Much larger scale channels (in the order of 50-100 m) are also observed at the base of the sequence, cutting regionally into the underlying Lopez de Bertodano Formation (Fig. 12). At one place (Station 72) a pebbly to conglomeratic sandstone, composed of rounded clasts (0.5-1 cm) of the underlying Lopez de Bertodano Formation was found (Fig. 68). Whereas this facies persists with minor interruptions for 50 m in Section E, it is only approximately 15 m thick in Section A, where channels have not been observed. At Section A, the basal layer is more glauconitic and contains large round concretions up to 1 m in diameter together with two conspicuous glauconitic beds. The glauconitic beds can be traced laterally for some hundreds of meters, after which they pinch out. Light gray massive silty sandstone is present in both sections.

A conspicuous 0.5 to 1 m thick white, massive clay layer is present in both sections but at slightly different stratigraphic levels. The upper part of Unit 1 is mostly composed of a light green, glauconitic, very friable silty sand with intercalations of massive, indurated, glauconitic sandstone. The invertebrate fauna is almost identical to
Figure 68-- Round concretions near the base of the Sobral Formation, some with reworked, small gastropods and bivalves, as well as small pebbles derived from the underlying Lopez de Bertodano Formation.

Figure 69-- Skolithos (vertical burrow) in a massive, medium grained sandstone. (Unit 2, Sobral Formation).
that of Unit 10 of the Lopez de Bertodano Formation. Fossils are very sparse and not very diverse, though they are relatively more abundant in Section A than in Section E:

**BIVALVIA**
- Nucula suboblonga (A)
- Malletia gracilis (A)
- Cucullaea elliottii (A)
- Pinna anderssoni (A)
- Acesta webbi (A)
- Lahilla larseni (A)
- Cyclorisma incognita (A)

**GASTROPODA**
- Perissoperca nordenskoldi (A)
- Pleurotomaria larseniana (A)
- Cerithium sp.
- Cinulia sp.
- Austrospheara patagonica
- Gastropoda n. gen. n. sp.

Echinoderm spines

Shark teeth

Fossil wood (abundant)

---

**Unit 2:** This unit is 46 m thick in Section E and 58 m thick in Section A. The lithology consists of very friable gray to light green silty sandstone with intercalations (usually 0.5 to 2 m thick) of massive to moderately bedded sandstone. Some yellowish (limonitic?) levels are particularly common in Section E. A distinctive reddish clay horizon is also present. Reddish stained concretions are found at some horizons. Towards the top of the unit, (particularly in Section E), oblique and vertical burrows (Skelithos) are abundant (Fig. 69). This unit has a typical "soft" relief and forms a low topography. Fossil wood is common, usually without the pholadid bivalve burrowing that is common in the underlying Lopez de Bertodano Formation (Fig. 70). With the exception of poorly preserved specimens of the bivalves *Malletia gracilis* and *Cucullaea elliottii*, macrofauna is almost completely absent.
Figure 70-- Well preserved fossil wood. Subral Formation.

Figure 71-- Trough cross-bedded glauconitic sandstone forming the base of the Cross Valley Formation. See hammer for scale.
The Cross Valley Formation was described by Trautman (1976), and formally established by Elliot and Trautman (1982). It includes a mostly non-marine sequence exposed in fault blocks in Cross Valley and at the northern part of Seymour Island (Fig. 9). The original definition of this formation includes poorly sorted, pebbly coarse-sand and sandstone which pass upward into plant-bearing silt and silty sandstone beds with thin limonite-stained sandy clay intervals, and scattered fossil wood. Upward, in the type section, is found a bluff-forming pebbly sandstone with volcanic (andesitic, with subordinate silicic fragments) clasts up to 15 cm in length (Elliot and Trautman, 1982). The base of the type section (that is 106 m thick) is not exposed, and hence the relation of this unit to the underlying Sobral Formation was not clearly established (Elliot and Trautman, 1982, p. 288).

Trautman (1976), also described an outcrop of this formation in the northern part of the island, in the vicinity of Cape Wiman. There the sequence consists of silt and silty sand beds which pass upward into poorly sorted pebbly coarse sand. As discussed previously, the boundary with the underlying Sobral Formation is exposed in the southern portion of the island, and it is placed at the first conspicuous cross-bedded unit found in the sequence. This cross-bedded unit which locally is very rich in glauconite, forms a prominent break in topography and is a continuous layer that can be followed throughout the island (Figs.
Figure 72. Cross-bedded eolianitic sandstone at the base of the Cross Valley Formation.
A: Planar cross-bedding deposited by the migration of dunes and sand waves.
B: Low-angle cross-stratification.
C: Ripple-drift cross-stratification.
71,72). The cross-bedded unit is also found, and forms a similar break in topography, in the Cape Wiman area.

The lithology and petrology of this formation has been treated in detail by Trautman (1976) and Elliot and Trautman (1982), and only the personal field observations, particularly in the SE portion of the Island and in the Cape Wiman area will be included here. Maximum thickness measured was in Section E with 76 m. The base of this formation is placed at a 0.6-1m thick glauconitic, tabular- as well as trough-cross-bedded, medium grained sandstone (Fig. 63). Foreset laminae are 0.5 to 1.5 cm thick and dip between 38 and 8' with a mean value of 23° (S=7°). Paleocurrents in the southeastern part of the island (n= 63) point towards the E-NE (N 66°) whereas the paleocurrents in the Cape Wiman area (n= 15) indicate a current almost due east (N. 88°)(Fig. 73). The cross-bedded interval is followed by a 0.15-0.20 m thick very low angle to planar-bedded sandstone. This in turn, is followed by 0.6-0.7 m of sandstone with small-scale crossbedding, and formed by the lateral migration of ripples. The dominant lithology is a greenish to dark brown friable sand with large fragments of fossil wood, some of them carbonaceous. Spherical concretions with a yellow patina are intercalated with more consolidated, approximately 1 m thick, sandstone layers. Yellowish and yellow-orange layers, probably limonitic, become more common upwards.

In sections A and B a second trough-cross-bedded unit, 2 to 5 m thick, with individual beds 1 m thick and occasional larger channels, is
Figure 73-- Distribution of cross-bedding measurements in the Cross Valley Formation.
Figure 74-- Irregular burrows in a pebbly sandstone. Cross Valley Formation, near to Penguin Bay. Station 140. (Tag is approx. 10 cm. wide).

Figure 75-- Irregular burrows, similar to those of Fig. 74. (Cross Valley Formation, Cape Wiman, Station 314).
present (Fig. 63). There is a noticeable upward increase in grain size and the highest beds on Section E are composed of a pebbly sandstone in which the pebbles are predominantly volcanic. Numerous burrows are present at this higher level as well as in the upper beds of this unit in the Cape Wiman area (Figs. 74, 75). These burrows, which are randomly oriented, have the appearance of roots, and are extremely abundant at certain horizons, weathering out as individual, irregular tubes.

Reconnaissance observations in the Cape Wiman area show the presence of two well defined members in the Cross Valley Formation exposed there. The lower member is very similar to that in sections A, B, E, having numerous crossbeds and glauconitic units. The top part of this unit has poorly preserved, scattered bivalves in a medium grained sandstone. The overlying unit is much better bedded, and carries abundant wood material. The dominant color of the rock is yellowish orange. Fining upwards cycles, approximately 1.5 to 2 m. thick were observed; pebbly sandstones occur at the base (usually cross-bedded) and more fine grained sandstones at the top, possibly indicating a phase of fluvial sedimentation.
CHAPTER V

BIOSTRATIGRAPHY

The macrofauna in the Lopez de Bertodano Formation is both abundant and very well preserved. The diversity found here (a total of 90 species of invertebrates) is moderate to poor, relative to Recent marine environments and other low latitude late Cretaceous localities. Taxa recovered from this formation include annelids, bivalves, echinoderms, corals, gastropods, brachiopods, cephalopods, and decapods. The general trend in diversity is well displayed when all the available taxa from each unit are plotted. A nearly linear increase in the total diversity from units 1 to 9 is observed, with a rapid decrease above the Pycnodonte Beds and a slight recovery in the overlying Sobral Formation (Fig. 76). These changes in diversity can not be directly related to changes in lithology. Fluctuations in the mud content and in the mean grain size (which are only minor) do not seem to affect this overall trend towards increase in diversity. Unit 8 provides an exception (Fig. 76). The latter shows a higher percentage of sand, a slight increase in the mean grain size, and a decrease in total diversity compared with units 7 and 9.

In the lower part of the Lopez de Bertodano Formation, the fauna is low in diversity and poorly preserved. This interval is dominated by
Figure 76-- Stratigraphic variations in the total macrofaunal diversity, compared to variations in mud and mean grain size.
serpulids (Rotularia), echinoderms, and corals, which are associated with Elasmosaurs and Mosasaurus vertebrae (Rotularia Units). The upper portion of this formation, referred to as the Molluscan Units, is dominated by a diverse fauna of bivalves, gastropods and ammonoids. Serpulids, echinoderms and corals are also common.

The overall increase in diversity is not readily apparent when individual sections are analyzed (Figs. 77, 78, 79, and 80). In Section A (Fig. 77) a maximum total diversity is found near the base of Unit 7. However, with the exception of the peak shown at the base of Unit 7, the overall diversity in this section is low. This may be a result of the shorter time devoted to collecting specimens in units 8 and 9 of Section A. On the other hand, Section C (Fig. 78) which is about one kilometer away from Section A, shows much higher diversity in Unit 9.

In Section D (Fig. 79) a sharp increase in diversity is observed at the contact of units 6 and 7. From this contact upwards, diversity is relatively constant with a maximum near the base of Unit 9. Section F (Fig. 80) also displays a sharp break in diversity at the contact of units 6 and 7. This section shows an almost constant, relatively high diversity with a sharp decrease in Unit 8. This pattern is also clearly displayed by the cephalopod diversity. A comparison of total diversity of sections A, C, D, and F is shown in Fig. 81. The break in diversity between the Rotularia and the Molluscan units is clear in sections A,D, and F.
| SECTION A |
|------------------|----------------|----------------|----------------|
| TOTAL INVERTEBRATE DIVERSITY | CEPHALOPODS | BIVALVES | GASTROPODS |
| 1200 m | | | |
| 200 m | SOBRAL Fm. | | |
| 1100 m | LOPEZ de BERTODANO Fm. | Unit 10 | |
| 1000 m | Unit 9 | | |
| 900 m | Unit 8 | | |
| 800 m | Unit 7 | | |
| 700 m | Unit 6 | | |
| 600 m | Unit 5 | | |
| 500 m | Unit 4 | | |
| 400 m | Unit 3 | | |
| 300 m | Unit 2 | | |
| 200 m | Unit 1 | | |
| 100 m | | | |

Figure 77—Variations in cephalopod, bivalve, gastropod, and total invertebrate diversity. Section A.
**SECTION C**

<table>
<thead>
<tr>
<th>TOTAL INVERTEBRATE DIVERSITY</th>
<th>CEPHALOPODS</th>
<th>BIVALVES</th>
<th>GASTROPODS</th>
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<td>Unit 10</td>
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<td>Unit 9</td>
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<tr>
<td>Unit 8</td>
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</table>

**Figure 78**— Variations in cephalopod, bivalve, gastropod, and total invertebrate diversity. Section C.
Figure 79—Variations in cephalopod, bivalve, gastropod, and total invertebrate diversity. Section D.
Figure 80— Variations in cephalopod, bivalve, gastropod, and total invertebrate diversity. Section F.
Figure 81-- Comparison of total invertebrate diversity found on sections A, C, D, and F.
This work has concentrated on the annelids, ammonites and gastropods, but the presence of other groups was also recorded. A description of the stratigraphic occurrence of the Cretaceous macrofossils from Seymour Island follows.

ANNELIDS

The annelids from Seymour Island have been described by Weller (1903), Wilckens (1910), Ball (1960), and more recently, by Macellari (1984). The calcareous worm tubes (Annelids) of the genus *Rotularia*, are the most common macrofauna present in Seymour Island. Approximately 400 specimens were collected during the 1982 expedition on Seymour Island. A small number were collected at Snow Hill, Vega, and James Ross (The Naze) islands. In addition, previous collections of specimens from this area, now deposited in the British Museum (Natural History) (aprox. 170 specimens) and in the Naturhistoriska Riksmuseet (Stockholm) (aprox. 220 specimens) have also been examined. During the 1983/84 Expedition, approximately 800 additional specimens were collected, but have not as yet been studied in detail. The annelids found on Seymour Island include:

- *Rotularia* (Rotularia) shackletoni (Wilckens)
- *Rotularia* (Australrotularia) fallax (Wilckens)
- *Rotularia* (Australrotularia) tenuilaevis Macellari
- *Rotularia* (Australrotularia) zinsmeisteri Macellari
- *Rotularia* (Australrotularia) sp.
- *Ditrupa* sp.

Stratigraphic distribution of *Rotularia*. Based on the distribution of different species of *Rotularia*, the sequence has been divided into four
Figure 82—Vertical variations of abundance, mean diameter of planispiral, conispiral and total forms, percentage of conispiral forms, mean diameter vs. height ratio of conispiral, planispiral and total forms, as well as vertical distribution of different species of *Rotularia*. 
informal local range zones that can be identified in each of the sections measured (Figs. 82 and 83). These zones are particularly useful in the lower part of the section where ammonites are sparse, poorly preserved, and long ranging. Zone I (oldest) is characterized by the presence of \textit{R. (Australorotaria) fallax} (Wilckens). It has been recognized on Vega Island, James Ross Island (Cape Gage, Ula Point, and The Naze), Humps Islet (based on the material preserved in the British Museum (Natural History)) as well as on Snow Hill Island and the lowermost portion of the Seymour Island sequence. On Snow Hill Island this species is associated with the \textit{Gunnarites antarcticus} (Weller) ammonite zone of Olivero (1981). This zone is present in sections A and D as well as in stations 386, 387 along the western coast of Seymour Island (Fig. 9).

Zone II, is based on the first occurrence of \textit{Rotula}ria (A.) \textit{tenuilaevis} Macellari. \textit{R. (Rotula) shackletoni} (Wilckens) is also present but not very abundant. This zone is well represented in sections A, D and F in Seymour Island.

Zone III, is based on the first occurrence of \textit{R. (Australorotaria) zinsmeisteri} Macellari. \textit{R. (Rotula) shackletoni} is also found in this zone. Zones II and III are associated with the ammonites \textit{Maorites seymourianus} (Kilian and Reboul), \textit{M. densicostatus} (Kilian and Reboul), \textit{Grossouvreites gemmatus} (Huppe), and \textit{Kitchinites darwini} (Steinmann), among others, and roughly coincide with the \textit{Pachydiscus ootacodensis} ammonite Zone.
Figure 83 -- Simplified geologic map of Seymour Island showing the spatial distribution of the *Rotularia* zones.
Zone IV, identified only in the uppermost portion of the late Cretaceous Seymour Island sequence, is characterized by the first occurrence of Rotularia (A.) sp.. Its distribution approximately coincides with the Pachydiscus riccardi n. sp. and P. ultimus n. sp. ammonite zones, and extends a few meters above the last ammonite occurrence, here interpreted to coincide with the Cretaceous–Tertiary boundary.

Abundance, size and mode of coiling—A semi-quantitative assessment of the abundance of the serpulid fauna from Seymour Island is presented in Fig. 82. It must be emphasized that the abundance data are only an estimate of the real abundance values based on field observations and the number of specimens present in each sample. Nevertheless, the abundance values can be regarded as indicators of general trends, which tend to be repeated in the different measured sections.

In general, a peak of maximum abundance is associated with each Rotularia zone. This pattern suggests a cyclicity with each new cyclic climax represented by a "bloom" of a different species. Due to the small number of control points in sections D and F, it is impossible to make definite correlations of abundance between sections. Abundance data are compared in Fig. 84 with total macrofaunal and ammonite diversity (number of species) in Section A. Between 600 and 700 m of Section A, where the only marked peak in diversity occurs, Rotularia abundance is reduced. A comparison of Rotularia abundance vs. the different granulometric constituents of the sediment suggests a
Figure 84-- Relation between total diversity, ammonite diversity, and estimated abundance of *R. (Australrotularia)* spp. in Section A.
Figure 85-- Variations in percentages of clay, silt, and sand in Section A, compared against relative abundance of *Rotularia* (*Austrorotularia*) spp.
correlation between higher percentages of mud and peaks in Rotularia abundance (Fig. 85).

All specimens of Rotularia examined display a conispiral mode of coiling in the juvenile stages with a tendency to become planispirally coiled in the adult. It is interesting to note in Fig. 82 (Section A) that peaks of maximum abundance are accompanied by an increase in diameter, a high D/H ratio, and a low percentage of conispiral forms. This suggests that during peaks of maximum abundance conditions were such that most individuals reached adult stages. In Zone II (Figure 82, Section A) even the conispiral forms attain a larger size at the maximum peak of relative abundance.

Rotularia shackletoni, which is less abundant, ranges up to the last ammonite horizon (contact between units 9 and 10). Ditrupa is still much less abundant, than R. shackletoni, and was found in Section D (Station 147), and at approximately the same level in Section F (Station 181).

CEPHALOPODS

Stratigraphic distribution of the ammonite fauna on Seymour Island

The ammonite fauna from Seymour Island has been described by Kilian and Rebound (1909); Spath (1953); Howarth (1958); Del Valle and Rinaldi (1975b); Del Valle et al. (1976); and Riccardi (1981). In general the stratigraphic location of this fauna has been poorly documented. Most
Figure 86-- Stratigraphic distribution of cephalopods in Section A.
Figure 87-- Stratigraphic distribution of cephalopods in Section C.
Figure 88-- Stratigraphic distribution of cephalopods in Section D.
<table>
<thead>
<tr>
<th>Lopasidoceras cf. melobolense</th>
<th>Verneuilites haggei</th>
<th>Zelandites sp.</th>
<th>Pseudophyllites lorni</th>
<th>Diplomoceras lamberi</th>
<th>Krichnikites laroe</th>
<th>Krichnikites tuberculatus</th>
<th>Maorites seymourianus</th>
<th>Maorites densicoctatus</th>
<th>Maorites suturalis</th>
<th>Maorites tenuicostatus</th>
<th>K. (Natolites) wahlenseis</th>
<th>Gunnarites kailerl</th>
<th>Pachydiscus gnomoides</th>
<th>Pachydiscus nicardi</th>
<th>Pachydiscus ultimus</th>
<th>Eutrephoceras similis</th>
</tr>
</thead>
</table>

**Section F**

**Figure 89**— Stratigraphic distribution of cephalopods in Section F.
authors have regarded this fauna as occurring in roughly the same stratigraphic interval, even though the Seymour Island sequence is quite thick.

During the austral summer of 1982, more than 300 ammonites were collected, and their precise stratigraphic location determined. Several hundreds more were identified and collected during the second field season. Cephalopods are restricted to units 1 to 9 of the Lopez de Bertodano Formation (Figs. 86, 87, 88, and 89), and disappear at the inferred Cretaceous/Tertiary boundary.

The cephalopod fauna from Seymour Island includes:

Neophylloceras ramosum (Meeh) (1)
Phyllopaechceras forbesianum (D'Orbigny)(6)
*Anagaudryceras cf. mikobokense Collignon (=Gaudryceras varagurense (Kossmat) (1,6,7)
Vertebrites kayei (Forbes) (7)
Zelandites sp. (7)
Pseudophyllites loryi (Kilian and Rebul) (=P. peregrinus Spath) (6,7)
*Diplomoceras lambi Spath (5,6,7)
*Kitchinites (K.) darwini (Steinman) (4,6,7)
Kitchinites (K.) laura n.sp. (7)
Kossmaticeras (Natalites) (?) wedelliensis n.sp. (7)
*Grossouwrites gemmatus (Huppe) (1,2,3,6,7)
Gunnarites kalika (Stoliczka) (7)
*Maorites seymcurianus (Kilian and Rebul) (1,6,7)
*Maorites densicostatus (Kilian and Rebul)(1,6,7)
*Maorites tenulcostatus Marshall (7)
*Maorites suturalis Marshall (7)
Maorites tuberculatus Howarth (3)
Pachydiscus (P.) ootacodensis (Stoliczka)(7)
*Pachydiscus (P.) riccardi n.sp. (1,6,7)
*Pachydiscus (P.) ultimus n.sp.(7)
@*Eutrephoceras simile Spath (6,7)

* = common species  
@ = nautiloid

Other ammonites from Seymour Island include *Baculites delvallei* Riccardi, and *Jimboiceras* (?) *antarcticum* Riccardi. These species were described by Riccardi (1981) from material collected in moraine deposits at the top of the meseta and represent a much older assemblage (Santonian?).

The total distribution of the cephalopod fauna in the Lopez de Bertodano Formation is shown in Figure 90. The basal 500 m of sediment contain very few ammonites and the only common macrofauna is the annelid *Rotularia*. A cast of *Gunnarites kalika* (Stoliczka) was found in the lowermost 25 m of Section A. This is the first confirmed occurrence of *Gunnarites* on Seymour Island, and it is useful in relating these beds to those of Snow Hill and Vega islands which also contain this species. *Maorites tuberculatus* Howarth is restricted to this lower interval. It is particularly abundant close to Cape Bodman (Locality G-83) where Howarth's (1958) specimens were probably collected. This species also occurs as poorly preserved casts in the southern portion of the island (Station 433). Other ammonites found in this lower interval include *Diplomoceras lambi* Spath as well as fragments of unidentified specimens.

The ammonite fauna in the upper portion of the Lopez de Bertodano Formation is more diverse and abundant than below, and is useful in subdividing the sequence into three zones (*Pachydiscus ootacodensis*, *P. riccardi*, and *P. ultimus* zones) (Fig. 90). The rationale behind this
|------------------|-----------------------|------------------|----------------------|----------------|-------------------------|-----------------------|---------------------|-------------------------|------------------|----------------|-----------------------------|----------------|-------------------------|----------------|-----------------|----------------|------------------|

**Figure 90**—Total ranges and zonation of cephalopods from the Lopez de Bertodano Formation.
zonation will be presented in Chapter VIII. The *P. ootacedensis* zone is dominated by *Maorites seymourianus* and *Kitchinities darwini*. The most common taxa in the *P. riccardi* Zone are compressed species of *Maorites* (*M. densicostatus*, *M. tenuicostatus*, and *M. suturalis*), *Grossouwrites gemmatus* (v. abundant), as well as *P. riccardi*, *Anagaudryceras cf. mikobokense*, and *Diplomoceras lambi*. This assemblage continues into the *P. ultimus* Zone, with the exception of *P. riccardi* which is replaced by *P. ultimus*.

The ammonite zones are useful for correlating units 7 to 9 of the Lopez de Bertodano Formation (Fig. 39). It is interesting to note, however, that in sections A, C, E, and F, the *P. ultimus* Zone is only c.20 to 40m thick, and includes the last ammonite-bearing horizon. In these four sections the range of *P. ultimus* also coincides with the *Pycnodonte* Beds which have large concretions with conspicuous trace fossils (Fig. 39). However, a different distribution is found in Section D. Here *P. ultimus*, as well as the *Pycnodonte* Beds with its typical trace fossils, disappear 36 m below the last ammonite occurrence. This last interval has very few cephalopods, and they are mostly found within five m of the last ammonite horizon. The most common species in the highest ammonite-bearing levels are *Diplomoceras lambi*, *Eutrephoceras simile*, *M. densicostatus*, *Kitchinities sp.*, and *Grossouwrites gemmatus*. Particularly interesting is the restriction of small specimens of *Zelandites* sp. to stations St.5 and 411. However, *Zelandites*, which has a cosmopolitan distribution, is long-ranging and is usually not considered a precise time indicator. These observations
may suggest that the last ammonite occurrence (here tentatively equated with the K/T boundary), is overlain by a minor gap in the sequence. Section D may preserve slightly younger sediments than the other four sections. Alternatively, this could be due to facies control (i.e. controlling the distribution of *P. ultimus* and *Pycnodonte cf. vesiculosa*), and might not be time significant. Additionally, errors in the measurement of Section D, or failure in collection may be the cause of this discrepancy. Further field work in the area should address this important problem.

Diversity and trends in the ammonite fauna from Seymour Island.

The total ammonite diversity of the Lopez de Bertodano Formation is plotted at 50 m intervals in Fig. 91. There is a steady increase in diversity from the *P. ootacodensis* to the *P. ultimus* zones. If the lower limit of the *P. ootacodensis* Zone represents the lower Maastrichtian, and the *P. ultimus* Zone the uppermost Maastrichtian (as discussed in Chapter VIII), then a general increase in diversity occurs as the ammonites approach their demise at the K/T boundary. This is almost opposite to the situation Ward and Wiedman (1983) found in Spain where a gradual decline in the specific diversity is observed during Maastrichtian time.

As will be discussed in Chapter VIII, the Seymour Island ammonite fauna bear a strong endemic imprint (Fig. 92). However, a steady increase in the cosmopolitan component of the fauna is observed up
Figure 91—Vertical variations in ammonite diversity (plotted at 50 m intervals), and variations in the percentage of cosmopolitan vs. endemic taxa (plotted for each ammonite zone), in the Lopez de Bertodano Formation.
Figure 92 -- Vertical distribution of endemic, and cosmopolitan cephalopods in the Lopez de Bertodano Formation. Levels with abundant juvenile ammonites are shown at the right.
Figure 23 - Vertical distribution of ammonites of the families Ross ()=>
ticatidae, Pachydiscidae, and Democeratidae. Note an upward trend towards more compressed, involute, and less ornamented forms.
section. This is verified by the presence of abundant specimens of Pachydiscus, Anagaudryceras, Pseudophyllites, Vertebrites, Zelandites, which are relatively smooth forms. This trend is accompanied by several other subtle trends that are repeated in the different ammonite groups, and result in a general tendency to develop more streamlined shells up section. This progressive change is achieved through: a) an increase in the compression of the shells; b) increase in the degree of involution; c) a tendency toward smoother ornamentation (Fig. 93). In the Kosmoticeratidae, this is reflected as a general increase in compression and involution from Maorites tuberculatus to M. seymourianus, and finally to M. densicostatus-tenuicostatus-suturalis. The tendency to less coarse ornamentation is clearly observed between M. seymourianus and M. densicostatus-tenuicostatus. It is interesting to note that radial costae in M. suturalis, which are widely separated, are flat, particularly in the more mature portions of the phragmacone, giving rise to an overall much smoother surface than that of M. seymourianus.

In the Desmoceratidae, Kitchinites changes from the coarsely ribbed K. darwini to the much smoother K. laurae n. sp. These trends are very well displayed in the Pachydiscidae, where the inflated and relatively coarsely ribbed Pachydiscus ootacodensis, even though not directly related, is replaced by the more compressed, and smoother P. ricardi. This trend is continued with P. ultimus, where a maximum degree of compression, involution and decrease of ornamentation is achieved.
Another interesting feature of the ammonite fauna in Seymour Island, is the presence of concretions with very abundant juvenile ammonites, particularly of the species *Maorites densicostatus*, *tenuicostatus*, and to a lesser degree *M. suturalis* and *Grossouvrletes gemmatus*. In general, these swarms of small ammonites are monospecific and could be related to "hatching grounds", as discussed by Kennedy and Cobban (1976).

BIVALVES

Bivalves from the Cretaceous-Paleocene sequence of Seymour Island are both abundant and diverse. A drastic increase in this fauna coincides with the beginning of the Molluscan Units (Unit 7) (Figs. 94,95,96,97, and 98). Few bivalves are stratigraphically restricted. Among them, *Nordenskjdalia* and *Indogrammatodon* are exclusively found in the Unit 7 of the Lopez de Bertodano Fm., and *Pycnodonte seymourianus* is mostly restricted to this unit. *Pycnodonte cf. vesiculosa*, *Entolium*, *Acesta snowhillensis*, *Limatula*, *Veniella*, and *Pulvinites* are mostly restricted to the Unit 9 of the Lopez de Bertodano Fm., whereas *Cyclorisma* and the extremely abundant species *Lahilla larseni* extend from this unit up into the Sobral Formation. *Cucullaea ellioti* is abundant in Unit 10 of the Lopez de Bertodano Formation, and in Unit 1 of the Sobral Formation. The highest occurrence of bivalves is represented by a poorly preserved specimen of *Malletia* sp. in the Unit 2 of the Sobral Formation. Bivalves found here include:

*Nucula (Leionucula) suboblonga* (Wilckens) (1,2,4)
*Malletia (Malletia) gracilis* Wilckens (1,2,4)
Section A

Figure 94: Stratigraphic distribution of brachiopods in Section A.

- Nucula subablanga
- Malteola gracilis
- Solemya rossiana
- Indogrammatodon cf. lomondi
- Nordenskiöldia nordenstjordi
- Cucullaea antarctica
- Cucullaea eilioti
- Limopsis antarctica
- Pinna anderssoni
- Phelopteria sp.
- Pulvinites antarctica
- Acestra snowhillensis
- Acestra webbi
- Limatula antarctica
- Lævitrignia acplecta
- Linotrignia pygoscelium
- Thyasira townsendi
- Elphidium drygalskiana
- Lohilla jraenii
- Cyclotella incognita
- Lucina P. scotti
- Thracia n. sp.
- Goniomya krylliformis
- Panope clausa
- Pycnodonte seymorianus
- Pycnodonte cf. resculosa
- Entolium sp.
Figure 95-- Stratigraphic distribution of bivalves in Section C.
Stratigraphic distribution of bivalves in Section D.
Figure 97: Stratigraphic distribution of bivalves in Section F.

- Nucula subobionga
- Malacia gracilis
- Solemya rossiana
- Indogrammatodon cf. formandi
- Nordenskjoldia nordenskjoldi
- Cucullaea antarctica
- Cucullaea ellioti
- Limopsis antarctica
- Pinna anderssoni
- Phelopterus sp.
- Pulvinites antarctica
- Acesta snowthiilensis
- Acesta webbi
- Limatula antarctica
- Loinvrigania excacta
- Loinvrigania pygascium
- Thyasira townsendi
- Neophila drygalskiana
- Lohilla larseni
- Cyclatisina incognita
- Lucina f. scotti
- Thracia n. sp.
- Goniomya hyriformis
- Panope clausa
- Pycnodonte seymourianus
- Pycnodonte cf. vesiculosus
- Entolium sp.
Figure 98-- Total ranges of bivalves in the Lopez de Bertodano and Sobral formations.
Solemya (Solemya) rossiana (Wilckens) (4)
Indogrammatodon cf. lormandi Freneix (4)
Nordenskjoldia nordenskjoldi Wilckens (1,2,4)
Cucuilaeae antarctica Wilckens (1,4)
Cucuilaeae grahamensis Wilckens (2?)
Cucuilaeae elioti n. sp. (4)
Limopsis (Limopsis) antarctica Wilckens (1,4)
Pinna (Pinna) anderssoni Wilckens (1,2,4)
Pheoleptra sp. (4)
Pulvinites antarctica Zinsmeister (3,4)
Entolium sp. (4)
Acesta (Acesta) snowhillensis (Wilckens) (4)
Acesta (Acesta) webbi n.sp. (4)
Limatula (Limatula) antarctica (Wilckens) (1,2,4)
Mytilus sp. (1)
Laevitrignia (Eselaevitrignia) ecplecta (Wilckens) (1,2,4)
Linotrigonia (Oistotrigonia) pygoscelium (Wilckens) (1,4)
Linotrigonia (Oistotrigonia) antarctica (Wilckens) (1)
Lucina (?) scotti (Wilckens) (1,4)
Thyasira (Conchocele) townsendi (White) (2,4)
Erithyla (Erithyla) drygalskiana Wilckens (1,4)
Lahilla (Lahilla) larseni (Sharman and Newton) (1,2,4)
Cyclorismina incognita n. sp. (1,4)
Thracia (Thracia) n. sp. (4)
Goniomya (Goniomya) hyriiformis (Wilckens) (1,2,4)
Panope (Panope) clausa (Wilckens) (1,2,4)
Sphaerium? nucleous Wilckens (1)
Pycnodonte (Phygraee) cf. vesiculosa (Forbes) (1,2,4)
Pycnodonte (Phygraee) seymourianus (Wilckens) (1,2,4)
Veniella globosa (1,4)

(Numbers to the right indicate sources of information: 1- Wilckens, 1910; Rinaldi et al., 1978; 3, Zinsmeister, 1978; 4) This work).

GASTROPODS

This group is not very diverse, but the number of specimens per species is very high. No clear stratigraphic trend has been found in the gastropod distribution (Figs. 99, 100, 101). They are absent in the lower 400 m of the Lopez de Bertodano Formation, with the exception of minor unidentifiable fragments. An abrupt increase in gastropod
Figure 99-- Vertical distribution of gastropods in sections A and C.
Figure 100-- Vertical distribution of gastropods in sections D-E and F.
Figure 101-- Total ranges of gastropods found in the Lopez de Bertodano and Sobral formations.
abundance and diversity is observed at 600 m, coincident with the base of Unit 7 (Figs. 99, 100, 101). *Eunaticina* is generally restricted to Unit 7, and *Perissoptera* is very abundant in units 9 and 10 of the Lopez de Bertodano, and in Unit 1 of the Sobral formations. Most gastropod species disappear at the K/T boundary, and only a restricted assemblage continues upwards, together with a few new appearances.

The scaphopod *Dentalium* was mentioned by Wilckens (1910) from what is probably the uppermost Lopez de Bertodano Formation (Loc. 8 of the Swedish Expedition). Gastropod species found in this sequence include:

- *Pleurotomaria larseniana* Wilckens (1,2,3)
- *Amberleya spinigera* Wilckens (1,2,3)
- *Capulus? sulcatus* Wilckens (1)
- *Vanikoro kiliani* Wilckens (1)
- *Eunaticina arctowskiana* Wilckens (2,3)
- *Gyroides* sp.
- *Turritella ekelofii* Wilckens (1,2)
- *Cerithium* sp. (1,3)
- *Perissoptera nordenskoldi* Wilckens (1,2,3)
- *Cassidaria mirabilis* Wilckens (1,2,3)
- *C. mirabilis* var. *papillosa* Wilckens (1)
- *Taioma charcotianus* (Wilckens) (1,2,3)
- *Pyropsis gracilis* Wilckens (1,3)
- *Cryptorhytis philippiana* Wilckens (2,3)
- *Cinulia* sp. (1,3)
- *Austrophaera patagonica* (Feruglio) (3)
- *Cominella?* sp. cf. *C. tumida* (Wilckens)(3)

(Numbers to the right indicate sources of information: 1- Wilckens, 1910; 2- Rinaldi et al., 1978; 3- This work).

**OTHER GROUPS**

Other invertebrates, vertebrates and fossil wood are common in the Cretaceous-Paleocene sequence of Seymour Island. The taxonomy of these
groups has not been addressed, but their stratigraphic distributions
have been noted during field work. A brief description of their
occurrence follows.

Corals

Solitary corals are very abundant in the Lopez de Bertodano
Formation (Figs. 102-103). Felix (1909) identified four species:

Cycloseris deltoidophora Felix (1,2)
Cycloseris larseni Felix (1,2)
Parasmilia anderssoni Felix (1,2)
Bothrophoria ornata Felix (1,2)

(1-Felix, 1909; 2-this work)

The new collection probably contains additional species of corals
but a detailed classification is not attempted. Corals are present
throughout the Lopez de Bertodano Formation, but they are most abundant
in units 5, 6, 7, and 9.

Crustacea

Decapods from the James Ross Island area were described by Weller
(1903) and latter by Ball (1960). However the first description of
decapods from Seymour Island was provided by Del Valle and Rinaldi
(1975a). The two species found in the island include:

Hoploparia stockesi (Weller) (1,2,3)
Callianasa meridionalis Ball (3)

(1-Del Valle and Rinaldi, 1975a; Rinaldi et al., 1978; 3- This work.)

The occurrence of decapods in the Lopez de Bertodano Formation is
not restricted to a particular horizon, but they are most abundant in
Figure 102-- Stratigraphic distribution of brachiopods, echinoderms, decapods, corals, reptile bones, shark vertebrae, bryozoans, and fossil wood in the Lopez de Bertodano and Sobral formations (sections A, C, D, F).
Section F (particularly Station 366), and in units 8 and 9 (Figs. 102-103). This material is usually very well preserved in calcarous concretions, and original cuticular features are still preserved in some specimens (Taylor, 1973).

**Echinoderms**

Fossil echinoderms, in which only the spines are usually preserved are very abundant in the Lopez de Bertodano Formation, and to a lesser degree within some intervals of the Sobral Formation. The only detailed study of this fauna was based on material collected by the Swedish Expedition (Lambert, 1910). Lambert (1910) recognized a very endemic fauna, with few affinities, except possibly Patagonia. The following species were recognized on Seymour Island:

- *Cyathocidaris patera* Lambert (1,2,5)
- *Cyathocidaris erebus* Lambert (1,5)
- *Cyathocidaris nordenskjoldi* Lambert (1,2,5)
- *Metacrinus seymouriensis* Rasmussen (3)
- Unidentified crinoids (2,5)
- *Cladaster carrioni* Medina and del Valle (4)

(Numbers to the right indicate sources of reference: 1- Lambert, 1910; 2- Rinaldi et al., 1978; 3- Gasparini, et al., in press; 4- Medina and del Valle, 1983; 5- This work).

A detailed study of this material might be useful in establishing a local echinoderm spines zonation. The species *Cyathocidaris patera* appears to be present in beds older than *C. nordenskjoldi*. The spines present in the upper portion of the Lopez de Bertodano Formation have a typical inflated base, and might belong to another species. Echinoderms are present throughout the Cretaceous portion of the sequence. They are most abundant in units 8 and 9, and they are a characteristic element of
Figure 103-- Total occurrences of brachiopods, echinoderms, decapods, corals, bryozoans, marine reptile bones, shark vertebrae, and fossil wood in the Lopez de Bertodano Formation.
the otherwise impoverished fauna of units 4 and 5 (Figs. 102-103).

Recently, Medina and Del Valle (1983) described a new starfish species from Unit 9 of the Lopez de Bertodano Formation (Cerro Bandera).

**Brachiopods**

Lopez de Bertodano Formation brachiopods are relatively rare, and usually poorly preserved. They were found in four localities, but only two specimens are potentially identifiable. Previous work on the brachiopods of the area (Buckman, 1910) concentrated mostly on the Tertiary fauna, and the late Cretaceous taxa described recently by Owen (1980) was collected lower in the section, mostly on James Ross Island. Rinaldi et al. (1978) mentioned *Magallania* sp. from the Cretaceous of Seymour Island. A specimen found at Station 356 is identified as *Terebratulina?* sp.

**Vertebrates**

Fossil vertebrates from Seymour Island were found by researchers of the Instituto Antartico Argentino (del Valle, et al., 1977). More recently, Gasparini et al. (in press) described fragments of a large *Elasmosaurus* (Plesiosaur) from the lower portion of the Lopez de Bertodano Formation in Seymour Island, at a locality very close to Station 42. *Mosasaurus* (marine lizards) were reported from this island by Chatterjee and Zinsmeister (1982), and Gasparini and del Valle (in press).

During this work fossil vertebrae appear to be more common in units
4 and 6, where they are usually well preserved. They are usually abundantly preserved in Unit 9 in calcareous concretions, particularly just below the inferred Cretaceous/Tertiary boundary (Figs. 102-103).

Shark vertebrae from the Cretaceous of Seymour Island were collected by the Swedish Expedition and described by Woodward (1906) who referred the material to the genus Ptychodus Agassiz. However, the identification of these vertebrae has been doubted by Welton and Zinsmeister (1980). These authors stated that the generic determination of these vertebrae in the genus Ptychodus must be considered tenuous, because they could also belong to other shark genera. Similar vertebrae are present (Macellari, unpubl. data) in the Rio Blanco Formation in the Brunswick Peninsula of southern Chile, which is a probably time equivalent of the Lopez de Bertodano Formation (cf. Chapter VIII). Chatterjee and Zinsmeister (1982) also mentioned the presence of abundant specimens of fish (holosteans) in these sediments. Shark teeth are relatively rare; one was found in Station 411, and several were found in the Sobral Formation.

**Fossil wood**

Fossil wood with well developed growth rings is particularly common in the upper portion of the Lopez de Bertodano Formation (Unit 10), and in the overlying Sobral and Cross Valley formations. Logs up to two meter long, were found in Unit 9 in the Lopez de Bertodano Formation. Most large fragments of fossil wood are densely bored by pholadid bivalves, whereas in the overlying Sobral and Cross Valley formations,
wood fragments are not bored. Fossil wood from Seymour Island was described by Gothan (1908).

**Microfossils**

A very abundant, well preserved foraminiferal fauna was reported from the Lopez de Bertodano Formation by Huber (1984). This author described 156 species, including 101 species of calcareous benthics, 37 agglutinated species and 18 planktonic taxa. Although less diverse, the agglutinated foraminifera dominate the assemblage, which may be a reflection of selective dissolution of calcareous tests and differential preservation of the most resistant forms (agglutinated) (Huber, 1984). Three foraminiferal zones, ranging from the late Campanian to possibly the early Tertiary, were defined by Huber (1984). No identifiable foraminifera have been found in the Sobral or Cross Valley formations.

Other microfossils recovered from the Lopez de Bertodano and Sobral formations include well preserved ostracodes, diatoms, and calcareous nannofossils (Huber, Harwood, and Webb, 1983). In thin section, diatoms are particularly abundant in Unit 10 of the Lopez de Bertodano Formation, and in Unit 1 of the Sobral Formation. Palynomorphs are abundant throughout the section and are being studied by R. Askin (Colorado School of Mines).

**CRETACEOUS-TERTIARY BOUNDARY**

Kilian and Reboul (1909) noted the disappearance of ammonites in
the upper part of the Cretaceous sequence of Seymour Island, followed by
the dominance of the bivalve *Lahilla larseni* ("L. luisa") ("couches a
*Lahilla luisa* Wilckens, sans ammonites (Loc. 9)"). Rinaldi et al.
(1978) were not specific about the disappearance of the ammonites; they
roughly extended their range to the contact between the Lopez de
Bertodano and the Sobral formations, which they considered to be
Campanian and Maastrichtian in age, respectively. Zinsmeister (1982a)
noted however that the upper portion of the Lopez de Bertodano Formation
was devoid of ammonites, and more precise evidence of this was presented
showed that a major change in the macrofauna takes place within a 20 m
interval, recognized as the Cretaceous/Tertiary boundary, approximately
60 m below the contact between the Lopez de Bertodano and the Sobral
Formations.

During the 1983/84 field season fieldwork was concentrated around
the Cretaceous/Tertiary boundary in an effort to identify the
macrofaunal changes. These new field data indicate that the
disappearance of the ammonites takes place over a very narrow interval
just below a continuous glauconitic unit (Fig. 104). Although there is
little lithologic change at the proposed boundary, the following
lithology has been noted, from bottom to top (Fig. 105a): a) a gray
massive sandy siltstone, usually containing strongly bioturbated
calcareous concretions. Well preserved *Rotularia* sp., abundant fossil
bones, possibly of marine reptiles, ammonites, nautiloids
(*Eutrephoceras*) as well as a suite of bivalves, gastropods, and abundant
Figure 104-- Proposed Cretaceous/Tertiary boundary in Seymour Island. g: glauconite. The ammonite (*Pachydiscus ultimus*) was found 1m. below the boundary, as shown in the photograph. Station 347.
Figure 105--A: Generalized stratigraphy of the Cretaceous/Tertiary boundary in Seymour Island. B: Detailed stratigraphy of the Cretaceous/Tertiary boundary, as observed in Station St. 5.
bored fossil wood where found in this bed. This gray, massive, sandy siltstone usually has a large percentage of glauconite, which increases upward. b) A glauconitic bed 15–30 cm thick, usually underlain and sometimes also followed by a very thin (2–10 cm) yellowish layer which is barren of macrofossils. c) A sandy siltstone, usually light green, sometimes brownish gray, with few macrofauna and without ammonites or marine reptiles. \textit{Rotularia} specimens usually have a reddish patina, are poorly preserved, and may be locally reworked. Bored fossil wood is quite abundant in this interval.

The following lines of evidence point to this interval as the position of the Cretaceous/Tertiary boundary in Seymour Island.

a) The sudden disappearance of the ammonites at this particular level.

b) Absence of marine reptile bones above this interval.

c) Latest Maastrichtian beds underneath this horizon, as demonstrated by the presence of the calcareous nanofossils \textit{Nephrolithus frequens} Gorka and \textit{Braarudosphaera turbinae} Stradner in Sample 148 (Harwood, in Huber et al, 1983), 250 m below this horizon.

d) Glauconite ages reported here (Appendix B) (64.1 ± 0.9 my at Station 153) (see Fig.106), 100 m below the boundary, also indicates that these sediments are latest Maastrichtian in age. A date obtained from the glauconite overlying the K/T boundary gave an age of 58.9 ± 1.0 m.y.

e) Preliminary work on palynomorphs collected in the same area by R. Askin also indicates that the K/T transition takes place in the
proximity of these beds (R. Askln pers. comm., 1984).

f) Diatoms found at Station 117 (coincident with the last ammonite occurrence) are also the first to have definite Tertiary affinities (Harwood, pers. comm., 1984).

The faunal changes observed at the inferred Cretaceous/Tertiary boundary on Seymour Island are shown in Figure 106. The group which was most affected dramatically are the cephalopods. The bivalves, in contrast, show a gradational pattern of disappearance several meters below the boundary. However, further field work may extend the range of many taxa upwards, which would indicate a more drastic change. Nevertheless, several taxa show extinction at the specific level, with the exception of the genus *Laevitrignon*a, which became extinct. Other genera continued as different species into the Cenozoic. The species *Lahilla larseni*, and *Cyclotismina incognita* continue unaffected through the boundary, and only two new species appear above it. The gastropods display a similar pattern to that of the bivalves. Particularly interesting is the distribution of *Perissoptera nordskoldi* which is similar to *Lahilla larseni*, being abundant below and above the boundary.

A plot of the total diversity of invertebrates found at 5 m intervals 250 m below the Cretaceous/Tertiary boundary shows a gradual increase in diversity (up to 150 m below the boundary). A constant high diversity (32 species x 5 m interval) is observed from approximately 100 m up to 50 m below the boundary, followed by a rapid decrease in the last 50 m interval. A decrease in diversity is also observed in the 100
Figure 106-- Distribution of bivalves, gastropods, and cephalopods in the vicinity of the Cretaceous/Tertiary boundary. Solid dots on the stratigraphic column are glauconite ages.
Figure 107-- Variations in total diversity, and disappearance of species (plotted at 5 m intervals), in the vicinity of the Cretaceous/Tertiary boundary.
m above the K/T (Fig. 107). The change in the macrofauna is more apparent in the figure showing the percent of taxa that disappeared at 5 m. intervals (Fig. 107). A minor fluctuation in the percentage of disappearances occurs below the Cretaceous/Tertiary boundary, but at this level, 61.1% of the species present below are absent from the overlying 5 m. In conclusion, a drastic disappearance of taxa at the end of the Cretaceous is observed on Seymour Island, as is also recognized in other localities of the world. The bivalves and gastropods show a gradational change, but the pattern of extinction observed in the cephalopods is consistent with a catastrophic event as proposed by some authors (i.e. Alvarez et al., 1984, among many others). This is particularly true considering that the ammonite fauna in Seymour Island shows a gradual trend towards increase in diversity during the Maastrichtian, with no prior indication of its final extinction at this particular horizon. Particularly interesting is the coincidence of this event with the inception of very active volcanism in the nearby peninsula, as witnessed by the sudden appearance of subaerially deposited volcanic glass fragments (cf. Chapter VI).
CHAPTER VI
SEDIMENTOLOGY

GRAIN SIZE ANALYSIS

The unconsolidated nature of most of the Cretaceous-Paleocene sequence of Seymour Island, provides a good opportunity for grain size analysis of these sediments. Forty one samples were analyzed to determine sand content, mean grain size, sorting, and general trends in the grain size populations, in order to better understand the depositional environments of these sediments, and the associated energy levels. These data are tabulated in Appendix C.

Methodology

Because of the availability of a coulter counter after the initiation of the grain size analysis, the samples were treated in two different ways:

Group A (13 samples): For each of these samples, a 100 grams split was dispersed in a solution of water, H_2O_2, and dispersant (Calgon) by repeated heating and ultrasonification. The dispersed sample was then wet sieved at 63 um using distilled water with a dispersant (Calgon 2 gr/l), following the procedure of Folk (1974). The sands (coarser than 63 um) were dried, weighed, and dry sieved at 1/4 Ø intervals. The material finer than 63 um was placed in a one liter sedimentation tube, and brought to volume with a solution of water and dispersant. Silts recovered in the pan after dry sieving were also
placed in the settling tube. Because the amount of mud was large (generally 60 to 80 grams), the solution was stirred vigorously and diluted by a factor of 3 to diminish interparticle interference and, therefore departure from Stoke's law settling. The total amount of mud (silt + clay), and different size classes were calculated at 1 ø intervals following the pipette method (i.e. Folk, 1974).

Group B. (28 samples). These samples were prepared with the intention of being processed in a coulter counter. Despite being strongly diluted, however, these samples were too concentrated for precise analysis by the available coulter counter; as a result, no data are available on the grain size distribution of their silt and clay fractions. For this group, two subsamples were obtained from each sample with a sample splitter. The first subsample weighed 40–60 grams, and was subjected to the pretreatments outlined above, although tap water was used in place of distilled water. Following wet sieving at 63µm, the mud was discarded, and the sands were dried, weighed, and dry sieved at 1/4 ø intervals. From the sieve data, sand grain size abundances, percentage of aggregates, and the percentage of silt retained in the pan were calculated. The second subsample was smaller (4 to 12 grams), and was used to determine the abundance of the mud and sand components. This subsample was pretreated as described above for group A. After wet sieving, the sand was dried, weighed and discarded, and the mud was dispersed in a one liter sedimentation tube. The mud weigh was calculated by removing a 20 ml aliquot from the tube, drying it, and weighing the residue. In addition, a correction for silt which
was included in the sand was applied by adding the percentage of silt retained in the pan of subsample 1. Another aliquot (20 ml) was removed from the tube for further analysis of the silts and clays by Coulter Counter. Two split samples (22 and 35) were processed twice as estimates of analytical reproducibility. Both analyses resulted in nearly identical values (see Appendix C).

Results

Most samples of the Lopez de Bertodano Formation are sandy silts to clayey silts, with occasional silty sands (Fig. 108). Clay percentages are relatively constant, with values around 17%. Typical silt values in the Lopez de Bertodano are 45% and sand values around 35%. The mud content is more variable, ranging from a maximum of 98% (Sample 33) to 37% (Sample 147)(Figs. 109, 110). An upward trend of decreasing mud (silt + clay) percentages as well as of increasing grain size is observed from the Lopez de Bertodano to the Sobral to the Cross Valley formations. In both sections analyzed, an increase in sand occurs at Unit 8 (samples 54, 147, 149). In the Lopez de Bertodano Formation, sand is relatively abundant in Unit 1; units 2-7 have variable, but lesser amounts of sand. A second peak in sand is found in Unit 10.

A marked change in the sand content occurs within the Sobral Formation. Unit 1 is similar in sand content (35%) to the Lopez de Bertodano Formation. The sand content increases sharply in Unit 2,
Figure 108—Triangular diagram showing percentages of clay, silt, and sand in some of the Lopez de Bertodano Formation samples. (Diagram after Shepard, 1954).
however, to approximately 85%. This change also occurs in the more cemented horizons, where clean sandstones are present (i.e., figs. 137, 138). In the Cross Valley Formation, samples are almost exclusively composed of sand and pebbly sands.

**Grain size**

Mean grain size and sorting were calculated for all the samples analyzed using the moment method (i.e. Krumbein and Pettijohn, 1938) and a programmable pocket calculator. For the samples where the silt and clay sizes were analyzed, the total mean grain size and total sorting were calculated. However, in the samples in which only the total amount of mud was determined, the mean grain size and sorting of only the sand fraction were calculated. In either case the sorting curve is essentially a mirror image of the mean grain size curve. This is similar to results for the Central Oregon Continental shelf (Carey, 1972), where a decrease in grain size in an offshore direction was mirrored by an increase in the sorting coefficient. This is taken to indicate that higher energy conditions (as indicated by the increase in grain size) are less likely to produce a well sorted sediment. However, Blatt, et al. (1980) point out the fact that fine grained sands are usually the best sorted, the explanation being that these sands are composed almost entirely of a single population. In general, the mean grain size is a function of the energy of the transporting medium, or of the sizes available for transportation, whereas sorting depends on several factors, including the type of material available, nature of the
Figure 109-- Grain size trends and sand percentages in the Cretaceous-Paleocene sequence of Seymour Island (Section A). 1 and 2 are different values obtained in duplicate analysis of the same sample. X: Mean grain size. S: Sorting.
Figure 110-- Grain size trends and sand percentages in the Cretaceous-Paleocene sequence of Seymour Island (Sections D-E). X: Mean grain size. S: Sorting.
sedimentary process, viscosity of the transporting medium, and uniformity and persistence of energy conditions. The trend observed here (i.e. negative correlation between grain size and sorting), could be explained in terms of more uniform flow regimes associated with the finer grained sediments (better sorted), and more variable flow regimes associated with the coarser grained sediments (more poorly sorted). Alternatively, this decrease in sorting in the coarser grained sediment may be a reflection of mixing from different sources under higher energy conditions. However, Folk (1974, among many others) indicated that a definite relationship generally exists between grain size and sorting, controlled by a fundamental distribution of particle sizes in nature in four modes (pebbles, sand, fine silt, and clay). As a result, the best sorted sediments in the sand range will be those with mean sizes of approximately 2-3 Ø. Sorting should decrease into the fine silt (6-8 Ø means). In view of the relatively minor change in the total grain size observed here, this mirror image relationship of size and sorting is most likely related to either the energy of the environment or the persistence of energy conditions. However, the mixing of different sources under higher energy conditions will also result in less well sorted sediments.

Mean grain size of the Lopez de Bertodano Formation sediments (including the sand, silt, and clay fractions), is 3.88 Ø. Mean sorting is 0.51 Ø, placing these sediments in the moderately well sorted category of Folk (1974). These two parameters remain approximately constant throughout the formation; the only significant variation is an
increase in the mean grain size at sample 54 (Unit 8). This increase occurs because the total sand content increases, not because of a real increase in grain size. In fact, mean sand size at sample 54 is similar to the mean sand size elsewhere in this formation (Fig. 109).

Mean grain size of the sand fraction remained essentially constant throughout the Lopez de Bertodano Formation and Unit 1 of the Sobral Formation (mean X: 3.48 and 3.45 Ø, respectively) (Figs. 109, 110), but increased rapidly in Unit 2 of the Sobral and in the Cross Valley formations (mean X: 2.73, and 2.19 Ø respectively). It is interesting to note that mean grain size, and trends in grain size up section obtained by sieving the unconsolidated samples, are very similar to trends observed in thin sections (Figs. 120, 121). In the Lopez de Bertodano Formation, departures from the general trend are observed in Unit 1 and in Unit 10, in which coarser grained sediments are found. The almost constant mean grain size of the sand fraction, regardless of important variations in the mud content of the samples, suggests two important facts: a) the process of mud deposition did not affect the sand fraction; b) a uniform fine sand population was available throughout the deposition of these sediments. These observations imply that variations in the mud content is a reflection of the effectiveness of the winnowing of the fine materials; most likely the sand input remained relatively constant. Alternatively, the variations in sand content can be a reflection of the dominance at a given time of one of two sources, one providing the mud and the other, fine sand. These sands, when considered without the mud, are very well sorted (mean
S:0.31 Ø). A marked change takes place in the upper Sobral Formation (Unit 2). Sands here are both coarser grained and well sorted (mean S:0.39 Ø), with a relatively minor amount of mud. Samples of the Cross Valley Formation are similar to the upper Sobral sands, but here poorly sorted pebbly sands (S: 1.2 Ø) appear in the uppermost beds.

Grain size curves

Representative histograms of grain size distribution are presented in Fig. 111. Histograms from the Lopez de Bertodano Formation are unimodal and strongly positively skewed (long tail of fine grained particles), with a mode in the very fine sand or coarse silt (Fig. 111, Locs. A, 38, 68). A very different distribution is found in some sands from the Cross Valley Formation (i.e. sample 140, Fig. 111), in which no well defined mode is observed and the distribution is more widely spread (poorly sorted).

Clastic sediments have been interpreted as mixtures of three or less log-normally distributed populations (i.e., Moss, 1962, 1963). These different populations, when plotted on log-probability paper form identifiable straight lines (i.e. Visher, 1969). Grains transported by three main types of processes are usually resolvable as identifiable straight segments of a log-normal distribution: a) traction or surface creep population, consisting of the coarser grained material; b) saltation population, consisting of the moving bed layer or traction carpet, and c) suspension population, consisting of the finer grained
Figure 111-- Histograms of grain size distribution of selected samples of the Cretaceous-Paleocene sequence of Seymour Island. The sand fraction was processed at 1/4 Ø intervals (dry sieving), and the silt and clay fractions were calculated at 1 Ø intervals (pipette method) up to 8 Ø. All the clay was included in the last class. Note strong positive skewness of most graphs.
material (Visher, 1969). However, some doubt exists regarding the exact
correlation of these populations with the proposed transport mechanisms
(i.e. Middleton, 1976). Christiansen, et al. (1984) concluded that the
grain size populations are better described as log-hyperbolic
distributions rather than a mixture of log-normal distributions. In
addition, Sengupta (1979) found that a mixture of different straight
segments on a log-probability plot need not result from different modes
of transportation, instead the segments may be related to particular
flow conditions or types of source material. As a result, any attempt
to rigorously relate a segment of the grain size distribution to a
definite transport mechanism must be viewed with caution. Visher (1969)
attempted to relate grain size curves to local factors as a key to the
identification of environments of deposition. However, similar grain
size distribution curves have been found in different environments. The
grain size distribution is related to local depositional conditions,
but, as pointed out by Taira and Scholle (1979), it does not necessarily
reflect a particular environment. Glaister and Nelson (1974), after
testing grain size data with conventional statistics and multivariate
analysis (factor analysis) techniques, concluded that the most reliable
approach is the graphic analysis of sediment distribution on
log-probability plots. The advantage of this kind of analysis is that
it does not concentrate on a particular parameter, but rather considers
the entire grain size distribution of a particular sample. Analysis of
the sediments of Seymour Island on log-probability plots shed important
information on their transport mechanisms. When used with other
environmental parameters, these data are an important aid in the
interpretation of the transport and depositional conditions of these sediments.

Some representative log-probability plots from the Cretaceous Paleocene sequence of Seymour Island are shown in Figs. 112, 113, and 114. In general, three types of graphs are observed here. The first type of curve, which was consistently found in the Lopez de Bertodano Formation, is portrayed in Figs. 112, 113, and localities 60 and 68 of Fig. 114. The ideal distribution is illustrated by localities 35 and 38 of Fig. 113. In these cases, two well defined populations are apparent: a) a very well sorted saltation population, and b) a moderately to poorly sorted suspension population. The truncation of the saltation population takes place at approximately 4.5 Ø. This value is an indication of the amount of turbulence of the environment (Visher, 1969), and this truncation value indicates fairly quiet deposition from suspension. This also indicates the presence of either a nearby source of mud (i.e. major river outflow) or a relatively enclosed or quiet environment which prevented bypassing of the fine grained sediments to the deeper portions of the basin.

The second type of curve, found in the uppermost Sobral and in part of the Cross Valley formations (i.e. Locality 84, Fig. 114), has three populations. The coarse fraction (up to 1.5%) is composed of a traction population which is moderately sorted. The break between this fraction and the saltation population occurs around a diameter of 2 Ø. This break, which commonly occurs at 2 Ø has been interpreted as the
Figure 112-- Log-probability plots of selected samples of the Lopez de Bertodano Formation.
Figure 113-- Log-probability plot of selected samples of the Lopez de Bertodano Formation.
Figure 114—Log-probability plots of selected samples of the Lopez de Bertodano Formation (Stations 60, 68), and of the Cross Valley Formation (stations 84, 140).
transition in size above which inertial forces produce rolling or sliding of particles rather than saltation (i.e. Visher, 1969). The saltation population is well sorted (steep slope), whereas the suspension population (which accounts for up to 35% of the sample) is moderately sorted. Truncation of these last two populations occurs at 3 Ø, indicating relatively high turbulence. The suspension population is composed of fine sand and finer material, and the data points do not align very well into a straight line, suggesting mixing between the saltating and suspension populations. This curve is typical of a high energy environment, such as is found in a very shallow marine setting near the surf zone (i.e. Visher, 1969). Sands deposited near the surf zone are usually clean, mainly because the mud is taken away in suspension. The presence of a large suspension population in sands from the Cross Valley Formation may be related to a large amount of fine materials being supplied to this area from a nearby source.

The third type of curve, found only in the uppermost Cross Valley Formation, shows very poor sorting (Fig. 114, Loc. 140). A poorly sorted surface creep population includes approximately 40% of the distribution, and the break is observed at 2 Ø. The saltation population is better sorted, accounting for approximately 40% of the distribution, whereas the suspension population accounts for 20% of the distribution. Truncation occurs at 3 Ø. The high concentration of a poorly sorted surface creep population suggests dumping of this fraction. Although the identification of environments on the basis of grain size distributions is very difficult, and not always reliable,
this curve is very similar to that found by Saitta (1968, in Visher, 1969) in a Pennsylvanian delta distributary sand, which in turn is similar to those sands of modern tidal channels (Visher, 1969). A similar distribution was presented by Glaister and Nelson (1974) for distributary channel deposits of a deltaic system. The dumping of the coarse fraction could then be a result of a large tidal range, similar to that of the Altamaha River estuary as described by Visher (1969), where the bedload may be concentrated in the estuary by reversing bottom currents. Alternatively, decreased flow velocity at the mouth of distributary channels would also result in the dumping of the coarse fraction.

In conclusion, the three types of grain size distributions found in the Cretaceous-Paleocene sequence of Seymour Island indicate the presence of an enclosed or quiet environment (to avoid the winnowing of the fine particles), and the presence of a nearby source of mud. The general increase in grain size and the change in the grain size distribution up section, together with other information, indicates a regressive event (possibly because of the progradation of a nearby delta), changing the environment from shelf to nearshore to possibly deltaic. A further discussion of these changes will be presented in Chapter VII.

PETROGRAPHY
Approximately 100 thin sections of samples from the Lopez de Bertodano, Sobral, and Cross Valley formations were examined. These rocks were collected from indurated horizons and concretions scattered throughout the predominantly friable sequence. Of these samples, 38 were chosen for modal analysis, and 400 to 600 points were counted in each thin section. Several grain mounts of the sand fraction of the more friable rocks were also observed in thin section, being components identical to those observed in the indurated counterparts. Matrix abundance was calculated, and the other constituent abundance were then recalculated, excluding the matrix. In samples where glauconite formed more than 10% of the grains, the rest of the classes were recalculated again excluding this constituent (Table 1). Grain size and degree of sorting were visually estimated (the latter by comparison with Folk's (1974) chart for sorting and sorting classes).

Grains are generally angular to subangular, with matrix contents from 0 to 59%. Rocks of the Lopez de Bertodano Formation are classified as subarkoses, sublithic arenites and lithic arenites. However, when the matrix is included, most fall into the field of lithic graywackes (Fig. 115; classification of Dott, 1964, and Pettijohn et al., 1973). The Sobral Formation includes sublithic arenites, lithic arenites, and lithic graywackes, whereas the Cross Valley Formation is almost devoid of matrix and ranges from sublithic to lithic arenite (Fig. 115). Although most samples are very well sorted, they are classified as immature (classification of Folk, 1974). However, samples from the upper member of the Sobral Formation are mature, and Cross Valley
Figure 115—Petrographic classification of sandstones from the Lopez de Bertodano, Sobral, and Cross Valley formations. (Classification after Pettijohn, Potter, and Siever, 1973).
Table 1-- Modal analysis of sandstones from the Cretaceous-Paleocene sequence of Seymour Island

**Lopez de Bertodano Formation** (Units 1-9)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Size</th>
<th>Roundness</th>
<th>Sorting</th>
<th>Matrix</th>
<th>Straight</th>
<th>Indolose</th>
<th>Poly.</th>
<th>K-Feldspar</th>
<th>Plagioclase</th>
<th>Total</th>
<th>QLithic fragments</th>
<th>Total</th>
<th>HEAVIES</th>
<th>Total</th>
<th>Opales.</th>
<th>Total</th>
<th>Glauconite</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>A-SA</td>
<td>W</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>60.0</td>
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<td>-</td>
<td>WV</td>
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<td>26.0</td>
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<td>4.0</td>
<td>69.2</td>
<td>9.9</td>
<td>1.8</td>
<td>9.7</td>
<td>76.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>F</td>
<td>SA-A</td>
<td>W</td>
<td>45.2</td>
<td>18.8</td>
<td>57.9</td>
<td>4.0</td>
<td>80.3</td>
<td>5.9</td>
<td>3.0</td>
<td>8.9</td>
<td>79.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>SA-SR</td>
<td>WV</td>
<td>34.2</td>
<td>21.6</td>
<td>39.8</td>
<td>7.8</td>
<td>69.2</td>
<td>9.5</td>
<td>2.2</td>
<td>11.7</td>
<td>82.7</td>
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<td>A-SA</td>
<td>WV</td>
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**Size:** C: coarse  **Roundness:** R: rounded  **Sorting:** WV: very well sorted  
M: medium  SR: subrounded  W: well sorted  
F: fine  SA: subangular  M: moderately sorted  
VF: very fine  A: angular  P: poorly sorted  

* Samples that were recalculated without glauconite.  
# Present in trace amounts.
Table 1-- (Continued)

LOPEZ DE BERTODANO FORMATION (Unit 10 + uppermost m. of Unit 9)

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SOBRAL FORMATION (Unit 1)

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Table 1-- (Continued)

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| X      |       |           |         |        | 37.9   | 16.3     | 2.1    | 56.3  | 4.7   | 6.5       | 11.3     | 0.8   | 2.2    | -         | 1.2      | 15.4  | 21.1  | 0.42   | 0.1  | 2.2  | 3.3     |

CROSS VALLEY FORMATION

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| X      |       |           |         |        | 30.0   | 10.5     | 2.9    | 43.2  | 4.9   | 6.5       | 11.9     | 2.1   | 2.4    | 0.2       | 4.1      | 21.8  | 33.0  | 0.92   | 4.1  | 7.3  | 2.6     | 2.2   |
sandstones range from submature to mature (classification of Folk, 1974). Grain size progressively increases from the Lopez de Bertodano Formation (very fine to fine sandstone) to the Sobral Formation (fine to medium sandstone) to the Cross Valley Formation (fine to coarse sandstone). For this reason, some of the lithologic changes predominantly reflect variations in grain size. This is particularly true for the rock fragments and heavy minerals (i.e. Van Andel, 1955), and perhaps to a lesser degree, for the feldspars (i.e. Odom et al., 1976). These rocks are cemented by calcite or micrite, except for the lowermost samples, which have some dolomite cement. Plagioclase, feldspar and quartz are extensively replaced by calcite cement, to the extent that in some samples most of the grains only remain as ghosts. Many samples of the Lopez de Bertodano Formation are typically composed of micrite with disseminated sand grains. These more micritic rocks are usually strongly bioturbated (Figs. 116, 117). Pellets and intraclasts are observed particularly in the Rotularia Units of the Lopez de Bertodano Formation (Figs. 118,119,120,121). Coquina levels, composed of molluscs and echinoderm fragments, with minor intraclasts, were found in Unit 9 (Lopez de Bertodano Formation).

Principal Components

Quartz. Quartz ranges from 80.3 to 32.8%. Three types of quartz can be recognized: straight, undulose, and polycrystalline. In the two sections analyzed (A and D-E) the quartz type changes markedly up section from predominantly undulose to predominantly straight. This
Figure 116-- Strongly bioturbated, fine grained lithic wacke with tubes oriented in random position. Sample 1, Unit 1, Lopez de Bertodano Formation. (Normal light).

Figure 117-- A branching burrow filled with matrix. Note the abundance of organic matter (small, elongated, dark fragments). Sample 15, Unit 3, Lopez de Bertodano Formation. (Normal light).
Figure 118-- Well rounded pellets cemented by sparry calcite. Sample 34, Unit 6, Lopez de Bertodano Formation. (Normal light).

Figure 119-- Large angular intraclasts, partially phosphatized (?) in a very fine grained lithic wacke. (Sample 22, Unit 4, Lopez de Bertodano Formation) (Crossed nicols).
Figure 120-- Distribution of matrix, bioturbation, pellets, intraclasts, and organic fibers, as observed in thin section, in the Cretaceous-Paleocene sequence of Seymour Island (Section A).
Figure 121-- Distribution of matrix, bioturbation, pellets, intraclasts, and organic fibers, as observed in thin section, in the Cretaceous-Paleocene sequence of Seymour Island (sections D-E).
change is sudden and occurs in the same interval in both sections. The quartz with straight extinction is usually very clear and "clean". Some grains higher in the section show embayments, clearly denoting a volcanic origin. Undulose quartz and minor straight quartz lower in the section, however, are "cloudy" or grayish in appearance (Fig. 122). Quartz grains are usually subangular, similar to the other components, but occasional rounded grains are found. Overgrowths, which are commonly partially replaced by the cement, are present on some grains (Fig. 129). A very few grains show rounded secondary overgrowths. Inclusions are common (usually apatite), particularly in the lower part of the Lopez de Bertodano Formation. Vacuoles and bubble trains are found in some monocrystalline slightly undulose grains ("plutonic quartz").

Polycrystalline quartz is not common (averaging 1-2%, with a maximum of 7.8%). These grains are generally composed of few, equant crystals with little or no intercrystalline suturing. The low abundance of polycrystalline quartz most likely reflects the small grain size of the sandstones studied.

Feldspars. The abundance of feldspar remained remarkably constant throughout the entire sequence at approximately 11%.

a) K-Feldspar: The abundance of K-feldspar ranges from 1% to 12.7%, being most abundant in the lower Lopez de Bertodano Formation. The K-feldspar is usually very strongly altered to a clay. As a result,
Figure 122-- Grain supported sublithic arenite showing subangular quartz grains, many with vacuoles and inclusions. Sample 7, Unit 2, Lopez de Bertodano Formation. (Normal light).

Figure 123-- Sublithic arenite showing plutonic fragment (p), clean quartz (q), green hornblende (h), and a large pumice fragment (Pu). Sample 64, Unit 9, Lopez de Bertodano Fm. (Crossed nicois).
Figure 124-- Large clinopyroxene fragment with a well preserved 100 twinning. This sample is a coquina. Sample N-84, Unit 9, Lopez de Bertodano Formation. (Crossed nicols).

Figure 125-- Lithic arenite, showing a volcanic fragment (V) with numerous plagioclase phenocrysts being replaced by the carbonatic matrix. Plagioclase, as well as "dirty" quartz also present. Sample 106, Unit 7, Lopez de Bertodano Fm. (Crossed nicols).
it is sometimes difficult to distinguish between altered aphanitic volcanic fragments and K-feldspar, particularly in the smallest grains. The dominant species identified is orthoclase. Microcline is second in abundance, but never very common, and sanidine is only present in trace amounts. Perithitic textures occur in Unit 2 of the Sobral and in the Cross Valley formations.

b) Plagioclase: Most plagioclase grains appear very fresh, but they are usually strongly replaced by calcite cement. Albite twinning dominates, but Carlsbad-albite and minor amounts of pericline twinning are also found. Plagioclase composition varies from An$_{28}$ to An$_{48}$ (Oligoclase to Andesine), with most grains falling in the andesine field. Very fresh looking, euhezal plagioclases, usually larger than the rest of the constituents (which are also more rounded), form a textural inversion, particularly in the uppermost Lopez de Bertodano and lower Sobral formations (Figs. 127, 132). Oscillatory zoning is common in the upper portion of the sequence (Fig. 130).

Lithic fragments. Rock fragments range from 9% to 48% in abundance. Two abundance peaks are observed, but with differing composition for each. The first peak (Unit 10 of the Lopez de Bertodano and Unit 1 of the Sobral formations, Figs. 136, 137) is characterized by the presence of pumice and glass shards. The second peak (Cross Valley Formation), contains abundant volcanic fragments, principally of andesitic composition. The following types of lithic fragments have been recognized:
a) Volcanic Rock Fragments: (pumice and glass shards are considered separately). These are the most abundant types of fragments, forming up to 29% of the rock. The fragments are identical to those described by Trautman (1976) from the Cross Valley Formation. It is generally difficult to identify the type of volcanic fragment in the samples from the Lopez de Bertodano Formation because of the smaller grain size. Furthermore, extensive replacement of these grains by the micrite matrix has been observed (Fig. 125), obliterating many of the grains. A basic andesite dominates in the Cross Valley Formation, characterized by feldspar laths in an aphanitic matrix (Figs. 130, 131). Most pebbles found in this formation are of volcanic origin. Some large phenocrysts show oscillatory zoning and an An content ~ An_{48}; a well developed trachytic texture is common. Other volcanic fragments are entirely aphanitic, while more siliceous rock fragments which contain euhedral feldspar phenocrysts and quartz, and may represent the groundmass of acidic volcanic rocks (possibly dacites and rhyolites, cf. Trautman, 1976), are also found.

b) Pumice and glass shards: These are exceptionally common in the upper portion of the sequence (Fig. 126). In some intervals they may form a still larger percentage of the rock (i.e. Unit 1 of the Sobral Formation), but they are strongly replaced by the calcareous matrix, remaining only as ghosts in many cases. The glass in both pumice and shards, is still preserved fresh when not replaced by the cement/matrix. Large pumice fragments with numerous bubbles and large fragments of tan-pale brown glass (under normal light) are abundant. The presence of
Figure 126-- Vitric lithic arenite. Note the abundant angular glass shards (s), pumice fragments (Pu), and volcanic glass (g). Hornblende (h) is also abundant. The extreme angularity of the glass shards indicate no reworking. Sample 73d, Unit 1, Sobral Formation. (Normal light).

Figure 127-- Lithic arenite showing a large plagioclase crystal (p) being replaced by calcite. g: glauconite; a: aphanitic volcanic fragment. Sample 126, Unit 1, Sobral Formation. (Crossed nicols).
Figure 128-- Slightly metamorphosed metagraywacke fragment (M). Foliation is well developed. Sample 141, Cross Valley Formation. (Crossed nicols).

Figure 129-- Typical "clean" sandstone of the Unit 2 of the Sobral Formation. Note secondary overgrowth in a quartz (Q) fragment. C: calcite cement. Sample 134, Crossed nicols.
very angular, tricusperate glass shards and very delicate bubbles indicate that the material has undergone very minor transport, this suggests that it was deposited by a subaerial ash fall. In most cases, the pumice fragments are much larger than the other grains (i.e. quartz). Up to 23.3% of pumice and 22.6% of glass shards were found in the lower Sobral Formation. Sample 82b is composed entirely of glass with minor scattered phenocrysts. Samples with a large number of glass shards also contain abundant diatoms.

c) **Plutonic fragments**: Maximum abundance of this component was 2.7%, and it is usually present only in trace amounts. However, this may reflect the small grain size of the samples. Typical plutonic fragments are composed of quartz and microcline grains in a hypidiomorphic-granular texture (Fig. 123). Most of the polycrystalline quartz probably represents fragments of plutonic origin.

d) **Metamorphic fragments**: Only present in trace amounts, its low abundance may be a reflection of grain size. In coarser-grained Sample 141, however, metamorphic fragments still form 0.3% of the rock. Metaquartzite fragments with well developed foliation are typical (Fig. 128).

e) **Sedimentary fragments**: Except for intraclasts, which were not included, sedimentary grains are extremely rare. The lowermost Lopez de Bertodano Formation contains up to 1.6% of "chert". However, this chert may be the aphanitic groundmass of siliceous volcanic fragments (cf.
Figure 130-- Volcanic lithic arenite displaying poorly sorted angular fragments. A: andesitic fragment; p: plagioclase displaying oscillatory zonning. S: quartzite fragment; Pu: rounded pumice fragment. Sample 140, Cross Valley Formation, crossed nicols.

Figure 131-- Andesitic fragment (A) with large plagioclase phenocryst. Note concentration of heavy minerals: g: garnet; e: epidote. Sample 141, Cross Valley Formation, normal light.
Dickinson, 1970; Trautman, 1976). In the upper portion of the section, trace amounts of quartz sandstone are found (Fig. 130). In this case the boundaries between the equant grains are usually straight, but these grains could also be classified as recrystallized metamorphic rocks (cf. Folk, 1974, p. 70).

Accessories.

**Micas:** Chlorite, muscovite, and biotite are common, forming up to 5.6% of the sample. Biotite is the most abundant mica present. It is even more common when analyzing loose grains under the binocular scope; in that case, the mica flakes form a larger percentage of the sample because of their predominantly bidimensional shape. Euohedral biotite is common in the upper portion of the Lopez de Bertodano Formation, and may be indicative of contemporaneous volcanism. Biotite displays a red-brown to pale brown pleochroism.

**Others.** An amphibole, identified as hornblende, is by far the most common accessory mineral present. It is absent in the lowermost Lopez de Bertodano Formation, but becomes abundant up section, particularly in Unit 10 of the Lopez de Bertodano and in the Unit 1 of the Sobral formations. A maximum of 7% of hornblende was found. This mineral usually has a grass-green pleochroism, but occasionally it is more brownish green. These grains are strongly angular, and in many cases perfectly euohedral, denoting very little transport. Subrounded grains of epidote are common in the lower 700 m of the Lopez de Bertodano Formation, but are also present in the rest of the sequence. Garnet is
common throughout the section, becoming much more abundant in the youngest beds. In the uppermost Cross Valley Formation (Station 141), garnet abundance reaches 3% (Fig. 131). A pinkish color is observed in some of these grains (almandine garnet?). A clinopyroxene (possibly augite) is also found, usually as angular, very fresh fragments in the upper Lopez de Bertodano, Sobral, and Cross Valley formations (Fig. 124). Euhedral zircons are present in the Lopez de Bertodano Formation, together with brown-red rutile, traces of apatite, and tourmaline.

Glaucophane

Glaucophane pellet abundances are as much as 57.3% in thin section and approximately 70% in loose sediments. The glauconite occurs in trace amounts in units 1 to 8, but shows a marked increase in units 9 and 10 of the Lopez de Bertodano Formation, and continues to be abundant in the Sobral and Cross Valley formations. Glaucophane pellets usually have a much larger size than the other components, indicating that it developed "in situ" (Figs. 132, 133). However, the pellets are clearly reworked at some levels, as in the cross-bedded glauconites of the lowermost Cross Valley Formation. The pellets are usually rounded with cracks that taper inward, frequently filled with calcite (Fig. 134). Their color ranges from yellowish green to dark green. Most are rounded, but angular and broken fragments are sometimes present. Some glauconites show a yellowish alteration rim. Numerous mafics are commonly found inside the pellets and, rarely, ghosts of previous plagioclase crystals are preserved inside (Fig. 133), indicating that at least some glauconites formed by replacement of aphanitic volcanic
Figure 132-- Glaucnite-rich sandstone. Note the cracks in the glauconite pellets, as well as the larger size of the fresh, cubic plagioclase (p) with respect to the other grains. Sample 126, Unit 1, Sobral Formation. (Crossed nicols).

Figure 133-- Glaucnite with some relict textures, possibly indicating derivation from a previous volcanic fragment. Sample 126, Unit 1, Sobral Formation. Crossed nicols.
Figure 134-- SEM photomicrograph of a glauconite grain, showing the typical cracked outline found in these pellets. 98X, Sample 83, Cross Valley Formation.

Figure 135-- Rosette structure, typical of evolved glauconite. (SEM photo, 2156 X). This sample contains 4.68% of K₂O. Sample 153, Lopez de Bertodano Formation.
Flaky, usually light green colored glauconites are also present, and probably developed from pre-existing micas. The correlation of glauconite with contemporaneous volcanism (as indicated by the glass shards and the pumice fragments) may be related to an increased supply of $K_2O$ to the system, or to the availability of a suitable substrate (i.e. volcanic fragments), or both. In either case, a paleoceanographic control favoring the formation of these grains must also have existed.

The nanostructure of the glauconites, as observed in the SEM, shows the presence of rosette structures, typical of evolved glauconites (Fig. 135, cf. Odin and Matter, 1981). However their $K_2O$ content is not very high (4.68 to 5.67%; see Appendix B).

**Organic matter:** Wood and plant fibers are common in the Lopez de Bertodano Formation, but have not been found in the younger portion of the sequence (Figs. 117, 120, 121).

**Petrologic trends and Provenance**

A QFL plot of the analyzed samples shows alignment along a clear trend, with the Cross Valley and the Sobral formations at one end (more lithic rich) and the Lopez de Bertodano Formation at the other (less lithic rich; Fig. 136). A previous petrographic analysis of the Cross
Figure 136-- QFL diagram showing the distribution of the modal analysis of sandstones from Seymour Island (Lopez de Bertodano, Sobral, Cross Valley, and La Meseta formations). Distribution found in this work is displayed in solid lines; Trautman's (1976) results are plotted in dotted lines.
Valley and the Eocene–Oligocene La Meseta formations by Trautman (1976), agree with this observed trend. The La Meseta Formation samples plot close to the Lopez de Bertodano samples, but are even more impoverished in lithic fragments (Fig. 136).

Both sections analyzed show similar trends in the Q–F–RF content, quartz types, feldspar types, glauconite, pumice, mafics, and hornblende abundances, suggesting that the two areas had similar sources (Figs. 137, 138). The rock fragment content remains low in the Lopez de Bertodano Formation, with a sharp increase at the K/T boundary (samples 69 and 117). This increase continues into Unit 1 of the Sobral Formation and is related to the influx of pumice and glass shards. Unit 2 of the Sobral Formation and the lower Cross Valley have relatively low abundances of rock fragments, but these increase rapidly upward, particularly due to the appearance of numerous andesitic grains.

Quartz changes from predominantly undulose to slightly undulose to predominantly clean grains with straight extinction up section. Although Blatt and Christie (1963) concluded that it is very difficult to relate quartz type to definite source terranes, they did determine that high proportions of non-undulose quartz suggest a volcanic extrusive source. The presence of embayments in some of the observed clear quartz grains also supports their volcanic origin. Plagioclase increases up section as compared to K-feldspar, with the major change occurring at approximately the same level as the change in quartz composition. The plagioclases found up section commonly show a textural
Figure 137-- Petrographic trends found in the Cretaceous-Paleocene sequence of Seymour Island, Section A. (QT: Total quartz; F: feldspars; RF: rock fragments; Tot. H: Total heavy minerals; Hornb.: hornblende).
Figure 138-- Petrographic trends found in sandstones from the Cretaceous-Paleocene sequence of Seymour Island (Section D-E). (Tot. H.: total heavy minerals). (QT: total quartz; F: feldspars; RF: rock fragments).
inversion with respect to other grains (i.e. they are larger and are usually euhedral, whereas the other grains are smaller and more rounded), denoting transport from a closer source. The presence of plagioclase with oscillatory zoning (found in the Sobral and Cross Valley formations) is characteristic of volcanic source rocks (Pittman, 1963). In conclusion, the increase in the plagioclase/feldspar ratio is taken as an indication of the initiation of a volcanic signal.

The accessory minerals also provide important clues. The micas, which are conspicuously present in the Lopez de Bertodano Formation, particularly in the upper part of Unit 8 and lower Unit 9, decrease and completely disappear in the upper Sobral and Cross Valley formations. This may reflect a change in source, or, on the other hand, may be related to the transport mechanism available for the particles. The upper Sobral and Cross Valley formations were deposited in a high energy environment, as reflected by the coarser grain size and near absence of matrix. Because of their hydraulic behavior, the mica flakes may have been transported in suspension from this high energy environment to deeper portions of the basin; as a result, their absence may be controlled by the energy of the environment and their hydraulic behavior, and not related to source effects. Biotite, chlorite and muscovite are present in igneous and metamorphic rocks of the Peninsula (Adie, 1954, 1955, 1957, Bibby, 1966), and a large percentage of the micas were probably derived from this source. However, the euhedral biotites found up section in the Lopez de Bertodano Formation are consistent with contemporaneous volcanic activity. Hornblende becomes
abundant approximately 600 m from the base of section A and approximately 300 m from the base of section D (which represents the same horizon). A maximum in hornblende abundance is observed in Unit 10 of the Lopez de Bertodano and in Unit 1 of the Sobral formations, and a second peak is found in the Cross Valley Formation. A green hornblende, similar to the one described here, was interpreted by Trautman (1976) to be of plutonic origin. Its presence in some volcanic fragments and its association with pumice fragments and glass shards is indicative of a volcanic origin for most, if not all, of this hornblende. The fresh fragments of clinopyroxene may also be related to this volcanic source. Again, at least a large portion of the hornblende is believed to be related to a new volcanic source.

In the lower Lopez de Bertodano Formation (units 1-8), the dominant heavy mineral suite is composed of epidote, minor garnet, rutile, and zircon. These minerals are consistent with a plutonic-high metamorphic source terrane. In the uppermost Cross Valley Formation, garnet becomes very abundant. This concentration of garnet is associated with an increase in grain size of the sediments, and may be related to concentration in a high energy environment; the abundant garnet is not necessarily related to a change in source.

A very minor sedimentary source is indicated by the presence of chert and some quartzite fragments. However, these fragments are suspect because the chert could also be the aphanitic groundmass of a volcanic rock, and the quartzite could also be a low grade metamorphic
rock. The metamorphic fragments found in the sequence indicate that at least a minor source of this type was available, particularly during the deposition of the Cross Valley sediments.

The presence of plutonic fragments clearly indicates that this source was available somewhere in the Peninsula. This, together with the presence of slightly undulose quartz with inclusions of apatite and some showing vacuole trains (typical "plutonic" quartz), and its association with orthoclase (which is usually strongly altered) and microcline, is consistent with a calc-alkaline plutonic or gneissic source. The heavy mineral suite found in the Lopez de Bertodano is also consistent with the presence of a plutonic source.

A volcanic source is clearly indicated throughout the sequence by the presence of abundant volcanic fragments. Even in the Lopez de Bertodano Formation, the predominant clast is an aphanitic volcanic rock with plagioclase microlites. These fragments, however, do not generally look as fresh as those found in the Cross Valley Formation. Two volcanic sources may have been present at this time, one older and one contemporaneous with deposition of the upper part of the sequence (as indicated by other petrographic evidence).

The cross-bedding measurements obtained in the Cross Valley Formation (Fig. 73) indicate paleocurrents from the SW and from the W. These data, together with the lack of evidence of a formerly uplifted terrane to the east of the basin (La Brecque and Barker, 1981), make the
Antarctic Peninsula the obvious choice for the source of these sediments. The Andean intrusive suite of the Peninsula provides a suitable source for the igneous/high grade metamorphic components. According to Adie (1955), the quartz diorite from Hope Bay is representative of diorites of the northern Trinity Peninsula. This quartz diorite contains plagioclase with $\text{An}_{35-47}$ (Andesine), altered orthoclase, quartz, very common biotite, and a green hornblende. Accessory minerals include magnetite, ilmenite, apatite, zircon, and sphene, with epidote and a pale green chlorite present as alteration products.

The garnet observed throughout, and concentrated in, the Cross Valley Formation may have been derived from the granite-gneisses described by Adie (1954); these rocks are composed of orthoclase, plagioclase, quartz, and abundant almandine garnet. A similar igneous rock was found in erratics on Seymour Island by Bodman (1916). However, garnets are also common in the Antarctic Peninsula Volcanic Group, as described by Bibby (1966) and Hamer and Moyes (1982). These rocks, are moderately chloritized, and the rhyolites contain small phenocrysts of orthoclase and abundant quartz (Bibby, 1966). In conclusion, suitable sources for the garnets are present in the Peninsula, both in igneous/high grade metamorphic rocks and in volcanic rocks of the Antarctic Peninsula Volcanic Group (APVG). Volcanic fragments present in the sequence, particularly those found in the Lopez de Bertodano Formation, could have been derived from the APVG. Metamorphic fragments are possibly derived from metasedimentary rocks of the Trinity Peninsula.
Group, and the chert grains may originate in the upper Jurassic-lower Cretaceous Ameghino Formation.

A different problem is presented by the presence of volcanic fragments in the Cross Valley Formation. These fragments may have been derived from: 1) the A.P.V.G., which contains rocks of andesitic composition; or 2) a contemporaneous volcanic source. The absence of similar andesite fragments up section in the La Meseta Formation (Trautman, 1976) is not expected if the source of these grains was the A.P.V.G., because abundant pebbles derived from the A.P.V.G. are found in this formation, although of a more acidic composition (Trautman, 1976). On the other hand, no latest Cretaceous-earliest Tertiary volcanic rocks have yet been found on the Peninsula; as noted by Trautman (1976), these contemporaneous volcanics were either eroded completely away or they have not yet been recognized in the Peninsula.

Model for the petrologic evolution of the upper Cretaceous-lower Tertiary sequence of Seymour Island

Dickinson and Suczek (1979) and Dickinson (1982) found that detritus eroded from arc orogens form a variety of sand types, from lithic-rich volcaniclastic debris at one extreme to more quartzo-feldspathic detritus of largely plutonic origin at the other. On this basis, two types of sources were defined: a) Undissected Arc provenances, and b) Dissected Arc provenances. In the undissected arc suite, large amounts of volcaniclastic debris are shed from volcanogenic
highlands that have undergone only limited erosion. Plagioclase feldspar grains and volcanic lithic fragments, many of which contain plagioclase phenocrysts, are the most characteristic constituents of sediments that were deposited in trenches, fore-arc basins, and marginal seas. In the dissected arc suite, the source consists of more mature and eroded magmatic arcs, particularly along continental margins. Sands are mixed plutonic and volcanic in origin, and are deposited in both fore-arc and back-arc basins, with some even reaching the trench. Typical modes plot in the center of the QFL diagram. Both feldspars are present in significant proportions. Plutonic quartz with train vacuoles and inclusions is more abundant than clear volcanic quartz (Dickinson and Suczcek, 1979).

Sandstone compositions from the Seymour Island sequence can be interpreted in terms of this model, with some portions of the sequence interpreted as derived from an undissected arc, while other portions are more consistent with a dissected arc provenance. In both cases, however, the observed feldspar content is smaller than that found in typical active margins (i.e. Dickinson and Suczcek, 1979, Dickinson and Valloni, 1980; Dickinson, 1982; Valloni and Maynard 1981, among others), although it is consistent with the value determined by Potter (1978) for sands of modern big rivers (11%). In general, the petrofacies observed in the Lopez de Bertodano-Sobral-Cross Valley formations can be interpreted in terms of a constant unroofing of a "background" source (the Antarctic Peninsula, with the Trinity Peninsula Group, the A.P.V.G., the Andean intrusive suite, and probably, a minor influence of older
sedimentary rocks), upon which a cycle of volcanic activity is superimposed. The age of this magmatic activity is given by the associated fossil faunas and glauconite ages; on this basis, four stages in the evolution of the nearby Peninsula are proposed (Fig. 139):

Stage 1. During the late Campanian to the middle Maastrichtian, an igneous-metamorphic and a volcanic source were supplying sediments to the James Ross Basin. This is suggested by the presence of volcanic and minor plutonic fragments. The heavy mineral, quartz, and feldspar suites present are consistent with both sources (igneous-metamorphic and volcanic). Contemporaneous volcanism may have already begun, as indicated by the presence of scattered pumice fragments, and the appearance of green hornblende grains.

Stage 2. Active volcanism began in the late Maastrichtian and extended to the early Paleocene (?). The volcanic signal is seen in the increasing occurrences of clear, straight quartz, angular and euhedral hornblende, and a higher plagioclase/K-feldspar ratio. The major volcanic event began at the K/T boundary, as indicated by the sudden appearance of subaerially deposited glass shards and pumice fragments. This early volcanism must have been acidic in composition, as reflected by the abundance of associated "volcanic" quartz and the explosive nature of the eruptions. The proximal source is denoted by the textural inversion found in some of these grains, indicating that the volcanic source was closer than the persistent "background" source (the igneous-metamorphic-older volcanic provenance).
Figure 139-- Schematic model showing the proposed variations in sources of the Seymour Island sandstones. A: metamorphic rocks (Trinity Peninsula Group, and Basement Complex); B: Andean intrusive suite; C: Antarctic Peninsula Volcanic Group; D: Late Cretaceous-Early Tertiary volcanics; D': subaerially deposited volcanic ash.
Stage 3. During the later Paleocene, most volcanic activity ceased. Pumice fragments found in the uppermost sediments are well abraded and rounded, evidence of significant transport. The increase in rock fragments observed at the top of the section (i.e. samples 85, 140, 141) is possibly related to an increase in grain size. In these samples, most fragments coarser than medium sand are usually volcanic in origin; as a result, an increase in grain size will result in a greater abundance of volcanic fragments. The newly developed andesitic source, which is also associated with aphanitic and more siliceous rocks, is interpreted here as the consequence of the stripping of the volcanics emplaced during Stage 2. The "background source" continued to shed fragments, including some of clear metamorphic origin, likely to have been derived from the Trinity Peninsula Group.

Stage 4. The complete removal of the volcanic pile led to the dominance again of the "background source", as recorded in the sediments of the Late Eocene-early Oligocene La Meseta Formation (Cf. Trautman, 1976).

In conclusion, the analysis of the sediments of Seymour Island allows the reconstruction and dating of a volcanic cycle that either has been obliterated by erosion, or remains hidden beneath the ice of the Antarctic Peninsula.
CHAPTER VII
PALEOECOLOGY AND DEPOSITIONAL ENVIRONMENTS

INTRODUCTION

The Lopez de Bertodano, Sobral and Cross Valley formations represent a marine cycle extending from late Campanian to Paleocene time. Except for the uppermost Cross Valley Formation, all of these sediments were deposited in a marine environment. Sedimentation took place in relatively quiet conditions with a strong terrigenous source, derived from the nearby high terrain of the Antarctic Peninsula. Several major fluvial systems may have contributed the large amounts of silt and clay characteristic of this sequence. In general terms, the depositional environments changed from mud flat to open marine, and outer shelf edge/slope in the Lopez de Bertodano Formation. The uppermost Lopez de Bertodano, the Sobral, and the Cross Valley formations represent the regressive facies of the cycle. A succession of sedimentary environments, ranging from prodelta slope to delta top facies, resulted from the progradation of a deltaic system.

Because the lithology is relatively homogeneous throughout, study of the macrofaunal assemblages as well as the autoecological aspects of the various taxa are of great assistance in the interpretation of the depositional environments represented in this sequence. Fossils provide information on the environment in which they lived, firstly by their distribution, abundance, and diversity as a total assemblage, and
secondly by their particular mode of life and the ecological requirements of individual species.

The first part of this chapter will concentrate on the paleoecological aspects of the macrofauna, first as it pertains to individual species, and second as it concerns assemblages of species or fossil associations. The second part of the chapter will combine this information with the sedimentological and stratigraphic evidence presented previously, in order to present an hypothetical reconstruction of the environment of deposition of this sequence.

MODE OF LIFE OF MACROFOSSILS

Annelids (Rotularia)

As Rotularia has no recent counterparts for comparison, it is difficult to assess its specific environmental requirements. The fact that earlier whorls of specimens are always broken was taken by Wilckens (1922) and Ball (1960) to indicate that shells were attached when young, but later adopted a free benthic mode of life. Wrigley (1951) suggested that the shell of Rotularia should be oriented with its apex downwards. He reached this conclusion after examining a specimen that was attached to another by the apex, and in which growth was such that the umbilical side of the individual pointed upward. Ball (1960) stated that serpulids attach themselves to surfaces in random position, and thus any orientation is essentially arbitrary. For this reason, Ball (1960) proposed to continue orienting the specimens in the
traditional way (that is, with the apex uppermost). This suggestion is followed in the present work.

The presence of a large apical tube in many of the adult specimens is interpreted as evidence that the animal lived buried beneath the water-seafloor interface. They were preyed upon by boring organisms, possibly by associated naticid gastropods, which produced a circular hole (Plate 3, figs 1b, 5b, 6b). Out of nine bored specimens, eight were perforated three to five mm to the right of the tube opening. This kind of predation pattern could be explained if Rotularia burrowed into the substrate with the tube pointing almost vertically upward.

Rotularia is commonly found in strongly bioturbated sediments, and a correlation exists between Rotularia abundance and the presence of abundant bioturbation. However, this bioturbation could have been produced by serpulids or other organisms also showing a preference for a high mud content in the sediment. Considering the suggested correlation between mud percentage and Rotularia abundance and assuming that bioturbation was in fact produced by these organisms, it can then be inferred that Rotularia was a deposit feeder. However, this conclusion conflicts with the previously inferred life position of this genus (i.e. with the tube pointing upward, probably extending above the sediment-water interface). Studies of Recent bottom assemblages from Cape Cod Bay by Young and Rhoads (1971) indicate that the tubicolous, suspension-feeding polychaete Euchone incolor occurs in highest densities in clayey-silt facies where other typical suspension-feeders
can not survive. The ability of this species to withstand a turbid environment lies in the presence of a tube which projects above the flocular mud surface of the bottom, as well as to a complicated feeding system (Young and Rhoads, 1971). A similar feeding mechanism could have been used by Rotularia. However, the available data are insufficient to ascertain whether Rotularia was a suspension or a deposit feeder.

The presence of large numbers of specimens of Rotularia in an otherwise very impoverished macrofauna, indicate a greater tolerance of this group to high stress conditions (probably highly turbid or brackish environments). The sudden "blooms" of Rotularia observed in the Lopez de Bertodano Formation may be interpreted as opportunistic episodes in which members of this genus took advantage of particular environmental conditions. The possible correlation between an increase in the percentage of mud and Rotularia abundance might indicate an increase in nutrient supply, or an ability to withstand turbidity levels that were intolerable for most groups.

Bivalves

The paleoecological requirements of the bivalves from Seymour Island are relatively easy to evaluate because many bivalves found in this sequence have Recent representatives of the same genus. Moreover, there is an extensive literature covering the ecology/paleoecology of Recent and fossil bivalves, and functional morphology analysis of this group allows interpretation of the mode of life in many extinct groups.
The stratigraphic distribution of bivalves with their feeding preferences are shown in Fig. 140, while the vertical variations in diversity and relative abundance of each trophic group are presented in Fig. 141.

**Nucula**—This is a moderately active shallow burrower that uses its long labial palps to gather food from the sediment (deposit feeder). **Nucula** is associated with very fine grained substrates, deposited in quiet conditions. Depth does not seem to be a controlling factor in its distribution. For example, **Nucula proxima** (Say) is found in organic-rich, muddy, medium sand at depths of 0.5 to 3m below mean low tide near Cape Cod, Massachusetts (Stanley, 1970). The same species, however, is a typical intermediate shelf constituent (22-72m) of the northern Gulf of Mexico (Parker, 1956, 1960). Other species of **Nucula** are found in much deeper settings (up to 1640m) off the northern Oregon Coast (Pereyra and Alton, 1972).

**Malletia**—This genus is a labial palp deposit feeder, possibly of high mobility, as inferred from its compressed shape (Rhoads et. al., 1972). It is usually found in mobile sediments at variable depths, ranging from shallow settings to abyssal depths (Nicol, 1966-67).

**Indogrammatodon** and **Nordenskjoldia**—These two genera have no Recent representatives, but have been considered epibyssate suspension feeders (Preneix, 1981). In the case of **Indogrammatodon**, the well rounded venter, crenulated inner margin, and low elongation (L/H < 1.35), is
Figure 140— Stratigraphic distribution and feeding types of Bivalves from the Marambio Group of Seymour Island.
Figure 141-- Bivalve diversity and percentage of different feeding types present at successive stratigraphic intervals in the Lopez de Bertodano Formation.
more consistent with semi-infauna, endobysate or sessile life position (Cf. Stanley, 1970, Thomas, 1978). *Nordenskjoldia* is, however, more elongated (L/H > 1.35), and some specimens have a flat venter. Thus, an epibysate mode of life is very possible for *Nordenskjoldia*.

**Cucullaea**—This is a shallow burrower, infaunal suspension feeder. According to Thomas (1978), most arcoids live in periodically unstable environments, although the infaunal arcoids (i.e. *Cucullaea*) are excluded from constant mobile substrates by their weak ligaments and lack of siphons, which preclude both deep and rapid burrowing.

**Solemya**—The Recent suspension feeder *Solemya velum* Say is a moderately rapid burrower that forms a U-shaped tube, up to 6-7 cm deep. The preferred environment of this species is organic-rich muddy medium sands at depths of 2-4 m, although it occasionally is found living intertidally in fine sand (Stanley, 1970). Other modern species (e.g. *Solemya agassizi* Dall) are found up to depths of 1920 m off the northern Oregon Coast (Pereyra and Alton, 1972), while Parker (1964) included the species *S. valvulus* Carpenter in his bathyal-abyssal assemblage. Most likely this genus is indicative of cohesive, very fine sand or mud, but no inferences regarding water depth can be drawn from its occurrence.

**Pinna**—This is a typical endobysate genus usually living in sandy or mud-sand substrates. Its apex is deeply buried and has a mass of byssal threads that help individuals attach to small stones or fragments of shells. The posterior margin projects approximately 2-3 cm above the
surface of the sediment (Abbott, 1974). Recent species of *Pinna* are usually restricted to shallow water settings, up to 30-40m deep. According to Keen (1971), *Pinna* is usually found on mud banks on the Pacific coast.

**Pheloptericia**—This Cretaceous genus, characterized by its long posterior wing, is very similar to the Recent *Pteria*. Rhoads et al. (1972), by comparison with this latter genus, considered that *Pheloptericia* was a suspension feeder that lived attached on the surface by means of a byssus. Observations on Seymour Island show that *Pheloptericia* lived gregariously and attached to hard objects, particularly, in this case, to a large shell of the gastropod *Amberleya spinigera*.

**Pulvinites**—This extinct suspension feeding genus probably lived on the sediment surface, attached by a byssus.

**Entolium**—This smooth pectinid was probably an epifaunal free-swimming suspension feeder (Cf. Warren and Speden, 1977).

**Acesta**—It is a sessile epifaunal suspension feeder. Recent species inhabit the substrate of shallow to very deep waters. For example, *Acesta mori* Hertlein was found up to a depth of 1400 m (Abbott, 1974).

**Limatula**—This is an epibysssate suspension feeder that lives attached to hard substrate. On Seymour Island, *Limatula* was found at several localities attached to ammonite shells. Recent species are common in
deep water habitats (Cf. Abbott, 1974).

"Trigonia"—(Eselaevitriona and Oistotrignon). From functional morphological analysis of the shell-form, and from comparisons with the living genus Neotrigonia, Stanley (1977) concluded that trigoniids were suspension feeders that lived infaunally with the truncated posterior end lying parallel to, and level with, the surface of the substratum. Stanley (1977) also concluded that most trigoniids were restricted to shallow water facies.

Lucina—This is an infaunal suspension feeder, with a long siphon and low mobility (Stanley, 1970). This genus is presently represented in shallow subtidal settings (Stanley, 1970), but is also common in the middle shelf (24-80m) of the northern Gulf Coast of Mexico on sandy substrate (Parker, 1960), and in deeper waters off the Gulf of California (Parker, 1964).

Thyasira—This genus lives erect, deeply buried in the substrate and is a suspension feeder of low mobility. The presence of a long inhalant tube allows individuals to burrow deeply in the sediment, and enables them to withstand conditions deleterious to other groups. For this reason, Thyasira is able to populate environments characterized by a limited food supply, and in some cases, oxygen-poor, hydrogen sulfide-rich waters (Kauffman, 1959). Recent Thyasira are most diverse and abundant in the outer sublittoral zone of continental shelves (70 to 200 m), but they are also known from shallow waters of the inner shelf,
to depths of more than 2000 m (Kauffman, 1969).

**Eriphyla**—This is a typical Cretaceous genus. According to its morphology, Warren and Speden (1977) considered *Eriphyla* an infaunal siphonate suspension feeder of low mobility.

**Lahilla**—Based on its shape, *Lahilla* is inferred to be a shallow infaunal suspension feeder, which in life position was oriented with its posterior margin parallel to the sediment water interface. In the Cretaceous of the Magallanes Basin (southern South America), it is typically found in shallow water settings. Specimens found on Seymour Island are relatively large (up to 10 cm.), and are very abundant, being in many cases the dominant species.

**Cyclorisma**—Warren and Speden (1977) interpreted this genus to be an infaunal, siphonate suspension feeder. Considering the large pallial sinus observed in *Cyclorisma incognita* n.sp., it is possible that it was a deep burrower.

**Thracia**—This genus is represented on Seymour Island only by a few examples. Recent species live buried in mud at a depth of about 12 cm, with the commisural plane horizontal and the left valve upward. *Thracia* is a suspension feeder, found at depths ranging from 20 to more than 2000 m.

**Goniomya**—The presence of the large anterior and posterior gapes in this
genus indicate that this was a deep burrower which accommodated a strong siphon. Freneix (1981) regards this genus as a suspension feeder of low mobility.

Panope—This is a suspension feeder that normally lives deeply buried in the substrate and feeds through long, prominent siphons. Panope clausa was observed "in situ" on several occasions, in an almost vertical position. Recent species are restricted to fine grained sediments and quiet environments (mud flats), with most species recorded in shallow waters, extending to depths of 50m.

Pycnodonte—This is an epifaunal suspension-feeder, typical of late Cretaceous molluscan assemblages. The two forms found on Seymour Island, however, may represent two different strategies for adapting to a soft substrate. The flat Pycnodonte seymouriensis usually had a small attachment surface, and overcame the problem of living free on soft substrate by means of the "snowshoe strategy" (Jablonski and Bottjer, 1983). In this strategy, free-living adults assume a broad flat form, thus distributing the weight of the organism over a large surface area. The grypeate shaped Pycnodonte cf. vesiculosa adapted to the substrate by means of the "iceberg strategy" (Jablonski and Bottjer, 1983). In this case, a free-living adult expands one of its valves ventrally so that the individual is supported by the denser sediment at depth, but still maintains contact with the sediment-water interface. According to Jablonski and Bottjer (1983), Pycnodonte of the Campanian-Maastrichtian Coastal Plains of the U.S. is an ubiquitous component of subtidal
assemblages, but reached a greater abundance in offshore shelf habitats (i.e. Turonian Greenhorn Limestone of Kansas, which represents deposition of predominantly pelagic carbonate muds under low energy conditions in relatively deep water (Bottjer et al., 1978)). Sohl (1977) notes that *Pycnodonte* from the Navesink Formation of New Jersey (Early Maastrichtian) (a strongly bioturbated clayey glauconitic sand) are more strongly convex than those occurring in the more near-shore environments of the overlying and underlying formations.

**Gastropods**

*Pleurotomaria* is an epifaunal browser that inhabits soft substrates (Warren and Speden, 1977). *Amberleya* was found on Seymour Island in two localities inside the living chamber of large specimens of the ammonite *Maurites*, and thus it could be inferred that it was an epifaunal carnivore or scavenger. *Eunaticina*, like most naticids, was probably an epifaunal carnivore. *Perissoptera* was a deposit feeder. However, there is some debate as to whether *Perissoptera* lived infaunally or epifaunally (cf. Popeoe, 1983). The Recent *Aphorrais pesselican* (Lamarck) spends part of its time buried beneath the sea-bottom, and probably shorter intervals epifaunally (Popeoe, 1983). *Taioma* was possibly an epifaunal carnivore, whereas *Cerithium*, well known in the Recent, is an epifaunal grazer that lives predominantly in very shallow waters. More off-shore species are also known.

**Ammonites**
Since this is an extinct group, ecological inferences about their habitats and feeding preferences depend on functional morphological analysis and comparisons with the living *Nautilus*. According to Kennedy and Cobban (1976), the majority of ammonites exploited the low levels of the food pyramid, eating phyto- and zooplankton (first order carnivores). Others were benthonic, probably vegetarian browsers. Still another group was carnivorous and scavenger such as the Recent *Nautilus*, but probably lacked the ability to capture large active prey.

A particular case is the uncoiled heteromorph *Diplomoceras*. This recurred, U-shaped (ancylocone) genus, was obviously not an active swimmer. According to Klinger (1981; among many others), *Diplomoceras* was a planktonic floater; however, it is not known if the animal was restricted to an habitat close to the substrate, or if it had the ability to migrate vertically through the water column. According to Klinger (1981), the U-shaped morphology also indicates an adaptation to a soft substrate, floating close to the sediment-water interface yet with the respiratory system held clear from the sediment.

The superfamily Lytocerataceae (which includes *Anagaudryceras*, *Vertebrites*, *Zelandites*, *Pseudophyllites*) has been known to occur more frequently in offshore, deeper-water facies than that other groups (Scott, 1940; Ward and Signor, 1983). This observation is consistent with the cosmopolitan distribution observed for many of these genera. Kennedy and Cobban (1976) warned, however, that the presence of Lytocerataceae in shallow water deposits would indicate that they were
not confined to deep water environments, and concluded that "offshore" rather than "deep water" may have been the milieu of this group.

The ornamentation of the ammonites may have served as protection from predators (Ward, 1981). One specimen of *Maorites suturalis* found on Seymour Island (Plate 15, Fig. 1) has several circular orifices distributed in a broad curve, in the region where the shell is crushed. This may have been produced by a predator (mosasaur?) in the manner described by Kauffman and Kesling (1960). The compressed *Pachydiscus* and smoother *Maorites*, found up-section in the Lopez de Bertodano Formation, probably were better adapted for swimming than those more coarsely ornamented and evolute species found down section.

Large concentrations of juvenile specimens, such as those observed in Unit 9 of the Lopez de Bertodano Formation, are common in portions of the Cretaceous western interior of the U.S. at localities hundreds of kilometers off the paleostrandline (Kennedy and Cobban, 1976). Juveniles apparently concentrated further offshore and then moved to more near-shore environments upon attaining more mature stages.

**PALEOECOLOGY**

Although the total macrofauna of the Marambio Group on Seymour Island includes more than 90 taxa, its diversity is quite low compared with other Maastrichtian localities of the world (i.e. Fox Hill Formation (Waage, 1968; Speden, 1970); Ripley Formation (Wade, 1926;
Sohl, 1960, 1964) of North America). This decreased diversity is much more apparent in the case of the gastropod fauna. Low macrofaunal diversity in the Lopez de Bertodano Formation cannot be fully explained by cool-water conditions. Tertiary shallow-water mollusc assemblages of the La Meseta Formation of Seymour Island are generally more diverse (Zinsmeister and Camacho, 1982) at a time when regional temperatures are believed to have been lower (Shackleton and Kennett, 1975).

The relatively low diversity of the assemblage is comparable with other assemblages found in the late Cretaceous of New Zealand, New Caledonia, and Southern South America (Weddellian Province, of Zinsmeister, 1979). This probably indicates that the relatively low diversity observed on Seymour Island is related to a general paleobiogeographic overprint (relatively impoverished fauna, mostly endemic to the Weddellian Province), and in part could be a reflection of the high latitude location of this province (Cf. Stehli et al, 1967). Local variations in the macrofauna diversity and composition are useful in evaluating variations in environmental parameters and provide insight into the paleoecological evolution of the Marambio Group on Seymour Island.

Macrofaunal diversity increases steadily through the Lopez de Bertodano Formation, followed by a rapid drop after the Cretaceous–Tertiary boundary (Fig. 76). As suggested by the review of macrofauna habitats in the previous section, the distribution of many organisms is more dependent upon the type of substrate rather than the water depth.
per se. Because water depth has a direct influence on the energy of the environment, and thus on the type of substrate available, an indirect relationship does exist between organisms and depth of the water column. Changes in depth will cause changes not only in the substrate, but also in very important factors such as temperature, salinity, and oxygen concentration of the bottom water; these parameters are important in restricting the distribution of species and controlling the total diversity of a given fauna.

On Seymour Island, changes in diversity are generally independent of the lithology, which is fairly homogeneous throughout (Fig. 75). Several authors (i.e., Purdy, 1964; Franz, 1976; Boucot, 1981) have pointed to the intimate dependence of benthic organisms upon sediment type. Purdy (1964) showed a positive correlation between number of deposit-feeding species and the amount of silt and clay in a given sample. This relationship may occur because a decrease in water turbulence allows organic detritus and clay particles with adsorbed organic materials, to settle out in quieter, deeper water settings. Carey (1972) also noted a steady increase in deposit feeding and epifaunal organisms, together with an increase in the biomass, moving offshore on the Central Oregon continental shelf.

In conclusion, the observed general increase in diversity in the macrofauna could be related to an increase in the depth of the basin through time. Maximum diversity is generally accepted (e.g., Heckel, 1972; Valentine, 1973) to occur in more stable environments. Valentine
(1973) also drew attention to the importance of resource level and spatial heterogeneity as primary controlling factors of total diversity. Because shallow environments are more susceptible to disturbances, they should sustain a less diverse fauna than their deeper counterparts, all other factors being equal. Spatial heterogeneity as observed in the sediment does not seem to have varied significantly through time.

Because the sediments on Seymour Island, remain fairly similar from the base to the top of the Lopez de Bertodano Fm., the interpretation of changes in macrofauna abundance, diversity, and composition provide valuable clues for the reconstruction of the paleoenvironment of these sediments.

The lowermost units of the Lopez de Bertodano Formation (units 1-4) contain a depauperate macrofauna (Fig. 142). In part, this may be a preservation problem, because most specimens are preserved as internal moulds (with the exception of Rotularia). Foraminiferal faunas are dominated by agglutinated forms, although abundant calcareous faunas are present at some intervals (Huber, 1984). After a preliminary observation of palynomorphs from these units, R. Askin (pers. comm., 1984), suggested that samples from units 1-2 contain a diverse non-marine, and less diverse marine palynomorph assemblage, probably indicative of a shallow marine environment. Samples from Unit 3 also indicate a nearshore marine setting. One sample yielded abundant small acritarchs, which could be indicative of an estuarine environment (?) (Askin, pers. comm, 1984).
Figure 142—Rotularia assemblage, dominant in the lower part of the Lopez de Bertodano Formation on Seymour Island.
Evidently the *Rotularia* facies were deleterious to most macro- and microfaunal groups. Palynomorphs, abundant organic fibers (Figs. 120, 121), and fragments of unbored fossil wood, indicate proximity to a coast. Low macrofaunal diversity may be the result of brackish conditions, low oxygen content, or high turbidity of the water that precluded colonization by suspension feeders. However, the presence of abundant bioturbation and the lack of lamination indicate extensive burrowing, uncharacteristic of low-oxygen environments. This faunal assemblage may, however, have been affected by intermittent exposure to brackish conditions in a shallow marine environment, as might occur near the mouth of an estuary or delta. Very small solitary corals settled during episodes of diminished deltaic influence. Gasparini et al. (in press) found stromatolites at the top of Unit 4, usually restricted to very thin horizons (approx. 5 cm.). This finding was corroborated by the author and is a further indication of a shallow water setting.

Faunas in units 5 and 6, are also dominated by the annelid *Rotularia*. A gradual increase in faunal diversity is observed up section. Better defined marine conditions are indicated by the presence of the ammonites *Maorites tuberculatus* and *Diplomoceras lambl*. The typical association for this interval is *Rotularia*, solitary corals, and echinoderm spines. The common presence of remains of marine reptiles are additional evidence for proximity to the coast (Gasparini et al., in press). Most bivalves found in and above units 5 and 6 have the two valves articulated, and are commonly still in a life position. These data indicate a low degree of disturbance on the bottom.
The sharp increase in macrofossil diversity observed between units 6 and 7 defines the contact between the \textit{Rotularia} (below) and the Molluscan units (above). Unit 7 has a relatively diverse macrofauna, probably indicating open marine conditions. The deposit-feeder \textit{Nucula} is common, but the macrofauna is dominated by infaunal suspension feeders; among these are several deep burrowers such as \textit{Panope}, \textit{Coniomya} and \textit{Thracia}, usually found in quiet environments. Diversity decreases in Unit 8, which is dominated by shallow burrowing, infaunal suspension feeding bivalves. The change in the bivalve assemblage is directly related to a more sand-rich substrate, and most of the species probably had the ability to burrow rapidly in order to adapt to shifting substrate conditions. \textit{Rotularia}, which has a preference for mud-rich substrates (Macellari, 1984), is almost completely absent in this unit. This probably was a time of stronger bottom circulation as would be expected from a lowering of sea-level that placed the sediment-water interface closer to wave base. A different explanation, preferred here, is that the increase in relative grain size observed in Unit 8 was caused by the strong winnowing action usually present on the shelf/slope break (Southard and Cacchione, 1972). The shelf/slope break is usually associated with a decrease in both biomass and diversity of the macrofauna. Most of the faunal components found in this facies are suspension feeders (Blake and Doyle, 1983). Late Cretaceous nearshore assemblages were dominated by infaunal suspension feeders (Jablonski et al., 1983), and these are the dominant feeding types of units 6, 7, 8.

The most diverse and abundant fauna of the Lopez de Bertodano
Formation occurs in Unit 9 (Fig. 143). Particularly interesting is the appearance of numerous suspension feeding epifaunal bivalves, such as the ostreid *Pycnodonte* cf. *vesiculosa*, which dominates in the upper 100m of the Unit 9. *Pycnodonte*-dominated paleocommunities are well known and widespread in late Cretaceous off-shore marine assemblages on soft substrate (Sohl and Kock, 1982; Jablonski and Bottjer, 1983; Jablonski et al., 1983). Other epifaunal taxa found here are *Limatula*, *Acesta*, *Phelopteria*, *Pulvinites*, and *Entolium*. Sedimentation conditions had to have been very quiet. One specimen of *Limatula* was found attached to an ammonite, but with its two valves dislodged and slightly displaced. The presence of the loose valve on the surface of the ammonite requires that local currents were extremely weak. Irregular tubes, similar to *Planolites*, and to *Thalassinodes*, are very common in Unit 9 and are comparable to those found in other late Cretaceous communities (i.e. McKerrow, 1978).

Other faunal data suggest that Unit 9 is the most off-shore environment of the Seymour Island sequence. First is the occurrence of horizons containing very abundant, small juvenile ammonites. As discussed previously, such horizons are common in offshore facies of the Western Interior of the U.S. Second is the appearance of several cosmopolitan genera of Lytocerataceae (*Anagaudryceras*, *Vertebrites*, *Zelandites*, *Pseudophyllites*), some of which attained very large sizes. These are generally considered as off-shore or deep water indicators. Third is the appearance of more involute, smoother, and streamlined species of *Pachydiscus* and *Maorites*, indicating better adaptation for
Figure 143-- *Pycnodonte* assemblage, present in the latest Maastrichtian of Seymour Island (upper portion of Unit 9 of the Lopez de Bertodano Formation).
swimming, and possibly, more open water conditions. It is difficult to assess the depth at which these sediments were deposited, but probably it was less than 200m.

Faunal diversity decreases drastically in Unit 10 of the Lopez de Bertodano Formation, with the epifaunal suspension feeding *Pycnodonte* assemblage disappearing completely. Abundant large fragments of fossil wood suggest proximity to a coast. Typical elements of Unit 10 are the infaunal suspension feeder bivalve *Lahilla larseni* and the deposit feeders *Perissoptera nordenskjoldi* and *Nucula suboblonga*. Most of these changes, however, are related to the massive extinction that occurs at the Cretaceous/Tertiary boundary. In view of the drastic world-wide faunal change occurring at this boundary, the local palaeoenvironmental significance of the decrease in diversity observed at this level is difficult to interpret. Because this fauna is very similar to that of the Sobral Formation, which was deposited in shallower water conditions, the Unit 10 assemblage may also represent a considerably shallower setting than that of the underlying unit. No independent sedimentological evidence, however, confirms this. As a result, the K/T boundary on Seymour Island may coincide with a rapid drop in sea-level. The abundance of *Lahilla* and *Perissoptera*, in both units 9 and 10, and the presence of bored fossil wood in the upper levels of Unit 9, on the other hand, suggest that no large facies change occurred across the Cretaceous/Tertiary boundary on Seymour Island. The new fauna, however, may also be a response to other less apparent parameters, such as a sudden temperature change. Oxygen isotope investigations of the
micro- and macrofauna in progress by E. Barrera (Case Western Reserve University), will add important data to the consideration of this alternative.

Unit 1 of the Sobral Formation contains a fauna identical to that of Unit 10 of the Lopez de Bertodano Formation, but a marked decrease in the abundance of specimens is observed. Fossil invertebrates are very sparse in Unit 2 of the Sobral Formation, but their presence indicates a marine environment. Fossil wood is very abundant, but logs are devoid of encrusting bivalves typically found in fossil wood in the Lopez de Bertodano Formation. This indicates that the wood underwent little transport in sea water, thereby suggesting proximity to the coast. Vertical burrows (Skolithos), usually indicative of shore, or very shallow water environment (Seilacher, 1967), provide additional evidence of a shallow water setting.

Fossil invertebrates are absent in the Cross Valley Formation, with the exception of a poorly preserved, yet unstudied fauna found approximately 80m above the base of the formation in the Cape Wiman area. Fragments of fossil wood, some carbonaceous, are very common, and the presence of structures similar to rootlets, and thin coal laminae, suggest that at least part of these sediments were deposited above sea-level.

ENVIRONMENTAL RESTORATION
The Marambio Group exposed on Seymour Island represents the youngest beds of the Cretaceous sequence and has no lateral equivalent in the James Ross Basin. As a result, reconstruction of the paleogeographic setting in which these sediments were deposited is only tentative since there are no laterally equivalent age beds to provide a three-dimensional perspective. However, an evaluation of all the available sedimentological, paleontological, stratigraphic, and petrographic data does provide definite constraints for the reconstruction of the paleoenvironments of these deposits.

One of the most striking characteristics of this sequence is the predominance of a high mud (silt+clay) content in the Lopez de Bertodano Formation and Unit 1 of the Sobral Formation, followed by relatively cleaner sands in Unit 2 of the Sobral Formation and the Cross Valley Formation. The abundant macrofauna indicates a marine environment for most of the Marambio Group, and the presence of abundant mud is indicative of a major source of fine grained material, probably an estuary or delta actively introducing sediments to the basin. An additional constraint is the necessity of a relatively quiet environment (low wave energy) that would prevent the bypassing of sediments to the outer shelf or slope. This interpretation is supported by the near absence of traction structures (i.e. crossbedding and widespread sand sheets) expected in the near-shore portion of an open shelf environment.

Lopez de Bertodano Formation
Rotularia Units—An important feature of this facies is the rapid decrease in thickness in a northerly direction. This occurs because several massive, strongly bioturbated mudstone beds pinch-out in this direction (Figs. 9, 18). This lateral variability suggests the presence of two major sources; one, acting over the entire island, producing the sandy siltstones and more clean sandstones, while an independent source of mud only affected the southwestern portion of the island.

Rivers are the main source of mud on the shelf environment (Drake, 1976). However, a large percentage of this mud is trapped in estuaries and coastal wetlands (Meade, 1972, Meade et al., 1975, McCave, 1972, Drake, 1976), particularly in areas where there is restricted wave activity. Clay particles transported in fresh water tend to flocculate when entering the ocean, but this process does not seem to be important in trapping fine sediments in estuaries (Drake, 1976). As demonstrated by petrographic data, sediments from the Lopez de Bertodano Formation were derived from the Antarctic Peninsula. It is envisioned that a major river outflow was located south of Seymour Island, influencing mostly the southern portion of the island. This estuary opened into a very shallow marine setting, and shed large amounts of fine material into the basin. Mudstone facies are interpreted as nearshore mud tongues that developed parallel to the coast, where a large percentage of the fine material from the nearby fluvial system became trapped (Fig. 144). Occasional periods of more brackish conditions, may have limited the ability of most macrofauna to settle in this region and, resulted in an almost monospecific, abundant "community" of Rotularia.
Figure 144 -- Diagram showing the interpreted paleoenvironmental setting of units 1 to 9 of the Lopez de Bertodano Formation on Seymour Island.
Other units of the Rotularia facies were deposited in a protected shallow shelf environment, not exposed to pervasive wave action. Periodical storms or times of increased current activity and decreased fine sediment input resulted in the winnowing of the fines, forming relatively clean sand surfaces on which solitary corals settled. Periods of even stronger current activity resulted in the formation of mud intraclasts (i.e. Fig. 119) and well sorted pellets (Fig. 118). The presence of flaser bedding implies that both sand and mud were available, and that periods of current activity alternated with periods of deposition from suspension (Reineck and Singh, 1975). Flaser bedding is characteristic of tidally influenced environments (Reineck and Singh, 1975), but is also found in the marine delta front (Coleman and Gagliano, 1965). Thick units of well-bedded, brownish, muddy sandy siltstone (Figs. 32 and 33) are also observed in the Rotularia facies. These well-bedded units are usually devoid of macrofauna and bioturbation, but in some cases (i.e. Station 28), the microfauna (foraminifera) is abundant and diverse (Huber, 1984), and similar to that of the massive gray siltstones. Similar well-bedded sediments are common in the delta front platform of the Mississippi Delta (Scrutton, 1960; Shepard, 1960), where they also sustain an impoverished macrofauna (Parker, 1956). This well-bedded facies has only been observed in the southwest portion of the island, and may represent a distal portion of the deltaic/estuarine system that was affecting this part of the island.

Sediments observed in the northern part of the island are generally similar to those in the south. The scarcity of fauna and the dominance
of *Rotularia* again indicate a restricted environment. However, a horizon containing a moderately abundant and well preserved fauna, including several specimens of the ammonite *Maorites tuberculatus*, was found at Station G-83 (Unit 5, near Cape Bodman), and forms a laterally continuous horizon throughout the island. This horizon approximately coincides with a peak in foraminifera diversity (Station 164; Huber, 1984), indicating the local establishment of more open marine conditions.

Variations in mud content of the Lopez de Bertodano Formation are an indication of the effectiveness of winnowing of the fine materials, or alternatively, an indication of variations in input to the basin. The sparsely intercalated and laterally continuous, grain supported sandstone beds in the predominantly muddy sequence (i.e. Fig. 36) can be compared to cheniers. According to T. Elliot (1978), cheniers form in conditions of low wave energy, low tidal range, effective long-shore currents and a variable supply of predominantly fine-grained sediments. Periods of high sediment supply produce poorly sorted mudflats that prograde seaward because long-shore currents are unable to sort the sediments. During periods of diminished sediment supply, longshore currents and waves erode and winnow the mud flat sediments into chenier ridges. Although these sandy layers were not generally exposed, as suggested by the widespread occurrence of echinoderm spines and solitary corals, they may have formed in very shallow settings, as indicated by the localized presence of thinly bedded, thin (less than 5 cm) stromatolites.
Molluscan Units—Unit 7—A middle shelf setting is proposed for this unit (Fig. 144). A rise in sea level from the Rotularia to the Molluscan units is suggested by the more laterally continuous beds and facies observed in the latter, as well as by the presence of a much more diverse and abundant macrofauna. Sandstone levels within this interval have a large percentage of matrix, indicating that the winnowing process was not as effective as in the Rotularia facies. Sedimentation took place in quiet conditions, as shown by the truncation values (around 4.5 Ø) found between the saltation and suspension populations in the grain size analysis, and the presence in many horizons of bivalves in life position. Most sedimentation took place by quiet deposition from suspension, although a well-sorted saltation population is present in all of the analyzed sediments.

Unit 8—Sand content increases in this unit. The dominant lithology is a massive to thickly bedded, bioturbated gray silty sandstone. These sediments are interpreted as a shelf-slope break facies (Fig. 144). Stanley and Wear (1978) have noted that sediments in the immediate vicinity of the shelf break are commonly coarser than those of the adjacent continental shelf. The shelf break is a zone of almost continuous resuspension, with only a minimum accumulation of fines (Stanley et al., 1983). Turbulence in this region is usually caused by shelf edge currents, upwelling, and possibly breaking internal waves (Southard and Cacchione, 1972). Infaunal biomass is generally greatly decreased in this region, but sand-sized planktonic foraminifera may show a relative increase (Blake and Doyle, 1983). In fact, a peak
in foraminifera diversity was found in sections D and F, at the base of Unit 8, but no size sorting was noted (Huber, 1984). The interpretation of Unit 8 as a shelf break facies, suggests a deepening of the basin, a trend that continues into the overlying unit.

**Unit 9**—This unit represents the deepest or most off-shore facies of the Lopez de Bertodano Formation, and the peak of the transgression observed in the Marambio Group on this island. The most important sedimentological change observed here is the appearance of widespread glauconite beds. Glauconites are common in the most offshore shelf environments of the late Cretaceous Gulf and Atlantic Coastal Plain of the U.S. (i.e. Jablonski and Bottjer, 1983). In Recent environments, abundant (up to 98% of the coarse fraction) glauconite occurs at the outer edge of the Oregon shelf (Kulm et al., 1975), while Hein et al. (1974) found that glauconite is concentrated on slopes between the shelf edge and canyon floors off the California coast. In general, this authigenic mineral forms at depths ranging from 100 to 500 m, and the extensive formation of glauconite suggests low terrigenous sedimentation rates (e.g. Odin and Matter, 1981).

A more cohesive bottom was probably present during deposition of the upper level of this unit, allowing the development and preservation of large and abundant trace fossils (burrows) (Figs. 59, 60). In Unit 9, the presence of a cohesive bottom, the presence of glauconite, and the macrofaunal evidence (predominance of an epifaunal suspension feeding community) suggest a decrease in sedimentation rate in a relatively
offshore setting. This interpretation agrees with modern environments of glauconite formation. Glauconite is also very abundant, however, in Unit 10 of the Lopez de Bertodano Formation and in the Sobral Formation, both of which are clearly shallower water deposits. In this upper portion of the sequence, the occurrence of glauconite is associated with the appearance of a volcanic signal (i.e. increase in the plagioclase/K-feldspar ratio, increase in the percentage of "clean" quartz, and increase in volcanic fragments); as a result, the presence of glauconite in these sediments may be more strongly controlled by the availability of a suitable substrate or chemical conditions necessary for its development than by specific water depth conditions.

Unit 10—This is interpreted as an inner shelf deposit (Fig. 145). A slight increase in grain size, the presence of abundant fossil wood, and a fauna similar to that of the overlying Sobral Formation suggest a shallower water setting than that interpreted for the preceding unit.

Sobral Formation

The Sobral and Cross Valley formations are interpreted as the progradation facies of a delta complex, probably similar to that of the Recent Niger Delta.

Unit 1—The base of the Sobral Formation is composed of distinctive dark brown, well-laminated clays and silty sands. Channels of different scales (first order: 50-100 m; and second order: 1-3 m) and soft sediment deformation structures were observed. An intraclast lag deposit is
Figure 145-- Diagram showing the proposed paleoenvironments in which the upper part of the Marambio Group was deposited.
found at the base of this formation (station 72, Fig. 68), but its occurrence is restricted to the southern exposures of the formation. Macrofauna is sparse, but more abundant in the south of the island. These sediments are similar to the recent prodelta slope facies of the modern Niger Delta (Allen, 1970; Fig. 145), and similar bedding types have been reported by Coleman and Gagliano (1965). Unit 1 was probably deposited in relatively quiet conditions, as inferred from the abundant mud matrix and the lack of high energy sedimentary structures in most horizons.

Unit 2—An increase in the mean grain size of the sand fraction, together with a marked decrease in the mud content, is characteristic of this unit. Sediments are well sorted, and sand grains are more rounded than in either higher or lower units. Grain size curves from this unit are very similar to curves found in foreshore deposits (i.e. Vish, 1969). A foreshore setting is also suggested by the occurrence of vertical burrows (Skolithos) usually found in nearshore deposits. These sediments have clearly been deposited above wave base, in a relatively high energy environment such as the foreshore of a beach. The presence of organic matter fragments and very abundant wood fragments indicate the proximity to the delta front (Fig. 145). This environment has a recent analogue in the lower portion of the coastal barrier sand of the Niger Delta (Allen, 1970; Oomken, 1974).

Cross Valley Formation

The environment of deposition of this formation was described by
Trautman (1976) and Elliot and Trautman (1982). The Cross Valley Formation represents the final progradation of a deltaic sequence, displaying the transition from marine to non-marine facies (Fig. 145). The base of the formation consists of a crossbedded sand, almost continuous throughout the island. This sand is partly glauconitic, but the grains have been transported, as demonstrated by the uniformity of grain size of the glauconites and the other constituents, and their well rounded edges. Unimodal tabular and trough-crossbedding, mostly dipping basinward (E-NE), indicate dispersal of these sediments from the Antarctic Peninsula. Individual foresets are steeply inclined (mean inclination: 23°). Figure 72 depicts the typical vertical sequence found in this basal unit. The lower beds (A; approximately 0.6m thick) show the basinward growth of a sand wave, probably deposited at the opening of a distributary channel. Waning flow conditions produce the overlying unit (B), composed of planar to low-angle crossbedded sand (lower flow regime), and, finally approximately 0.4m of ripple-drift cross-stratification (C), probably indicating the filling of the channel. This laterally continuous unit is formed by the lateral migration of distributary channels, thereby developing a broad delta front sheet sand. This interpretation coincides with that of Trautman (1976). The basal unit is overlain by relatively clean, well-sorted sands with rounded grains, indicating the persistence of deposition near the surf zone. Coarser grained, poorly sorted pebbly sandstones at the top of the sequence examined, have grain size distributions comparable to that found in interdistributary channels of a delta complex (Glaister and Nelson, 1974). The fining-upward cycles found in Cape
Wiman are indicative of channel migrations on the delta plain. Well preserved leaf fossils and minor coal laminae are concentrated in the interdistributary areas of the delta top. A large portion of the Cross Valley Formation was deposited under non-marine conditions, but episodes of marine influence are apparent as shown by a horizon containing a poorly preserved molluscan fauna.

CONCLUSIONS

The Marambio Group on Seymour Island records a complete transgressive-regressive cycle that was initiated during the late Campanian and ended during Paleocene time. Macrofauna provide invaluable assistance in recognizing the facies succession in a predominantly fine grained sequence.

Units 1 to 6 of the Lopez de Bertodano Formation were deposited in a very shallow delta/estuary influenced environment. Mud facies may have developed in subaqueous mud lenses, while sporadic intercalations of clean sand formed during periods of more intense winnowing or decreased fluvial input (Fig. 146). Units 7 to 9 were deposited in progressively deeper water conditions, with Unit 7 forming under middle shelf conditions, Unit 8 under outer shelf/slope break conditions, and Unit 9 under upper slope conditions. Unit 9 contains the most offshore facies of the studied sequence. It is difficult to evaluate the absolute depth at which these sediments were deposited, but microfaunal (Huber, 1984) and macrofaunal studies suggest that maximum depths did
Figure 146-- Inferred sea-level changes during the late Campanian to Paleocene, as interpreted from the Seymour Island sequence.
not exceed 150 to 200m. The relative terms offshore/inshore are more appropriate for depicting most changes observed in this sequence.

Regression started at the K/T boundary, preceded by a decrease in sedimentation rate as observed in Unit 9 (Fig. 146). Unit 10 was probably deposited in a middle to inner shelf environment. The Sobral and Cross Valley formations formed as the basin was filled by the progradation of a deltaic system. Unit 1 of the Sobral Formation is interpreted as a prodelta facies, followed by clean sands deposited as a coastal barrier (Unit 2). The Cross Valley Formation contains the delta top facies, including distributary channels and interdistributary marshes. Fluctuations in the extent of delta progradation produced an alternation of non-marine and very shallow marine facies in the Cross Valley Formation.
CHAPTER VIII

AMMONITE FAUNA: PALEOBIOGEOGRAPHY, CORRELATION, AND AGE

INTRODUCTION

The age of the Cretaceous sequence from the James Ross Island Basin has been documented mainly on the basis of its ammonite fauna (Weller, 1903; Kilian and Reboul, 1909; Spath, 1953; Howarth, 1958, 1966; Olivero, 1981, and in press; Riccardi, 1981). In order to define the age of the Lopez de Bertodano Formation, it is necessary to revise the distribution of ammonites in this sequence in the light of the stratigraphic ranges found on Seymour Island, as well as on the basis of occurrences of species not previously recorded in this area. Additionally, independent information on the age of the sequence and associated ammonite fauna comes from recent micropaleontological studies (Huber et al., 1983) and glauconite ages reported here (Appendix B).

The ammonite fauna from Seymour Island is strongly endemic, and is similar to Southern Hemisphere Cretaceous ammonite assemblages such as those described from New Zealand, New Caledonia, Madagascar, India, South Africa, and Australia. A smaller degree of affinity is also observed with other Indopacific faunas, including those from California, British Columbia (Canada) and Japan. However, the closest affinities are observed with ammonite localities of the Magallanes Basin (southern
South America) (Tierra del Fuego, Sierra Dorotea, Cerro Cazador-Ulmita
Esperanza Region) and Isla Quiriquina (Chile).

Because the Seymour Island fauna is strongly endemic, in order to
define a zonation it is first necessary to establish the pattern of
endemicity and general distribution of the fauna. This will be
approached through a review of the ammonites from the other localities
of the James Ross Island Basin as well as the stratigraphic analysis of
the southern South American fauna. The comparison of the Antarctic
Peninsula/southern South America fauna with other contemporaneous faunas
indicates the species potentially useful in establishing a zonation on
Seymour Island.

OTHER LOCALITIES IN THE JAMES ROSS ISLAND AREA

Spath (1953), Howarth (1966), and Olivero (1981) summarized the
ammonite distribution in the James Ross Basin (Fig. 147). Gunnarites
antarcticus (Weller) is by far the most common taxon found in several
localities of the basin. The total Late Cretaceous cephalopod fauna
from the James Ross Island Basin (with the exception of Seymour Island)
includes:

- Neophylloceras hetonaiense Matsumoto (3)
- Neophylloceras meridianum Spath (3)
- Neophylloceras ramosum (Meek) (2)
- Neophylloceras surya (Forbes) (2)
- Phyllopachyceras forbesianum (d’Orbigny) (3,6,8)
- Gaudryceras pictum (Yabe) (3)
- Gaudryceras multiplexum (Kossmat) (2)
- Gaudryceras vertebratum (Kossmat) (2)
- Gaudryceras varagurense (Kossmat) (5,6,7,8)
- Gaudryceras sp. (2,3)
- Anagaudryceras politissimum (Kossmat) (2)
- Vertebrites kayei (Forbes) (2,7)
Tetragonites cf. epigonus (Kossmat) (2,4)
Tetragonites (Saghallinites) cala (Forbes) (3,4,7)
Pseudophyllites loryi (Kilian and Rebound) (=P. peregrinus
Spath) (2,3,7,8)
Baculites bailyi Woods (7,9)
Baculites rectus Marshall (3,9)
Solenoceras aff. mortoni (Meek and Hayden) (3)
*Diplomoceras lambi Spath (2,3,8,10)
Phylloptychoceras "zelandicum (Marshall)" (3)
Ryugasella sp. (*Polyptychoceras sp. ind.) (3,7)
Hoploscaphites quiriquinensis (Wilckens) (3)
Hoploscaphites sp. (7)
Eosparites aff. (8)
?Puzosia sp. indet. (2)
Parapuzosia sp. (3)
Kitchinites (K.) darwini (Steinmann) (5,8)
Kitchinites (K.) angolaensis Howarth (9)
Kitchinites (Neopuzosia) cf. japonica (Spath) (7,9)
Desmophyllites sp. indet. (4)
Hauericeras aff. gardeni (Baily) (2,7,9)
Oliophyllites decipiens Spath (3)
Kossmaticeras (Natalites) rossensis (Olivero) (7,9)
Grossuvrites gemmatus (Huppe) (3,8,9)
*Gunnarites antarcticus (Weller) (1,2,3,4,8,10)
*Gunnarites kalka (Stoliczka) (2,3,8)
*Gunnarites bhavaniformis (Kilian and Rebound) (2,3)
Gunnarites pachys Spath (3)
Maorites seymourianus (Kilian and Rebound) (3,8)
Maorites densicostatus (Kilian and Rebound) (3,5,7,8,9)
Maorites suturalis (Marshall) (3)
Neograhamites taylori Spath (3,7,9)
Neograhamites kiliani Spath (2,3,6)
*Jacobites crofti Spath (3,4,8)
*Jacobites anderssoni (Kilian and Rebound) (2,4)
Caledonites validus Olivero (7,9)
Submortoniceras chicoense (Trask) (5)
Patagosites aff. amarus (Paulcke) (3,8)
Eupachydiscus grossourei (Kossmat) (4,6,8)
Eupachydiscus paucituberculatus Olivero (7,9)
Anapachydiscus constrictus Olivero (7,9)
@Eutrephoceras similis Spath (2,3,8,10)
@Naefia? sp. (aff. Belemnitella) (2,7)

1) Weller, 1903; 2) Kilian and Rebound, 1909; 3) Spath, 1953; 4) Howarth,
1978; 8) Del Valle et al., 1982; 9) Oliviero, in press; 10) this
work.

*= common species
@= nautiloids
### Figure 147

Distribution of cephalopods and some bivalves in the James Ross Basin. (After Olivero, 1981.)
All these ammonites, with the exception of *Submortoniceras chicoense*, were found in the Lopez de Bertodano Formation. The lowermost portion of this formation, in Brandy Bay, contains specimens of *Anapachydiscus* spp. (Olivero, in press)(information not included in the Fig. 147). Above the level with *Anapachydiscus*, and in beds older than those containing * Gunnarites*, Olivero (in press) found an assemblage of *kossmaticerids* including *Kossmaticeras* (*Natalites*) *rossensis*, and *Caledonites validus*.

The next ammonite-bearing level contains specimens of *Eupachydiscus grossouvrei* (*Kossmat*), associated with *Gunnarites*. The specimen of *E. grossouvrei* that Howarth (1966) mentioned from Brandy Bay (*James Ross Island*) (where older beds crop out), was examined in the British Museum, and in the opinion of the author, it should be reassigned to the genus *Anapachydiscus*.

Several species of *Gunnarites* were found at Lachman Crags, The Naze, Cape Hamilton (*James Ross Island*); Vega Island, as well as on Snow Hill and Cockburn islands, however this genus is conspicuously absent (with the exception of a single specimen at the base of the sequence) on Seymour Island.

Among the species present in other localities of the *James Ross Island Basin* and common to those from Seymour Island is *Maorites densicostatus* (Kilian and Reboul). This species has been mentioned for Brandy Bay (Malagnino, et al., 1978) and revised as *Maorites* cf.
densicostatus by Olivero (in press); it was also mentioned from Lachman Crag North, South, The Naze (James Ross Island), and Vega Island (Spath, 1953; Del Valle et al., 1982), and figured from Snow Hill Island (Olivero, 1975). The occurrences in Brandy Bay and Snow Hill are questionable because the specimens are poorly preserved and fragmentary, and they should be classified as *Maorites* sp. The material from Lachman Crag identified by Spath (1953) consist of small specimens, and as discussed in the systematic of this species (Chapter IX), they would be very difficult or impossible to distinguish from juveniles of some species of *Jacobites*, *Natalites*, *Caledonites*, and *Karapadites*. However the material described by Howarth (1966) from Vega Island undoubtedly belongs to this species.

*Maorites seymourianus* (Kilian and Reboul) was described from Lachman Crag South (Spath, 1953, pp. IV, fig. 19, b), however this specimen probably belongs to *Gunnarites bhavaniformis*. *M. seymourianus* was also found in Vega Island, and The Naze (James Ross Island) by Del Valle, et al. (1982), but these specimens have not been figured so far.

Specimens of *K.(Kitchinites) darwini* (Steinmann) which are very similar to those from Seymour Island were described by Howarth (1966) from Vega Island. *Diplooceras lambi* Spath, present on Seymour Island was also found on James Ross Island (The Naze), in Vega Island (Spath, 1953; Del Valle et al., 1982, and the author) as well as on Snow Hill Island (Kilian and Reboul, 1909).
Discussion—The presence of *Maorites densicostatus* at The Naze (James Ross Island) and on Vega Island, together with *Kitchinites darwinii* and *Grossouvrites gemmatus* in this latter locality, is very interesting because these taxa are some of the most common species on Seymour Island, and are virtually absent at the rest of the localities of the James Ross Basin. However, it is difficult to explain the fact that on Seymour Island, where only the upper part of the Lopez de Bertodano Formation crops out, and where stratigraphic control is more adequate, *M. densicostatus* occurs stratigraphically above *M. seymourianus* (Fig. 91), and it is not associated with *Kitchinites darwinii*, but with *K. laura* n.sp. This can be explained in two ways: a) that *M. densicostatus*, *K. (Kitchinites) darwinii* and *Grossouvrites gemmatus* have an extended stratigraphic range, and that their discontinuous occurrence is due to inadequate collecting or to facies control; b) that, as proposed by Bibby (1966), this sequence is folded. In this way younger beds equivalent to those of Seymour Island could be covered by ice in the vicinity of Lachman Crags and the Naze (James Ross Island) and in Vega Island. Then, hypothetically, the co-ocurrence in these localities of *Maorites* and *Gunnarites* could be due to the presence of a mixed fauna with an older autochtonous component (*Gunnarites, Eupachydiscus*, etc.) and a younger "allochtonous" component (*Maorites densicostatus, Kitchinites darwinii, Grossouvrites gemmatus*). Short visits to these localities confirmed the presence "in situ" of the typical fauna of *G. antarcticus*, but failed to yield specimens of *Maorites*, *Kitchinites*, or *Grossouvrites*. Further work on Vega Island should be devoted to solving this problem.
It is interesting to note that specimens of *Gunnarites* dominate over those of *Maorites* in the lower levels of the Lopez de Bertodano Formation, including the beds of Snow Hill and Cockburn islands. A single specimen of *Gunnarites* was found on the base of the Seymour Island sequence, and above it there are 1000 m of sediment bearing the abundant *Maorites* fauna that is typical of this island.

SOUTHERN SOUTH AMERICA

The following review is based on two field seasons spent in southern Chile visiting localities, collecting specimens and measuring sections, as well as on a revision of the available literature and paleontological material from the area preserved in different Chilean institutions (Cf. Chapter I).

The *similarites* of the late Cretaceous ammonite faunas from the Antarctic Peninsula and those from southern South America are such that any attempt to establish the age and vertical succession of the Antarctic faunas can strongly benefit from a detailed analysis of the information obtained from Patagonia. For this reason a general description is presented here of the previous stratigraphic and paleontological work in the late Cretaceous of southern South America as well as new field observations in the area and its faunas.

Regional background of the Magallanes Basin
Figure 148.-A- Distribution of late Cretaceous marine outcrops in southern South America. 1- Tierra del Fuego; 2-Brunswick Peninsula; 3-Isla Riesco; 4-Sierra Dorotea; 5-Cerro Cazador; 6-Ultima Esperanza Region. (Modified from Ruiz C. (In Charrrier and Lahsen, 1969). B- Simplified geologic map of the Ultima Esperanza Region, showing location of measured sections (After unpub. maps of E.N.A.P.).
Cretaceous outcrops in southern South America follow a trend parallel to that of the Cordillera, trending N-S in Ultima Esperanza, and swinging to E-W in Tierra del Fuego (Fig. 148). The Cretaceous rocks overlie the late Jurassic Tobifera Series or Complejo El Quemado. The base of the Cretaceous sequence is formed by a quartzitic sandstone blanket deposited in a shallow marine setting (Springhill Formation) (Riccardi, 1976). To the west and southwest, lower Cretaceous sediments were deposited in a marginal basin that opened between the arc to the west and the continent to the east; a thick sedimentary sequence accumulated there. To the east, sedimentation occurred over a stable platform (Katz, 1973; Dalziel et al., 1974; Dalziel, 1981). Euxinic conditions predominated throughout the basin during the early-Cretaceous (Riccardi and Rolleri, 1980, Russo et al. 1980, Dott, et al., 1982). During the Albian-Cenomanian, intense folding and uplift associated with the closure and deformation of the marginal basin formed the "Paleoandes" to the west (Cecioni, 1957a, Dalziel et al., 1974, Winslow, 1980). Flysch-type sedimentation predominated adjacent to the uplifted terrain during the earlier part of the late Cretaceous (Kranck 1932; Feruglio, 1949; Katz, 1963; Leanza, 1972; Natland et al., 1974; Riccardi and Rolleri, 1980; Nullo et al., 1981; Winslow, 1980, among others).

During the late Cretaceous the Magallanes basin developed in a foreland setting. Marine sediments in this triangular shaped basin extended close to latitude 49°N near Lago Viedma, and opened southward in a SE direction to the Atlantic coast (Fig. 149). This basin, which
Figure 149-- Maastrichtian paleogeography of the Magallanes Basin. (Modified from Russo et al., 1980, and Riccardi and Rolleri, 1980).
developed during the late Jurassic–early Cretaceous became more restricted in extent. Sediment sources for the late Cretaceous Magallanes basin were the recently uplifted Cordillera to the west and the cratonic Deseado Massif or Dungeness High to the northeast. In this sense the Magallanes Basins conforms to a typical retroarc basin and grades laterally into a platform or foreland setting. Greater thicknesses of sediment were deposited close to the Cordillera, particularly in the south in Tierra del Fuego and in the Magallanes Strait area (Urien et al., 1981), and sediments became progressively finer grained towards the center of the basin. Outcrops of latest Cretaceous rocks are only found along the Andean fold and thrust belt, extending from south of Lago Viedma to Tierra del Fuego. Middle to Upper Campanian sediments throughout are represented by black shales with minor calcareous intercalations, deposited under deep water conditions. In the Ultima Esperanza Region, large amounts of sediment were dumped below wave-base by turbidity flows on a deep sea fan system (Smith, 1977, Dott, et al., 1982). Deposition by turbidity currents might have also occurred in the Tierra del Fuego area (cf. Winslow, 1980).

A rapid change to a predominantly sandy sequence is observed northward, together with a marked decrease in the thickness of the beds. Continental beds (Pari Aike Fm) of possibly late Campanian age are present in the Rio Shehuen area. A marked change in facies is observed in the exposed sediments during Maastrichtian times. These sediments, which represent the edge of the basin, became much coarser and glauconitic, and were largely deposited above wave base as documented by
the presence of crossbedded intervals laid down by traction currents (i.e. Smith, 1977; Dott et al., 1982; Winslow, 1980; Wilson, 1983). Farther north there is an interdigitation of marine and continental deposits, the latter containing dinosaur bones and fossil plants (Furque, 1973). These continental beds, previously known as "Estratos con Dinosaurios" (Keidel, 1917; Feruglio, 1949), are included in the Pari Aike and Chorrillo formations (Fig. 150).

During the late Cretaceous the northern portion of the Magallanes Basin was filled by the N-S progradation of shallow water marine sediments (Feruglio, 1949; Cecioni, 1970; Cecioni and Charrier, 1974; Leanza, 1972; Riccardi and Rolleri, 1980; Russo, et al., 1980; Nullo et al., 1981; Aguirrez and Ramos, 1981). This shallowing of the basin resulted in the interdigitation in the upper portion of the sequence of deltaic, lacustrine and fluvial sediments with occasional coal beds (cf. Cecioni, 1957b). The rapid change to continental facies at the end of the Cretaceous resulted from the progradation of the clastic shallow marine wedge, together with the shifting of the axis of deposition in a ENE direction as a consequence of the uplift of the foreland fold-thrust belt of the Andean precordillera, (Katz, 1963, 1973; Riccardi and Rolleri, 1980; Wilson, 1983).

**Ammonite Faunas**

An ammonite fauna similar to that of Seymour Island is found in the Magallanes Basin. Since the classic work of Paulcke (1907), several authors have discussed the stratigraphy and the paleontology of these deposits but there is still a diversity of opinion regarding their age.
In general the material here is sparse and poorly preserved, particularly in those localities that have been more affected tectonically.

Tierra del Fuego—In Tierra del Fuego, Leanza (1964) described *Maurites densicostatus* in rocks presently known as Bahía Tethis Formation. In the Fuegian Precordillera Hunicken et al. (1975) described *Baculites duharti* Hunicken and figured two columns measured by Duhart (1961, 1963), but these authors indicated that the stratigraphic location of the fossils was not very accurate.

In the Rio Sur column, the Cerro Matrero Formation, a flysch-type sequence, was divided into five members (Fig. 151). In member A, *Baculites duharti*, interpreted by these authors as indicative of a middle to late Campanian age, is associated with the bivalve *Inoceramus steinmanni* Wilckens. In member E, *Baculites duharti* was found together with *Anapachydiscus patagonicus* (Paulcke) (identified by G. Cecioni) and a fauna of *Maurites-Grossouvreites*. Hunicken et al. (1975) thought that the association of *Maurites-Gunnarites-Grossouvreites*, as proposed by Cecioni (1955a) and by Lahsen and Charrier (1972), was indicative of a Maastrichtian age. The co-occurrence of *B. duharti* together with this fauna of antarctic affinities was attributed by these authors to an error in the location of this specimen. It is also difficult to explain the presence of "*Pachydiscus* patagonicus (=*Anapachydiscus patagonicus* (Paulcke)) if this association is considered as Maastrichtian in age. The second section (Fig. 151) includes the Rio García Formation, which
Figure 151---Geologic sections in Tierra del Fuego. See location in Fig. 148. (Modified from Duhart, 1961, 1963).
is composed of black shales, silty shales, and calcareous concretions. Here *Baculites duharti* was found approximately 100 m below *Gunnarites* cf. *antarcticus*.

**Brunswick Peninsula—Isla Riesco**—In the Brunswick Peninsula, Charrier and Lahsen (1969), and Lahsen and Charrier (1972) found *Diplomoceras notabile* (Whiteaves), *Maorites* cf. *tenucostatus*, *M*. cf. *densicostatus*, and *Pachydiscus* sp. in the Santa Ana Formation, and *M*. cf. *densicostatus* and *Maorites* sp. in the overlying Río Blanco Formation (Fig. 152). Von Goetsche (1953) (in Lahsen and Charrier, 1972) also found *Gunnarites* cf. *C. kalika*, *M*. cf. *M. suturalis* and *Diplomoceras* aff. *D. undulatum* (Forbes) in the Río Blanco Formation. Macellari (unpubl. data) also found poorly preserved moulds of *Maorites* sp. in this unit. Cecioni (in Hoffstetter et al., 1957, p. 329) mentioned *Gunnarites zelandicus* (Marshall) in the Santa Ana Formation. The material from this section is very poorly preserved, thus the specific, and in some cases even the generic identifications have to be treated with caution.

On the north coast of Isla Riesco there is a continuous sequence comprising the Rosa, Fuentes and Rocallosa formations (Fig. 152). Here Hunicken et al. (1975, 1980) found *Baculites duharti* close to the base of the shales of the Fuentes Formation. Towards the top of these beds, Lahsen and Charrier (1972) mentioned the occurrence of several species of *Gunnarites* and *Maorites* cf. *tenucostatus*. This occurrence of *M. tenucostatus* together with a typical *Gunnarites* fauna is not in accord with the distribution of this species on Seymour Island where *M.*
Figure 152-- A- Sections in the Seno Skyring-Magallanes Strait region (See location in Fig. 148a). (After Charrier and Lahsen, 1969, and Hunicken et al., 1975, 1980). B- Kossmaticeratidae vertical distribution in the Magallanes Basin, as proposed by Cecioni, 1955b.
tenuicostatus occurs approximately 1000 m above the last record of Gunnarites. Several meters above this, in the Rocallossa Formation, was found the foram Bolivinoides draco dorreeni Finlay, indicative of a late Maastrichtian age (Martinez-Pardo, 1965), followed by the occurrence of Gunnarites sp. in immediately overlying beds. Along the south coast of Seno Otway, Charrier and Lahsen (1969) mentioned a foraminiferal association that includes Bolivinoides draco dorreeni, however, the exact relationship between this fauna and the Gunnarites fauna from the top of the Fuentes Formation in the north of Isla Riesco is not known because these two localities are separated by more than 65 km.

Charrier and Lahsen (1969) and Lahsen and Charrier (1972) correlated the upper part of the Fuentes Formation with the Santa Ana and Rio Blanco formations. An alternative interpretation, proposed by Cecioni (1955a,b), is that the Fuentes Formation, bearing a fauna mostly of Gunnarites antarcticus, represents a lower level than that of the Rio Blanco Formation with Gunnarites of the kalika type and Maorites (Fig. 152). This interpretation is more in line with evidences found in Antarctica.

Ultima Esperanza-Sierra Dorotea-Cerro Cazador--In the Ultima Esperanza region, Katz (1963) mentioned Anapachydiscus steinmanni (Paulcke) associated with Maorites seymourianus and M. densicostatus in levels near the top of the Cerro Toro Formation (Fig. 153). This fauna is followed in beds of the Tres Pasos Formation by an association with Hoplitoplacenticeras spp., Neograhamites taylori Spath, Baculites cf, B.
Figure 153--Sections, and ammonite fauna in the Sierra Dorotea-Ultima Esperanza Region (See location in Fig. 148). (Modified from Paulcke, 1907; Wilckens, 1907b; Brandmayr, 1945; Hunicken, 1955, 1965; and Katz, 1963).
inornatus Meek and Pseudokosmaticeras paulceki Collignon, among others. Also, according to this author, Hoplitoplacenticeras spp. and Maorites are found in the overlying Dorotea Formation. However, the location of fossils in this work (Katz, 1963) is extremely imprecise. Furthermore, the unpublished report of Reeside (1950) which is the basis for most of Katz's faunal lists, records that some identification labels were lost on the way to the U.S.A. (Reeside, 1950). Also, most identifications are only at the generic level and no description or illustration accompanies this work. From this, it follows that the presence of Maorites beneath the "level" with Hoplitoplacenticeras, as described by Katz (1963), needs to be reconfirmed independently. Personal observations in the Ultima Esperanza Region (Fig. 154) show that the "level" with Hoplitoplacenticeras is at least 1600 m thick (from the base of the Chorrillo Picana section to the top of the Cerro Cazador section) (Macellari, in press).

In the Sierra Dorotea, to the east of the previous region and in Argentina, Hunicken (1955, 1965) provided a detailed description of the stratigraphy and paleontology of the Cretaceous-Tertiary sequence (Fig. 153). In the middle of the Cerro Cazador Formation (on top of the level with Hoplitoplacenticeras and in levels partially equivalent to the Dorotea Formation [sensu Katz, 1963]), Hunicken (1955, 1965) found Diplomoceras australae Hunicken, Pseudophyllites peregrinus Spath, Maorites densistatus, M. suturalis Marshall, Eutrephoceras simile Spath, Grossouvierites gemmatus (Huppe), Gaudryceras sp., Baculites cfr. anceps (Lamarck), and B. rioturbiensis Hunicken. With the exception of
Figure 154-- Measured sections in the Ultima Esperanza Region. (See location in Fig. 148b).
Baculites spp., this fauna is almost identical to that of Seymour Island.

In the Cerro Cazador region, Brandmayr (1945) mentioned Maorites densicostatus together with "Pseudokossmaticeras" hauthali (Paulcke) approximately 500 m over the level F of Hauthal (in Wilckens, 1907b) or Hoplitoplacenticeras level (Fig. 153). These beds in turn, overlie those of Cerro Toro Formation with Anapachydiscus spp. [or Estratos de Laguna Amarga (Feruglio, 1938), or Laguna Amarga Group (Groeber, 1959)]. Cecioni (1957b) mentioned the presence of Pachydiscus aff. gollevillensis (d'Orbigny) (identified by Reeside) approximately 15 km south of Cerro Cazador, near the Estancia Castillo and several meters above the "level" with Hoplitoplacenticeras. Approximately 90 m above the occurrence of Pachydiscus, Cecioni (1957b) found specimens of Gunnarites flexuosus Spath [≡G. bhavaniformis (Kilian and Reboul)]. In the Estancia Los Leones, on the left bank of the Río Baguales, Macellari (in press) found Baculites sp. approximately 20 m below the top of the Dorotea Formation (in the usage of Katz, 1963) (Fig. 154). This specimen, which is well preserved, is very similar to Baculites sp. described by Hunicken (1965) from the Dorotea Formation.

Lago Argentino—Maorites and Gunnarites, two of the most common genera in Antarctica, have also been mentioned in Lago Argentino (Fig. 148). Feruglio (1938, 1945) mentioned "Holcodiscus" hauthali Paulcke (= Pseudokossmaticeras hauthali (in Leanza, 1967a) (= Kossmaticeras (Natalites) cf. hauthali, in Riccardi, 1983) in the La Anita Formation.
Feruglio (1936) also described *Gunnarites* cf. *antarcticus* from the Estancia La Geronima, but Leanza (1968) concluded that this specimen was unidentifiable even at the generic level. Riccardi and Rolleri (1980) mentioned poorly preserved specimens of *Maorites densicostatus* in the top of the Cerro Toro Formation, immediately below the La Anita Formation. Subsequently, Riccardi (1983) included this material in *Kossmaticeras* (Krapadites) *centinelaensis* (Blasco, Nullo and Proserpio). Blasco et al. (1980) found deformed casts of juvenile specimens that were identified as *Maoites* or *Gunnarites* of the kalika type in the Arroyo Centinela. Blasco et al. (1980) described also an assemblage with *Kossmaticeras* (Natalites) sp.; *K. (N.) altavistensis* Blasco de Nullo; *Neograhamites taylori*, *Gunnarites kalika*, *Maoites tenuicostatus?*, and *Gunnarites* aff. *antarcticus*, that they considered to be early to middle Campanian in age. This fauna was completely revised by Riccardi (1983) and was included in *Kossmaticeras* (Krapadites) *centinelaensis* (Blasco, Nullo and Proserpio), *K. (Natalites)* cf. *hauthali* (Paulcke), and in *Neograhamites morenoi* Riccardi.

In conclusion, *Gunnarites*, as well as *Maoites* are not present in the Lago Argentino region. According to Riccardi (1983), the Kossmaticeratidae from this area occupy a stratigraphic position intermediate between an older assemblage bearing *Anapachydiscus* spp. and a younger assemblage with *Maoites*.

**Isla Quiriquina**— The ammonite fauna from the Isla Quiriquina bear strong resemblances to that of Seymour Island, but the
Maorites—Gunnarites component is extremely impoverished. Here predominates an association with Eubaculites and Pachydiscus spp. (Steinmann, 1985; Wilckens, 1904; Wetzcl, 1930; Hoffstetter et al., 1957; Hunicken and Covacevich, 1975). Maorites densicostatus is also present but very rare. This species has never been figured in the description of the Quiriquina's fauna, but the author had the opportunity to observe one specimen in the Geology Department of the Universidad de Concepcion, and it is identical to the Antarctic material. Other species identical to those from Seymour Island include Grossouvreites gemmatus, Kitchinites darwini, Neophyloceras ramosum (Meek), Vertebrites kayei and possibly Diplomoceras cf. cylindraceus (Deffrance) and Pachydiscus sp., as well as several gaudrycerids and tetragonitids, but a precise identity of these last groups only could be done after a modern revision of this fauna. Gunnarites spinossisimus Wetzcl, the only representative of this genus, was described on the basis of a poorly preserved fragment. The presence of Eubaculites indicates a Maastrichtian age for these beds. However, the stratigraphic position of most of these specimens is not known (with the exception of Eubaculites, which is found in the highest levels), because most of them were found loose at the foot of cliffs (Lajos Biro, personal communication, 1983).

Cecioni (1980) also mentioned the presence of Gunnarites sp.; Grossouvreites sp., and Pachydiscus quiriquinae Steinmann in outcrops of the Punta Topocalma Formation (located at 34° South latitude, in the proximity of Navidad, Chile). This is the northernmost report of the
kossmaticerid fauna in South America.

AMMONITE ZONATIONS PROPOSED FOR PATAGONIA AND ANTARCTICA

Previous zonations in the Magallanes Basin have used different species of the family Kossmaticeratidae as time-diagnostic species, however, because of the still inadequate knowledge of this endemic fauna, these zonations have not been successful. For example, the age of the genus Maorites (Kossmaticeratidae), one of the most common taxa in the Magallanes Basin and in Seymour Island has been considered as:


b) Early (to middle) Campanian: Collignon (1955); Bessaire and Collignon (1959); Howarth (1958, 1966); Blasco et al. (1980); Nulio et al. (1981).

c) Late Campanian to Maastrichtian: Spath (1953); Hunicken (1965); Katz (1963); Henderson (1970); Riccardi and Rollerli (1980, p. 1228); Leanza (1967b, 1972)(Late Campanian only).

d) Maastrichtian: Cecioni, (1955a); Charrier and Lhasen (1969); Lahsen and Charrier (1972); Hunicken et al.(1975); Macellari, (in press).

Two zonations have been proposed for the Campanian-Maastrichtian of southern South America. The first, even though not specifically defined as such, is based on the vertical distribution of different species of Kossmaticeratidae (Cecioni, 1955a,b). Seven "zones" were recognized by
Cecioni (Fig. 152); the upper three zones (Maurites denticostatus, Gunnarites ex. gr. G. kalika, and G. ex. gr. G. antarcticus) were combined into one by Lahsen and Charrrier (1972), which they called the Gunnarites kalika Zone. The basis for this was that these ammonites were found together in several localities of the Magallanes Basin. The age of the G. kalika Zone was considered to be late Maastrichtian (on the basis of its relationship to diagnostic foraminifera) (Lahsen and Charrrier, 1972).

The second zonation was proposed by Leanza (1967b, 1972)(Fig. 155), who recognized four zones: Anapachydiscus steinmanni (Paulcke) (lower Campanian), Hoplitoplacenticeras plasticum (Paulcke) (Middle Campanian); Maurites denticostatus (Kilian and Reboul) (Upper Campanian); and "Pseudokossmaticeras" hauthali (Paulcke) (= Kossmaticeras (Natalites) hauthali (Paulcke) (Maastrichtian). However serious doubts exist about the stratigraphic relationship of the last two zones, and very likely the order should be reversed, (Maurites younger than Kossmaticeras)(Riccardi, 1983; Macellari, in press).

In the James Ross Island area, Olivero (1981) established four local "zones" based on the geographic distribution of different fossiliferous localities, and assuming an homoclinal disposition of the entire sequence (Fig. 147). The two upper zones are of interest here (Gunnarites antarcticus (Weller) Zone and Pachydiscus gollevillensis (d'Orbigny) Zone). The Gunnarites antarcticus Zone was subdivided by Olivero into a lower subzone with Eupachydiscus grossouvrei (Kossmat)
<table>
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<td>(Kil. et Reb.)</td>
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<td><em>plasticum</em> (Pauleke)</td>
<td>pl. costatum, baithali, laeve,</td>
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<td><em>Anapachydiscus</em> steinmanni</td>
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<td>(Pauleke)</td>
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<td>Leanza</td>
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*Figure 155-- Ammonite zonation proposed by Leanza, 1967, 1972.*
and an upper subzone with *Jacobites andersonii* (Kilian and Reboul). The *C. antarcticus* Zone is present in James Ross Island (Lachman Crags South, and The Naze); Vega, Humps, Snow Hill and Cockburn islands. The *Pachydiscus gollevillensis* Zone represents the younger beds of the Cretaceous sequence and is restricted to Seymour Island where *Maorites* is the most common species.

Spath (1953) considered the age of the Antarctic fauna to be mostly Campanian but possibly extending to the Maastrichtian in the youngest beds (Seymour Island). However Howarth (1966) and later Olivero (1981) accepted an early to late Campanian age for the entire association, including the beds from Seymour Island.

**Conclusion**

A problem observed in the zonations reviewed above, is that authors have not clearly stated the criteria used for establishing such zones. In most of these cases, it can be inferred that the authors are implying total range zones. The usage of the total range of species to establish a zonation is a practice that may lead to confusion, particularly in the case of superposition of stratigraphic ranges of diagnostic species. More appropriate (as pointed out by Murphy (1977), and also the North American Commission of Stratigraphic Nomenclature (1983) among many others) is to define a zone on first occurrences of species, particularly if this first occurrence can be interpreted as an evolutionary event.
In general the confusion regarding the age of the *Maorites*- *Gunnarites* fauna from Patagonia and Antarctica stems from four fundamental aspects:

1) The lack of comprehensive detailed stratigraphic works in Patagonia as well as in Antarctica and New Zealand.

2) The presence in other Indopacific localities of *Maorites* in beds which are believed to be older than those from Patagonia and Antarctica. For example, *Maorites* in Madagascar is present in beds considered to be lower Campanian in age (besaire and Collignon, 1959; Collignon, 1955, 1977) in the *Karapadites karapadensis* Zone. A similar situation is present in South Africa where *Maorites* sp. was also found in lower Campanian beds (Kennedy and Klinger, 1975), but here *Gunnarites* sp. cf. *C. kalika* is found in higher levels than those of *Maorites*, and it is associated with *Eubaculites latecarinatus* (Brunnschweiler), indicative of a lower Maastrichtian age (Kennedy and Klinger, 1975, Klinger et al., 1980). Nevertheless, the presence of *Maorites* above the "level" with *Hopliteplacenticeras*; its association in Quiriquina with *Eubaculites*, as well as new discoveries in Seymour Island, clearly demonstrate a younger age for this genus in South America and Antarctica than that which is accepted in Madagascar.

3) Problems with the definition of the Campanian-Maastrichtian boundary in the type section in Europe. This problem is due to several factors, including the presence of a Campanian type section (Grande Champagne) and a reference section (Aubeterre) both in the Aquitanie Basin (France), but including slightly different stratigraphic intervals. Also, it can be added the ambiguities in the exact
definition of the type Maastrichtian in the Mont Saint Pierre in Holland, and the presence of a hiatus between the type Campanian in Aquitaine and the type Maastrichtian in Holland (Van der Heide, 1954; Van Corsel, 1973; Seronie-Vivien, 1972; and Felder et al., 1980, among others).

These discrepancies are reflected in the different ammonite zonations proposed. Thus the Bostrychoceras polyplocum (Roemer) Zone was included in the base of the Maastrichtian (Haug, 1909, Muller and Schenck, 1943), or alternatively on the top of the Campanian (Jeletzky, 1951; Van Hinte, 1976; among others) this last option being the one presently followed (Kauffman, 1979, Wiedman, 1979). The different opinions on the Campanian- Maastrichtian boundary have direct consequences in Patagonia where Hoplitoplacenticeras plasticum (Paulcke) and its varieties, which correlate with the Hoplitoplacenticeras vari (Schluter) Zone (below the Bostrychoceras polyplocum Zone) of the reference sections, would alternatively represent the base of the late Campanian or its top. In Madagascar, where the ammonite succession has been studied in detail, the Hoplitoplacenticeras vari Zone was placed in the top of the Campanian (Besaire and Collignon, 1959; Collignon, 1970). In Patagonia, even though there is no species that could be assigned to the Bostrychoceras polyplocum Zone, there exist at least 500 m of section in between the last occurrence of Hoplitoplacenticeras and the typical Maorites fauna described by Hönicken (1965) and interpreted here as having a Maastrichtian age. For this reason, it is possible that the uppermost part of the Campanian in southern Patagonia is devoid of
4) Absence in the Magallanes Basin and Antarctica of genera such as *Eubaculites*, *Sphenodiscus*, *Brahmaites*, typical index fossils of the Maastrichtian of the Tethyan region.

In order to establish an ammonite zonation for the upper Cretaceous sequences of Antarctica and Patagonia first it is necessary to recognize patterns of paleobiogeographic distribution that affected this fauna. This analysis will help us recognize the degree of endemicity of different groups, and hence to qualify their validity in the construction of a zonal scheme. These aspects are discussed further in the next section.

**PALEOBIOGEOGRAPHY**

Matsumoto (1973) and more recently Thompson (1981, 1982a) among others, have considered aspects of the paleobiogeographic distribution of ammonites during the late Cretaceous in the Southern Hemisphere. However, due to the lack of detailed stratigraphic data, these works have used longer time units than the span represented by the *Maorites–Gunnarites* fauna in Antarctica and Patagonia.

In an attempt to overcome such problems, faunal lists from several late Campanian-Maastrichtian localities have been compiled, particularly from the Southern Hemisphere and from localities with strong Indopacific affinities. The following sources were used: 1- *Antarctica*: Weller
(1903); Killan and Reboul (1909); Spath (1953); Howarth (1958, 1966); Del Valle and Rinaldi (1975); Del Valle and Fourcade (1976); Del Valle et al. (1976); Rinaldi et al. (1978); Managino et al. (1978); Olivero (1981); Del Valle et al. (1982), and this work. 2- Tierra del Fuego, Brunswick Peninsula and Isla Riesco: Cecioni (1955a, b); Leanza (1964); Lahn and Charrier (1972); Hunicken et al. (1975); Hunicken et al. (1980). 3- Sierra Dorotea-Ultima Esperanza region: Paulcke (1907); Peruglio (1949); Brandmayr (1945); Cecioni (1955a, b, 1957b); Hoffstetter et al. (1957); Katz (1963); Leanza (1963, 1967b); and Hunicken (1965). 4- Isla Quiriquina: Steinmann (1895); Wilckens (1904); Wetzel (1930); Hoffstetter et al. (1957); Hunicken and Covacevich (1975). 5- New Zealand: Woods (1917); Marshall (1926); Wellman (1959); Henderson (1970). 6- New Caledonia: Avias (1959); Collignon (1977). 7- Australia: Spath (1940); Brunnschweiler (1966). 8- South Africa: Van Hoepen (1920); Spath (1921a, b, 1922); Venzo (1936); Kennedy et al., (1973); Kennedy and Klinger, (1975, 1977, 1979), Klinger et al. (1980). 9- Angola: Spath (1953); Howarth (1965). 10- India: Kossmatt (1895-98, 1897); Stoliczka (1865); Forbes (1846). 11- California: Anderson (1958); Matsumoto (1959b, 1960). 12- Japan: Matsumoto (1955, 1959a); Matsumoto and Obara (1955); Matsumoto et al. (1979). 13- Madagascar: Collignon (1938, 1951, 1955, 1970); Besairie and Collignon (1959).

The Maorites-Gunnarites fauna from Patagonia and Antarctica was compared quantitatively with others of similar age by means of the Jaccard coefficient (Table 2). Some comparisons were duplicated using
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<th>SPECIES</th>
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**Table 2:** Comparison of different late Companian-Maastrichtian ammonite faunas by means of the Jaccard Coefficient.

- 2a = Species in common
- 2b = Genera and subgenera in common
- 2c = Jaccard coefficient (Species) $C_j = \frac{N_1 + N_2 - C}{N_1 + N_2}$
- 2d = Jaccard coefficient (Gen. and subgen.)
- (C) = Shared taxa
- (N) = Total number of taxa in one locality.
Figure 156-- Comparison of different upper Campanian-Maastrichtian localities by means of the Jaccard coefficient (Data in Table 2). TF-PB-TR= Tierra del Fuego, Peninsula Brunswick, Isla Riesco; Ultima Esperanza (T.P.)= Tres Pasos Formation; Ultima Esperanza (C.T.)= Cerro Toro Formation.
the Otsuka coefficient, but the results were very similar (Cheettham and Hazel, 1969). This analysis shows the high degree of similarity between the latest Cretaceous faunas from Seymour Island, Patagonia, I. Quiriquina, New Zealand, and Australia (Fig. 156). These localities coincide with what has been called the Weddellian Province (Zinsmeister, 1979, 1982 b). During the late Cretaceous–Early Cenozoic an endemic fauna developed in the shallow seas off an almost rectilinear coast comprising South America, Antarctica, New Zealand, and Australia. The endemic character of the fauna is attributed to the isolation of this area with respect to the rest of the world.

The distribution of selected taxa, either because they are important in Antarctica and Patagonia, or because they are typical Maastrichtian index fossils, but are conspicuously absent in the study area (i.e. Sphenodiscus, Brahmaiites), is shown in figures 157 and 158. Other groups, such as the Gaudryceratidae, Phylloceratidae, Pachydiscidae and Tetragonitidae have not been included because they have a cosmopolitan distribution, and do not offer clues to the explanation of the endemism of the fauna (i.e. Matsumoto, 1973; Kennedy and Cobban, 1976).

Important Maastrichtian index fossils such as Sphenodiscus, and Eubaculites, with the exception of a doubtful occurrence in Santa Cruz (Rossi de García and Camacho, 1965), are absent in the Magallanes Basin, as well as in Antarctica, and New Zealand. However, Eubaculites is a characteristic component of other Maastrichtian faunas from the Southern
Figure 157-- Distribution of selected late Campanian-Maastrichtian taxa, particularly from the southern Hemisphere or with Indopacific affinities. 1- Isla Quiriquina; 2- Sierra Dorotea-Ultima Esperanza Region; 3- Tierra del Fuego, Brunswick Peninsula, Isla Riesco; 4- Seymour Island; 5- New Zealand; 6- Carnarvon Basin (Australia); 7- India; 8- Madagascar; 9- South Africa; 10- Angola; 11- California; 12- Japan. Base map after Smith (1981) (80 m.y.).
Hemisphere (located at paleolatitudes lower than 40°-45°), including North Patagonia (Weaver, 1931; Leanza, 1964, 1967a; Camacho, 1967a; Riccardi, 1974), Quiriquina Island (Hunicken and Covacevich, 1975), Australia (Brunnschweiler, 1966), South Africa (Klinger et al., 1980), and Madagascar (Collignon, 1970). Brahmaites, absent in the Weddellian Province, is restricted almost exclusively to the proto-Indian Ocean.

Other important taxa from Seymour Island include Diplomoceras, which has a world-wide distribution (Klinger and Wiedmann, 1983); Pachydiscus, of stratigraphic importance in this island, and hopefully in the Magallanes Basin as well, also has a cosmopolitan distribution. Kitchininites has been found in most localities of the Weddellian Province, with the exception of the Magallanes Basin. It is also present in Peninsular India, and interestingly, also in Angola (Howarth, 1965).

There is a clear dominance of species of Kossmaticeratidae (Gunnarites, Maorites, Natalites, Jacobites, Neograhamites and Grossouvreites) in the Weddellian Province (Fig. 158). The percentage of species of Kossmaticeratidae with respect to the total fauna is presented in figure 158. Pseudokossmaticeras and Brahmaites (because they are believed to belong to a different family (Collignon, 1977)), and Kossmaticeras (Natalites) (because it apparently has a different distribution than the other mentioned genera (i.e. Japan? (Matsumoto, 1959a); U.S.S.R. (Vereschagin, et al., 1965), were excluded from this analysis. The maximum level of endemism is observed in the New Caledonia region with 71% of the total ammonite fauna belong to this
Figure 158-- Distribution of genera of the family Kossmaticeratidae and Kitchinites (Desmoceratidae) during the late Campanian and Maastrichtian. Isopleths showing the percentage of species of the genera Maurites, Grossouvrites, Gunnarites, Jacobites, and Neograhamites (Kossmaticeratidae) in respect to the total ammonite composition, are shown superimposed. 1- Isla Quiriquina; 2- Ultima Esperanza-Sierra Dorotea; 3- Tierra del Fuego, Brunswick Peninsula, Isla Riesco; 4- Seymour Island; 5- New Zealand; 6- New Caledonia; 7- Carnarvon Basin (Australia); 8- India; 9- Madagascar; 10- South Africa; 11- Angola. Base map after Smith (1981).
family. New Zealand has 44% whereas in Rio Turbio, Tierra del Fuego-I. Riesco and Seymour Island, the percentage of species of this family is almost constant (38, 38 and 37% respectively).

Thompson (1981) postulated that Maorites, Jacobites, Neograhamites, Grossouvrites, and Gunnarites were restricted to paleolatitudes higher than 60°S. However several elements of this fauna inhabited much lower latitudes, up to the Quiriquina-Concepcion region (approximately 40° paleolatitude south). This suggests that the distribution of this endemic kossmaticerid fauna, rather than being controlled by latitude, was controlled by its geographically isolated position with respect to other late Cretaceous shallow seas.

Contrary to what happened in Madagascar where the percentage of Kossmaticeratidae decreased rapidly during the Campanian (Besaire and Collignon, 1959; Collignon, 1977), in Patagonia an increase is observed in the percentage of these taxa during Campanian-Maastrichtian times. For example, in the Ultima Esperanza-Rio Turbio region 10% of the members of this family occur in the Cerro Toro Formation, whereas in the overlying Cerro Cazador Formation this number increases to 38%. This can be interpreted as a consequence of the progressive isolation of the Weddellian Province as the fragmentation of Gondwanaland continued, giving rise to higher levels of endemism.

Hoplitoplacenticeras, the most common genus in the Ultima Esperanza Region has not been found to the south, in Tierra del Fuego and
Figure 159-- Paleogeographic reconstruction of southern South America and the Antarctic Peninsula during the late Cretaceous, showing inferred pattern of paleocirculation. (Base map in part after Urien et al., 1981).
Antarctica, nor in New Zealand, New Caledonia or Australia. The absence of *Hoplitoplacenticeras* in the James Ross basin, *Baculites* in Seymour Island, and the drastic decrease in number of individuals and species of *Kossmaticeratidae* found north of Isla Riesco, could be a reflection of particular oceanographic conditions. Based on a study of microfossils in the D.S.D.P. site 327 cores, in the vicinity of the Malvinas or Falkland Platform, Ciesielski and Wise (1977), postulated the presence of divergent oceanic currents in the area (Fig. 159) which gave rise to a marked faunistic gradient (also cf. Malumian, 1978). Although these authors proposed their model for the open ocean, a similar pattern of paleocirculation seems to have existed in shallower waters. In this sense, Scott (1966), Smith (1977), and Winn and Dott (1979), among others, observed a predominantly N-S paleoflow direction in the Ultima Esperanza region during the late Cretaceous. On Seymour Island, the paleoflow direction was predominantly SW-NE. This tends to support the notion that the faunistic differences between the Ultima Esperanza-Cerro Cazador region on the one hand, and Isla Riesco, and Tierra del Fuego-Seymour Island on the other hand, could be the consequence of a divergent current pattern (Fig. 159). Other faunal differences very likely can be related to latitudinal gradients superimposed on a generalized pattern of distribution.

**AMMONITE ZONATION ON SEYMOUR ISLAND**

Seymour Island has ideal characteristics, generally not found in other Southern Hemisphere localities, for the establishment of an
ammonite zonation. Among the unique characteristics found here are: a) the presence of a thick sedimentary sequence (1200 m) with continuous outcrops exhibiting little tectonic disturbance; b) a very abundant and well-preserved ammonite fauna; and c) the coexistence with a diverse fauna of foraminifera, calcareous nanofossils, diatoms (Huber, 1984; Huber et al., 1983), and pollen remains (R. Askin, personal communication, 1983), that allow an independent evaluation of the regional correlations and age determinations.

As shown previously, the Kossmaticeratidae, developed a high degree of endemism in the Wedellian Province during the late Campanian to the Maastrichtian. It is not surprising then, that the stratigraphic range of genera in this family is different here from other Indopacific localities. For this reason, zonations that included species of this family as diagnostic elements have been difficult to correlate with the standard reference section in Europe. Olivero (1981) (Fig. 147) included the totality of the Seymour Island sequence in his Pachydiscus gollevillensis Zone. However, the first occurrence of this ammonite is recorded 950 m above the base of the sequence (Fig. 91). The family Pachydiscidae, which attained an almost world-wide distribution, offers a better alternative on which to base an ammonite zonation. For this reason, the first occurrences of different species of Pachydiscus have been used to develop a zonation on Seymour Island (Fig. 91). Using this approach, three zones are recognized here. From oldest to youngest they are:
1) *Pachydiscus ootacodensis* Zone—*Maurites seymourianus* and *K. (Kitchinites) darwinii* are the most abundant species. *Kossmaticerases (Natalites) wedelliensis*, and the wider ranging *Grossouwrites gemmatus* and *Diplomoceras lambi* are also present in this zone. *Pachydiscus ootacodensis* (Stoliczka) is not very abundant, and is represented only by three specimens. These are identical to specimens from Hornby Island (British Columbia, Canada) interpreted as having an age close to the Campanian–Maastrichtian boundary (Jones, 1963). These Canadian specimens were included by Muller and Jeletzky (1970) and Ward (1977) in the *Pachydiscus suciaensis* Meek Zone. The Antarctic specimens are also very similar to *P. ootacodensis* from the lower Maastrichtian of several Indopacific localities such as South Africa (Spath, 1922), India (Kossmat, 1895–98), and Madagascar (Collignon, 1938, 1971; Besaire and Collignon, 1959). They also have close similarities with *P. ambatryensis* Collignon from the Maastrichtian of Madagascar (Collignon, 1951), and with *Pachydiscus sp.* from Quiriquina (Wetzel, 1930). In brief, this species is interpreted to be indicative of an early Maastrichtian age or an age close to the Campanian–Maastrichtian boundary.

2) *Pachydiscus ricardi* Zone—It is defined on the basis of the first occurrence of large specimens of *Pachydiscus* (up to 38 cm in diameter) which are identical to that figured by Kilian and Reboul (1909, Pl. 20) as *P. aff. P. gollevillensis* (d'Orbigny). These specimens, which are very abundant, can be distinguished from *P. gollevillelus* by their more inflated section and by the presence of
more numerous and less defined radial ribs in the umbilical region. Other frequent species in this zone are *Maorites densicostatus*, *M. suturalis*, *M. tenuicostatus*, and *K.(Kitchinites) laura*. *Anagaudryceras cf. mikobokense* Collignon, also present here, is associated in Madagascar with *Pachydiscus gollevilensis* and interpreted to represent a lower Maastrichtian age (Collignon, 1956). This species is also present in beds thought to represent the lower Maastrichtian to possibly the highest Campanian in California (Matsumoto, 1959b), but in Angola it was found in beds considered as upper Campanian by Howarth (1965). *Pachydiscus gollevilensis* was found recently in the highest ammonitiferous levels of the Maastrichtian of Spain, and only 15 m below the iridium-rich clay horizon marking the Cretaceous-Tertiary boundary (Ward and Wiedmann, 1983).

3) *Pachydiscus ultimus* Zone—It is mostly represented by several specimens of another large *Pachydiscus* of compressed section that can be included in the "typical group" of Matsumoto (1959b, p. 41) along with *P. (P.) egertoni* (Forbes), *P. (P.) neubergicus* (v.Hauer), and *P. (P.) gollevilensis*, among others. The general similarity of this species with *P. riccardi* leads me to believe in the existence of an evolutionary lineage. This species is related to *P. subcompressus* (Matsumoto) (i.e. Matsumoto et al., 1979, fig. 5) and to *P. gollevilensis* (d'Orbigny) (i.e. de Grossouvre, 1893, Pl. 29, fig. 4), both indicative of a Maastrichtian age. Standard zonal schemes have considered *Pachydiscus [(P. neubergicus (v. Hauer))] as an index fossil of the lower Maastrichtian. However Birkelund (1979) has recently challenged this
concept because this species was found in the Lower/Upper Maastrichtian boundary in the Maastrichtian chalk of Denmark, and *P. aff. colligatus* (v. Binkhorst) extends to the top hardground (just beneath the K/T boundary) in the Stevens Klint section in Denmark. Ward and Wiedmann (1983) have also found *Pachydiscus* in the highest Maastrichtian levels of Spain. Along with this, *P. ultimus* n.sp. is also present in the last ammonite bearing horizon in Seymour Island, and could well represent the uppermost Maastrichtian as suggested by palynological data (Askin, personal communication, 1983), and glauconite ages (Appendix B).

Other ammonites found in this zone include: *Maorites densicostatus*, *M. suturalis*, *Diplomoceras lambi*, *Grossouvrites gemmatus*, *Kitchinities laurae*, *Anagaudryceras cf. mikobokense*, *Pseudophyllites loryi*, and *Zelandites* sp.

It is very interesting to note the presence of large numbers of juvenile specimens of *Maorites* spp. and *Grossouvrites*, usually excellently preserved, at the top of the *P. riccardii* Zone. Wiedmann (1969) also found a large number of small specimens (that he considered as dwarfs) close to the K/T boundary. According to Wiedmann (1969) this occurrence was an anticipation of the final extinction of the group at the end of the Maastrichtian. Birkeland (1979) also found a large number of juvenile ammonites at the top of the Maastrichtian in Denmark, but she ascribed this occurrence to changing ecological conditions caused by the regression of the sea. The preferred interpretation for the presence of small ammonites near to the K/T boundary on Seymour
Island, is that they are represent hatching grounds in the more off-shore portion of the basin. Regardless of the final explanation for this appearance of juvenile specimens close to the K/T boundary, it is quite puzzling to find a similar record in a place as distant from Denmark as Seymour Island.

These age determinations coincide with micropaleontological data. Huber (1984) described a rich foraminifera fauna including more than 120 species. Among the stratigraphically important taxa are the globigerinids Hedbergella holmdelensis Olsson, Globigerinelloides multispinatus (Lalicker), Globotruncanella monmouthensis (Olsson), G. havanensis (Voorwijk), Rugoglobigerina rugosa (Plummer), R. rotundata Bronnimann, R. macrocephala Bronnimann, Heterohelix glabrans (Cushman), and Guembelitria cretacea Cushman. These species have an age range extending from the late Campanian to the Maastrichtian. Nevertheless, according to Huber et al. (1983), this fauna has its maximum affinities with Maastrichtian assemblages from the Magalilies Basin, the Malvinas (Falkland) Platform (Sliter, 1976), and New Zealand (Webb, 1971). The calcareous-nannofossils, studied by Harwood (in Huber et al., 1983) are particularly diagnostic. The co-occurrence of Nephrolitus corystus Wind and N. frequens Gorka at 640 m. from the base of the Seymour Island sequence (in the Pachydiscus ootacodensis Zone), indicates a middle Maastrichtian age (cf. Wind, 1983). At 880 m. from the base, the co-occurrence of N. frequens and Braarudosphaera turbinae Stradner (and approximately 60 m below the Pachydiscus riccardi Zone) indicate a late Maastrichtian age.
Radiometric dating of glauconites from the Lopez de Bertodano Formation yielded ages of 64.1 ± 0.9 my (Sample 153, located in the upper part of the Pachydiscus riccardi Zone), and 58.9 ± 1.0 my (Sample 411, collected from the glauconite immediately overlying the K/T boundary)(Cf. Appendix B). Evidently these ages are artificially young, as is frequently the case with this radiometric method. Nevertheless a late Maastrichtian age is indicated for the highest ammonite-bearing horizon on Seymour Island. The large difference in age found in the glauconite above the K/T boundary could be indicating that this boundary represents a non-depositional event, but this will have to be tested with additional age determinations along the boundary.

CONCLUSIONS

A marked endemicity in the ammonite faunas is recognized in the Weddellian Province during the late Campanian and the Maastrichtian. This is particularly true in the case of the family kossmaticeratidae which is almost restricted to this province during this interval. For this reason, species of the cosmopolitan genus Pachydiscus, have been used to subdivide the Cretaceous sequence of Seymour Island. On this basis the age of the Lopez de Bertodano Formation is also revised, comprising in Seymour Island a time span extending from the latest Campanian-earliest Maastrichtian, to the Paleocene (instead of late Campanian to possibly Maastrichtian as previously believed). The typical species Maorites densicostatus, which is very abundant in Seymour Island and Patagonia, is now considered to be representative of
a Maastrichtian age. However, there are still problems to solve, such as the presence of *Maorites* in Vega Island, co-occurring with *Eupachydiscus grossouvrei* which is an index fossil for the middle Campanian in Madagascar (Collignon, 1970); the association of *M. densicostatus* and *M. tenuicostatus* with *Anapachydiscus patagonicus* and *Baculites duhartei* in the Rio Sur profile in Tierra del Fuego; the presence of *M. seymourianus* and *M. densicostatus* together with *Anapachydiscus steinmanni* (thought to represent a lower Campanian age) in the Cerro Toro Formation (Fig. 151).

*Gunnarites* occupies a lower stratigraphic level than that of *Maorites*, and thus its age in Antarctica is restricted to levels believed to be Campanian in age; however an apparently different range exist in the Isla Riesco-Brunswick Peninsula area where this genus was found above foraminifera indicative of a late Maastrichtian age.
LATE CRETACEOUS STRATIGRAPHY, SEDIMENTOLOGY, AND
MACROPALEONTOLOGY OF SEYMOUR ISLAND,
ANTARCTIC PENINSULA
VOLUME II

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Carlos Enrique Macellari, Lic., M.Sc.

* * * * *

The Ohio State University
1984

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<td>360</td>
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<tr>
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<td>375</td>
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<td>375</td>
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<td>375</td>
</tr>
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CHAPTER IX

SYSTEMATIC DESCRIPTIONS

Phylum ANNELIDA Lamarck, 1809
Class POLYCHAETIA Grube, 1850
Family SERPULIDAE Burmeister, 1837
Subfamily SPIRORBINAE Chamberlin, 1919

Genus *Rotularia* Defrance, 1827

*Type species*—*Rotularia spirulaea* (Lamarck, 1818, p. 366), (by subsequent designation, Wrigley, 1951, p. 184).

*Shell structure*—The morphology of the shell was treated by Wilckens (1910), Wrigley (1951), and in more detail by Schmidt (1955), Ball (1960) and Regenhardt (1961). As discussed by Wrigley (1951) the original composition of the tube was calcitic. Only very minor signs of recrystallization were observed in the specimens studied. Schmidt (1955) and Ball (1960) showed that the wall tube of *Rotularia* is composed of a thin inner structureless layer and a thick outer lamellar layer. In most longitudinal sections the lamellae are arranged concentrically around the tube, but in many cases a complex pattern is observed, wherein the lamellae radiate almost perpendicularly from the tube wall (Plate 1). In horizontal sections the distinctions of the different layers are more apparent. The outer wall of the tube is
composed of a clear outer lamellar layer, which is rursiradiate (i.e. the lamellae are backward projecting). At a variable distance from the external margin (close to the external margin in R. (Rotularia) shackletoni and to the internal margin in R. (Australorotularia) spp. (Ball, 1960)) the lamellae display a sharp bend and are prorsiradiate (i.e. forward projected) relative to the lumen of the tube. In R. (Australorotularia) spp. this zone of prorsiradiate lamellae is thin, darker, and apparently composed of more numerous lamellae than the more external rursiradiate lamellae. A dark, inner structureless layer follows inward from the lamellar layer with its two subdivisions, but it may be partially absent due to preservation factors. The inner wall of the tube is composed of the inner structureless layer and a lamellar layer that is prorsiradiate.

Geologic Range—Rotularia ranges from the Upper Lias to the Eocene (or ?Lower Oligocene), and has a world-wide distribution (Ball, 1960).

Subgenus Rotularia (Australorotularia) Macellari, 1984

Type species—Rotularia (Australorotularia) callosa (Stoliczka, 1868), by original designation.

Diagnosis—Planispiral to conispiral tube of highly variable shape; coiling dominantly sinistral but sometimes dextral. Tricarinate keel present in the juvenile, adult, or in both stages. Tube commonly thickened by an external callosity. In well preserved specimens the tube extends tangentially to the last whorl.
Remarks—Regenhardt (1961) proposed the subgenus Rotularia (Tectorotularia) for those species that have a tube with a polygonal outline, and used Rotularia (Rotularia) for those species with a rounded outline. Ball (1960) considered the presence of a tricarinate keel as a specific characteristic of R. callosa (Stoliczka). Following this criterion he included all Antarctic specimens displaying this ornamentation within this species. Ball (1960) also included Rotularia fallax (Wilckens), from the Antarctic Peninsula, R. ornata (Wilckens) from the Lower Amuri Group of New Zealand, R. ornata and R. andina (Camacho) from the Hito XIX Formation in Tierra del Fuego and Rotularia sp. from Alexander Island within R. callosa (Stoliczka). As a result of this synonymy the stratigraphic range of R. callosa (Stoliczka) extended from the Aptian (Alexander Island and Tierra del Fuego) to the Maastrichtian (New Zealand). However, Stevens (1967) and Fleming (1971) preferred to maintain R. ornata (Wilckens) as an independent species.

The present study reports the presence of four different species with almost mutually exclusive stratigraphic occurrences. All specimens display a tricarinate keel, but are clearly distinguished on the basis of other morphologic criteria. The tricarinate keel that is present in several different species of Rotularia is a supraspecific character and thus justifies the creation of a new subgenus.

Chiplonkar and Tapaswi (1973) considered that Rotularia callosa should be included within the subgenus Tectorotularia. In my opinion R. (Australorotularia) should include all species with a tricarinate keel, whereas R. (Tectorotularia) should be used for species with other polygonal outlines. R. (Rotularia) includes species with a rounded
outline such as R. (Rotularia) phillipsii (Roemer) from the lower Cretaceous of Germany, England and Argentina (Weaver, 1931; Regenhardt, 1961; Ware, 1975), and R. (Rotularia) gregaria (Etheridge) from the upper Cretaceous of West Australia (Regenhardt, 1961). Wilckens (1910) included Burtinella Morsh as a subgenus of Tubulostium (=Rotularia). The systematic affinities of Burtinella were discussed by Gardner (1939) and more fully by Schmidt (1955). This last author concluded that Rotularia and Burtinella are not synonyms and that the latter should be included in the gastropod family Vermetidae. In conclusion, Burtinella is not a valid subgenus of Rotularia.

The range of R. (Australrotularia) extends from the Aptian to the Maastrichtian. The subgenus is presently known only from the Mesozoic Southern Hemisphere, with the exception of one record in the late Cretaceous of Japan (Yabe and Nagao, 1928).

Rotularia (Australrotularia) fallax (Wilckens), 1910
(Plate 1, figs. 1,6; Plate 2, figs. 1-10)

Tubulostium callosum Stoliczka, Weller, 1903, pp. 416-17, Pl. 1, figs. 6-17.

Tubulostium fallax Wilckens, 1910, pp. 7-11, Pl. 1, figs. 3a-c, 4a-c

Rotularia callosa (Stoliczka), Ball, 1960 (in part), pp. 17-23, Pl. V, figs. 1 a-c, 2 a-c, 3 a-c, 5 a-c, 6 a-c, 8 a-c, 9; Pl. VI, figs. 1 a-c, 3 a-c. Not Pl. VI, fig. 6 a-c, 7 a-c.

Rotularia (Australrotularia) fallax (Wilckens), Macellari, 1984, pp. 1105-1108; Fig. 6 A,F; 7 A-DD.
Lectotype—Tubulostium fallax Wilckens 1910, Pl. 1, Fig 3 a–c, (housed in the Naturhistoriska Riksmuseet, Stockholm, An 27).

Type locality—Snow Hill Island.

Material—42 specimens from Snow Hill and Seymour Island.

Supplementary description—Conispirally and planispirally, sinistrally coiled tube with a high diameter to height ratio (mean D/H: 2.52), which results in a relatively flat shape. Tube displays three well defined carinae, which are separated by broad depressions. The central carina is much more expanded than the other two. In the last portion of the last whorl of many specimens a constriction is observed after which the callosity of the tube increases, and the growth lines are much more evident and spaced. Both dorsal and umbilical carinae are separated from the thicker and usually convex dorsal and umbilical callosities by a small depression that ends in a furrow, which defines the contact between those two parts of the tube. In general the umbilical side is flatter than the dorsal side. Most individuals have three and one-half whorls.

Measurements—

<table>
<thead>
<tr>
<th># Specimen N.</th>
<th># Diameter</th>
<th>Height</th>
<th># D/H</th>
<th># Locality</th>
<th># Pl.2, Fig.#</th>
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<td># S:</td>
<td># 21.5</td>
<td># 5</td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
</tbody>
</table>
Localities—Southwestern portion of Seymour Island (localities 6, 16 and 88), also Snow Hill, James Ross and Vega islands, and Humps Islet. During the second field season was found in stations 386 and 387, on the southwest coast of Seymour Island.

Remarks—The specimens collected from the lower portion of the Lopez de Bertodano Formation on Seymour Island and on Snow Hill Island, are identical to those figured by Wilckens (1910) from Snow Hill, and to several of Ball’s (1960) figures. A large collection with very well preserved specimens of this species is kept in the Naturhistoriska Riksmuseet, mostly from Snow Hill Island. Wilckens (1910) differentiated this species from R. (Australorotaria) callosa (Stoliczka) based on the smaller height of R. (Australorotaria) fallax, the absence in this species of the callosity which occurs on the earlier whorls of R. (A) callosa and the difference in the mode of coiling (dextral and sinistral in R. (A.) callosa and only sinistral in R. (A.) fallax). Ball (1960) rejected this last criterion because no quantitative assessment of the percentage of dextral and sinistral individuals was specified by Stoliczka (1868). Ball further commented that many serpulids display both left and right coiling. In a more recent paper, Chiplonkar and Tapaswi (1973) described six specimens from the Utatur Group of India. Even though these authors did not specify the percentage of each type, some of their specimens are sinistrally coiled and some are dextrally coiled (for example, Pl. IX, fig. 9). Contrary to Ball’s (1960) statement, the type of coiling is a criterion used in recognizing some recent serpulid species (cf. De Silva, 1967). In conclusion, R. (Australorotaria) fallax differs from R. (Australorotaria) callosa by
its mode of coiling (only sinistral), by the more prominent development of the three peripheral carinae, and also by the smaller number of whorls (three and one half vs four and one half in some of Stoliczka's (1868) specimens). *R. (Austrorotaria) callosa* described by Yabe and Nagao (1928, Pl. XVI (1), figs. 14 and 15) from the Trigonia Sandstone (?) of Japan, shows three well developed peripheral carinae, but the shell consists of four to five whorls. The figured material is too poorly preserved to make a more detailed comparison.

**Rotularia (Austrorotaria) tenuilaevi** Macellari

(Plate 1, figs. 2,3,7; Plate 3, figs. 1-8; Plate 5, figs. 8-10)

**Rotularia (Austrorotaria) tenuilaevi** Macellari, 1984, pp. 1108-1110;

Figs. 6 B,C,G; 8 A-X; 9 E-H.

**Holotype**--OSU,36661.

**Paratypes**--OSU 36662; OSU 36663; OSU 36664; OSU 36665; OSU 36666; OSU 36667; OSU 36668.

**Type locality**--Seymour Island

**Material**--180 specimens, mostly very well preserved.

**Diagnosis**--Sinistrally coiled; tube covered by a relatively thin callosity; three carinae on the juvenile and adult portions of the shell. Carinae faintly developed and gradually continued onto dorsal and umbilical margins, resulting in an overall relatively acute periphery. In adult forms the last one-third of the outside whorl
usually strongly overlaps previous whorls, and its margin is tangential to the juvenile portion of the shell, which as in other Rotularia species, is always broken. Observed specimens are composed of three and a half whorls.

**Measurements**

<table>
<thead>
<tr>
<th># Specimen N.</th>
<th># Diameter</th>
<th>Height</th>
<th># D/H</th>
<th># Locality</th>
<th># Pl.3, Fig.#</th>
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<td># 91</td>
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<td># 2.77</td>
<td># 167</td>
<td># 8a-c</td>
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</tbody>
</table>

X: # 201.9 # 88 # 2.31 #
S: # 21 # 8 # #

**Localities**—Seymour Island, stations 19; 25; 30; 32; 37; 42; A; 107; 142; 163; 164; 166; 167. Several hundreds more specimens were collected during the second field expedition, but are not included in this study. Stations were this species was found in the second expedition are: 390; 392; 393; 418; 420; 421; 422; 424; 425; 426; 427; 428; 432; G-83; K-84; L-84; and M-84.

**Remarks**—Both conispiral and planispiral specimens are present. In many cases the juvenile portions of the individual are conispiral but become planispiral in the adult portion. This characteristic is clearly shown in thin sections (Plate 1, figs. 2,3). This species differs from R. (Australrotularia) fallax in that its shell is more inflated, has a relatively rounded margin and particularly in its less developed peripheral carinae. It can be distinguished from the shell of R.
(Austrorotularia) callosa because all specimens of R. (Austrorotularia) tenuilaevis are sinistrally coiled, are more compressed and their shell margins are less rounded. The number of whorls observed in shells of this new species is always three and one-half, whereas at least some specimens of R. (Austrorotularia) callosa (cf. Stoliczka, 1868, Pl. XVIII, Fig. 26) with four and one-half whorls are known. The shell of R. (Austrorotularia) ornata (Wilckens) does not show the three carinae in its adult portion and is generally smaller.

Rotularia (Austrorotularia) zinsmeisteri Macellari

(Plate 1, fig. 4, 5, 11; Plate 4, figs. 1-8; Plate 5, figs. 5-7)

Rotularia (Austrorotularia) zinsmeisteri Macellari, 1984, p. 1111; Figs. 6 D, E, K; 9 A-D; 10 A-X.

Holotype--OSU 36669
Paratypes—OSU 36670; OSU 36671; OSU 36672; OSU 36673; OSU 36674; OSU 36675; OSU 36676.

Type locality—Seymour Island.

Material—66 specimens, mostly well preserved.

Diagnosis—Shell planispiral to conispiral, moderately inflated, sinistrally coiled. Three peripheral carinae, about equally developed and separated by marked depressions, are present from the early stages of development (Plate 1, fig. 4). In the adult shell the three carinae form a prominent central ridge, and the umbilical and dorsal sides
become almost symmetrical displaying a thick, angular callosity. In
cross section the adult portion of the tube has a characteristic
three-pointed outline (Plate 1, figs. 4,5).

**Measurements—**

| # Specimen N. | # Diameter # Height # D/H | # Locality | # Pl. 4; Fig. # |
|--------------|---------------------------|--------------------|
| OSU 36669    | 188 # 108 # 1.74          | 45                 | 1a-c          |
| OSU 36670    | 221 # 127 # 1.74          | 143                | 2a-c          |
| OSU 36671    | 190 # 85 # 2.24           | 45                 | 3a-c          |
| OSU 36672    | 182 # 82 # 2.22           | 45                 | 4a-c          |
| OSU 36673    | 185 # 97 # 1.91           | 45                 | 5a-c          |
| OSU 36674    | 146 # 81 # 1.80           | 45                 | 6a-c          |
| OSU 36675    | 183 # 87 # 2.10           | 143                | 7a-c          |
| OSU 36676    | 189 # 97 # 1.95           | 45                 | 8a-c          |
| X:           | 185.5                  | 95.5 #1.96         |                |
| S:           | 20                     | 16                 |                |

**Localities—** Seymour Island, Stations 42; 45; 47; 60; 142; 143; 145;
172; 175; 185; Loc. F. Even though the material is not included in this
study, during the second expedition this species was found in stations
321; 383; 384; 394; and 423.

**Remarks—** The presence of a central ridge bearing three well-
developed carinae, clearly distinguishes the shell of this species from
those of previously described species. The immature portions of the
shell have a tendency to display a conispiral mode of coiling which
becomes planispiral in the adult. The three peripheral carinae are
observed throughout, but the central ridge and the tricuspidate outline
becomes more prominent in the adult stages, mainly due to a pronounced
increase in callosity in the umbilical and dorsal sides. This species
consistently has a lower diameter to height ratio (mean D/H=1.96) than
either R. (Australorotularia) fallax (X=2.54) or R. (Australorotularia)
tenuilaevi (X=2.31).
Rotularia (Austrorotularia) sp.

(Plate 1, Figs. 8-10; Plate 5, Figs. 1,2,3,11)

Rotularia (Austrorotularia) sp., Macellari, 1984, pp. 1111-1114; Figs. 6 H, I, J; 9 I; 11 A-I.

Material—38 specimens ranging from poor to moderately well preserved.

Description—Sinistral, planispiral and less frequently conispirally coiled specimens. Younger portions of the shell are conispiral and later become planispiral. Growth lines are strongly rursiradate. Moderate to very thick calllosities are developed on the dorsal and umbilical portions of the shell. The three carinae characteristic of Austrorotularia are only faintly indicated; in many specimens they are impossible to distinguish and only a rounded broad central ridge is present. On a lateral view the shell tends to be symmetrical with rounded umbilical and dorsal portions and a more expanded and rounded central ridge.

Measurements—

<table>
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<th># Specimen N.</th>
<th># Diameter</th>
<th># Height</th>
<th># D/H</th>
<th># Locality #</th>
<th>Pl. 5; Fig. #</th>
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<td># 13</td>
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</table>

Localities—Seymour Island, stations 61; 68; 117; 153; 156; 160; 185; 186; 459. Additionally several hundreds more specimens were collected during the second expedition from the following stations: 322;
320
323; 324; 326; 327; 328; 329; 332; 336; 337; 340; 341; 342; 343; 347;
350; 356; 357; 359; 360; 363; 366; 367; 368; 369; 371; 372; 373; 377;
378; 397; 400; 401; 409; 410; 412; St. 5; St. 7; B-83; C-83; D-83; E-83;
and N-84.

Remarks—I have not given these specimens a formal name because
there is a large range of variations, which might be a matter of
preservation. The true range of variation will be determined after the
study of the extensive collection now available from the second
expedition.

These specimens resemble _R. (Australotularia) ornata_ (Wilckens)
from the Mata Series of New Zealand, in the absence of the three
peripheral carinae in the adult stages and in the lateral outline, which
has three rounded portions. After examining several specimens from New
Zealand, it is observed that _R. (Australotularia) sp._ differs from _R._
(Australotularia) _ornata_ by the diameter to height ratio (mean D/H: 1.98
in the former and X: 2.62 in the latter). Also _R. (Australotularia)_
sp., as well as all the other Antarctic species described here, are much
larger than the New Zealand species. Furthermore, in _R._
(Australotularia) sp. the three carinae are faintly developed in the
early growth stages (Plate 1, Figs. 8-10) whereas in _R. (A.) ornata_ sharp
carinae are observed in the early stages of development (also cf.
Stevens, 1967).

_R. (Australotularia) sp._ is similar to "_Tubulostium ornatum_"
Wilckens described by Camacho (1949) from the Aptian of Tierra del Fuego
and to _Rotularia "callosa_" (Stolpichka) figured from the same beds by
Macellari (1979). However, the specimens in these two works are identical and belong either to a new species or might be included in \textit{R. (Australorotularia) andina} (Camacho). The difference between \textit{R. (Australorotularia)} sp. and the \textit{Rotularia} from Tierra del Fuego is the presence in the latter of slightly curved, profound radial constrictions which cross the umbilical and dorsal callosities.

**Subgenus Rotularia (Rotularia) Regenhardt, 1961**

\textit{Rotularia (Rotularia) shackletoni} (Wilckens), 1910

(Plate 5, Figs. 4a,b)

\textit{Serpula (Burtinella?)} shackletoni Wilckens, 1910, pp. 6-7; Pl. 1, figs. 1, 2 a-c.

\textit{Rotularia shackletoni} (Wilckens), Ball, 1960, pp. 23-25; Fig. 4b; Pl. IV, figs. 1a, b; Pl. VII, figs. 6-12.

\textit{Rotularia shackletoni} (Wilckens), Medina and Del Valle, 1980, p. 103, Fig. 4 a-c, e-g, i-j.

\textit{Rotularia (Rotularia) shackletoni} (Wilckens), Macellari, 1984, p. 1114; Figs. 11 J, K.

**Types**—Syntypes in the collection of the Naturhistoriska Riksmuseet in Stockholm (An 19 and 20), designated by Ball (1960).

**Material**—40 specimens in an excellent degree of preservation.

**Supplementary description**—Large (up to 4.3 mm in diameter),
planispirally to conispirally coiled shell. Tube circular with thick
irregular callosities which become more prominent at the whorl sutures.
Juvenile portion of the tube and some adult specimens with a flat
preipheral ridge moderately developed. Growth lines irregular, projected
backward. Among 40 specimens studied, 42.5% are dextrally coiled and
57.5% are sinistrally coiled. Additional descriptions in Wilckens (1910)
and Ball (1960).

Measurements—

<table>
<thead>
<tr>
<th># Specimen N</th>
<th>Diameter</th>
<th>Height</th>
<th>D/H</th>
<th>Locality</th>
<th>Pl. 5, Fig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSU 36680</td>
<td>413</td>
<td>214</td>
<td>1.93</td>
<td>E</td>
<td>4a-b</td>
</tr>
</tbody>
</table>

Mean values of all available specimens: X: 308 214 1.44
S: 56 41

Localities—Seymour Island, stations E; F; B; 41; 105; 106; 142;
144; 145; 147; 180; 181; 317; 333; 368; 383; 384; 390; 392; 394; 421;
422; 423; 428; 429; 432; St. 5; B-83; F-83; K-84; M-84. The Naze (James
Ross Island), coast east of Lachman Craggs, James Ross Island (Ball,
1960); Robertson Island (Medina and Del Valle, 1980); Cockburn Island
(Wilckens, 1910).

Remarks—This typical species was first described by Wilckens
(1910) as *Serpula (Burtinella?)* shackletoni. However, it clearly
belongs to the genus *Rotularia*, which as discussed previously is not a
synonym of the gastropod genus *Burtinella*.
Class CEPHALOPODA Cuvier, 1797

Subclass NAUTILEOIDEA Agassiz, 1847

Family NAUTILIDAE de Blainville, 1825

Genus Eutrephoceras Hyatt, 1894

Type species—Nautilus dekayai Morton, 1834, by original designation.

Eutrephoceras simile Spath

(Plate 5, Figs. 12, 13a,b)

Nautilus blanfordianus Kilian and Reboul, 1909, p. 8, Pl. 1, figs. 1-2.

Eutrephoceras simile Spath, 1953, p. 40, Pl. 12, fig. 4; Pl. 13, figs. 1-5.

Eutrephoceras simile Spath, Hunicken, 1965, p. 50-53, Pl. 1, figs. 1-4; Pl. 7, fig. 5.

Holotype—Eutrephoceras simile Spath, 1953, Pl. 15, fig. la,b

Material—Ten specimens from Seymour Island; one from The Naze, James Ross Island; one from Vega Island. Several isolated air chambers.

Supplementary description—Involute species with reniform whorls that are much wider than high. Umbilicus closed by a callosity. Siphuncle central, one third of the whorl beneath the venter, slightly closer to the dorsum in juveniles. Suture almost straight with a distinctive backward bend in the umbilical region. Ornamentation
composed of weak numerous radial striæ that are deflected backward when crossing the venter. Younger specimens with a reticulate ornamentation resulting from the intersection of the radial pattern with the longitudinal lyrae. Shell completely smooth when the external layer is removed.

Remarks—There is a close agreement between these specimens and those figured and described by Spath (1953), and Hunicken (1965).

Localities—Seymour Island, stations 117; 145; 153; 347; 357; 399; 427; locs. B; F, and K-84. Present also in James Ross and Vega islands.

Stratigraphic distribution—This species has a long stratigraphic range, and in Seymour Island extends to the last ammonite horizon (contact between units 9 and 10 of the Lopez de Bertodano Formation.

Subclass AMMONOIDEA Zittel, 1884
Superfamily LYTOCERATACEAE Neumayr, 1875
Family TETRAGONITIDAE Hyatt, 1900
Subfamily GAUDRYCERATINAE Spath, 1927
Genus Anagaudryceras Shimizu, 1934

Type species—Ammonites sacya Forbes, 1846, by original designation of Shimizu, 1934, p. 67.

Anagaudryceras cf. mikobokense Collignon

(Plate 6, Figs. 1-4; Text-Figs. 160, 161, 162)

Lytoceras (Gaudryceras) varagurense Kossmat, Kilian and Reboul, 1909, p.
Figure 160-- Suture line and cross-sections of *Anagaudryceras cf. mikobokense* Collignon.

Figure 161-- Suture line of *Anagaudryceras cf. mikobokense* Collignon.
12-13, Pl. I, fig. 6.


cf. *Gaudryceras* *politissimum* Collignon, 1938, p. 92, Pl. 7, fig. 2-2a.

cf. *Anagaudryceras mikobokense* Collignon, 1956, p. 59, P. 8, fig. 1, la-b.


cf. *Anagaudryceras mikobokense* Collignon, Matsumoto, 1959b, p. 139-41, Pl. 38, fig. 1a-c; Text-fig. 70.

cf. *Anagaudryceras mikobokense* Collignon, Howarth, 1965, p. 358-60, Pl. 4, figs. 1-3; Text-fig. 1.

**Material**—Three specimens, one very well preserved, and with portions of the original shell material.

**Description**—Shell of medium to very large size with a wide umbilicus and displaying an increase in the degree of involution from the juvenile to the adult stages (Fig. 162). Whorl section more wide than high in the young stages (up to a diameter of approx. 40 mm), but later the height exceeds the breadth after a diameter of 65 mm or more. External surface almost smooth, with the exception of very fine lyrae, only visible with a hand lense. After a diameter of approximately 100 mm the shell bears very subtle onduations that have a typical gaudrycerid pattern. Constrictions are frequent (5-6 per whorl) in diameters smaller than 130 mm, disappearing latter. Constrictions are
Figure 162-- Graph showing the relation of Umbilical Diameter vs. Diameter, in several specimens of *Anagaudryceras cf. mikobokense* Collignon.
rectiradiate in the earlier stages and become more falcate in the later stages. Suture like *Gaudryceras*, with four saddles (three in the flank). Latteral saddles bifid, with each end divided again, giving rise to quadrifid saddles (Figs. 160-161).

**Measurements**

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
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<td>15.14</td>
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<td>--</td>
<td>4.23</td>
<td>32</td>
</tr>
<tr>
<td>+153-2</td>
<td>7.77</td>
<td>3.14</td>
<td>2.84</td>
<td>0.90</td>
<td>2.90</td>
<td>37</td>
</tr>
<tr>
<td>S.I.-1</td>
<td>8.97</td>
<td>3.67</td>
<td>3.40</td>
<td>0.93</td>
<td>3.21</td>
<td>36</td>
</tr>
</tbody>
</table>

+ Phragmacone

(D= diameter; H= whorl height; W=Whorl width; U=umbilical diameter)

**Remarks**—Wright and Matsumoto (1954, p. 113) defined *Anagaudryceras* by its fine and weak ornamentation (much more so than in *Gaudryceras* Grossouvre), which is not markedly sinuous on the sides or shoulders. Collignon (1956, p. 47) defined *Anagaudryceras* as a very evolute form, higher than wide, with the umbilical walls almost vertical, finely ornamented, with radial riblets, sometimes only visible under a magnifying lense, and a suture with three saddles on the flanks and a large suspensive lobe.

Howarth (1965, p. 358)(and later discussed by Kennedy and Klinger, 1979, p. 146) recognized two basic groups within *Anagaudryceras*: one with strong fold-like ribs on the body chamber, exemplified by *Anagaudryceras buddha* (Forbes) (=*A. sacya* (Forbes)); and the other only having weak constrictions and more compressed in later growth. *A. mikobokense* Collignon was included in this second group.
The new material collected on Seymour Island is identical to the specimen figured by Kilian and Reboul (1909, Pl. I, fig. 6). These authors included their specimen in Gaudryceras varagurense Kossmat on the assumption that the stronger ribs characteristic of this species were weathered. Two of the new specimens have portions of the original shell preserved in different parts. The ornamentation observed here is composed of fine lyrae, usually not distinguishable with the naked eye, and somewhat more rectiradiate than the constrictions. These specimens are very similar to the holotype of Anagaudryderas mikobokense (in Collignon, 1956, Pl. 8, fig. 1, 1a-b) as well as to the specimen figured by Howarth (1965 Pl. 4, figs. 1-3) from Angola. The ontogenetic change towards a greater degree of involution and more compressed whorl section is clearly defined in my specimens (Figs. 160 and 162). However, they differ slightly from the typical Anagaudryceras because the constrictions in the larger diameters are more projected across the venter and they seem to be less numerous in the ventral region than what it is observed either in the holotype or in Howarth's specimen.

These specimens show intermediate characteristics between Gaudryceras (because of the shape of the constrictions) and Anagaudryceras, because of their almost lack of ornamentation and change in whorl shape. The ornamentation in this species, however, is much weaker than in any known species of Gaudryceras, including G. denseplicatum and its subspecies denseplicatum, tenuillratum and intermedium (in Hirano, 1978, Pls. 33-35).

Localities—Seymour Island, K-153 (two specimens) and S.I. (float).
During field work in 1983/84, several additional specimens were collected, including a large individual, 67 cm in diameter. The new localities are: 329; 330; 333; St. 6.

Stratigraphic distribution—Lopez de Bertodano Formation, *Pachydiscus ricardi* to *P. ultimus* zones (middle to late Maastrichtian). *Anagaudryceras mikobokense* was originally described from the lower Maastrichtian of Madagascar (associated with *Pachydiscus gollevillensis* (d'Orbigny)(Collignon, 1956), and latter from the lower Maastrichtian to possibly highest Campanian of California (Matsumoto, 1959b) and from the upper Campanian of Angola (Howarth, 1965).

Genus *Zelandites* Marshall, 1926

Type species—*Zelandites kaiparaensis* Marshall, by original designation of Marshall, 1926, p. 147.

*Zelandites* sp. cf. *Z. varuna japonica* Matsumoto

(Plate 7, Figs. 7,8)

cf. *Zelandites varuna* (Forbes) var. *japonica* Matsumoto, 1938, p. Fl. 14, figs. 5a-b; 6a-b; 7a-c; text-fig. 1a-d.

Material—Three well preserved specimens.

Description—Shell small, involute, with narrow and impressed umbilicus. Whorl section compressed with flanks converging towards an acute venter. Maximum width near to the umbilicus. Young stages
totally smooth, two or three constrictions per whorl developing after a
diameter of 2.5 cm. Constrictions moderately incised in the middle of
the flank, disappearing towards the venter. Shell almost smooth, with
only weak lirae following the shape of the constrictions. Suture not
observed.

**Dimensions—**

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>411-1</td>
<td>3.26</td>
<td>1.80</td>
<td>1.13</td>
<td>0.63</td>
<td>0.50</td>
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<tr>
<td>St.5-1</td>
<td>2.81</td>
<td>1.50</td>
<td>0.96</td>
<td>0.64</td>
<td>0.43</td>
<td>0.15</td>
</tr>
<tr>
<td>St.5-2</td>
<td>2.47</td>
<td>1.43</td>
<td>0.86</td>
<td>0.60</td>
<td>0.46</td>
<td>0.18</td>
</tr>
</tbody>
</table>

**Remarks—** These specimens are the first record of *Zelandites* in
Antarctica. They differ from *Z. kaiparaensis* Marshall from New Zealand
by their smaller number of constrictions, which are slightly flexuose
and not straight as in the New Zealand species (cf. Henderson, 1970).
These specimens are very similar to *Zelandites varuna* (Forbes) from
India (Forbes, 1846, p. 107, Pl. VIII, Fig. 5a-c), and Quiriquina
(Steinmann, 1895, p. 84; Pl. 5, fig. 2a,b), and might be proven
indistinguishable when better material from India is collected. The
maximum affinities are observed with *Z. varuna japonica* Matsumoto, which
is characterized by a more involute coiling, narrower umbilicus and more
compressed whorl section than the typical *Z. varuna*. Agreement with the
Japanese sub-species is not complete, because the adult antarctic
specimens display well developed sinuous constrictions that disappear
towards the venter. *Zelandites odiensis* (Kossmat) from South Africa
(i.e. Kennedy and Klinger, 1979, p. 163-164, Pl. 14, fig. 4) has a more
compressed whorl section, and the maximum whorl breadth is displaced more
to the venter than in the typical *Z. varuna*.
Stratigraphic distribution—Zelandites sp. cf. Z. varuna japonica is restricted on Seymour Island to the uppermost ammonite bearing horizon of the Pachydiscus ultimus Zone (uppermost Maastrichtian), Stations 411 and St. 5.

Genus Vertebrites Marshall, 1926

Type species—Vertebrites murdochii Marshall, 1926, by original designation (Marshall, 1926, pp. 138-139).

Vertebrites kayei (Forbes)
(Plate 6, Figs. 5-6)

Ammonites kayei Forbes, 1846, p. 101-2, Pl. 8, fig. 3
Ammonites kayei Forbes, Stoliczka, 1865, p. 156, Pl. 77, fig. 1.
Lytoceras kayei (Forbes), Steinmann, 1895, p. 86-88, Pl. 5, fig. 5a-b.
Lytoceras (Gaudryceras) kayei (Forbes), Kossmat, 1895-97, Pl. 16 (2), fig. 5a-b; Pl 17(3), fig. 2a-b.
?Lytoceras (Gaudryceras) kayei (Forbes), Kilian and Reboul, 1909, p.12
Gaudryceras kayei (Forbes) Woods, 1907, p. 335, P. 41, fig. 8a-b; Pl. 42, Fig. 2a-b.
Gaudryceras kayei (Forbes), Bose 1927, p. 269, Pl. 10, figs. 10-14; Pl. 11, figs. 5-10.
Vertebrites kayei (Forbes), Collignon, 1956, p. 64, Pl. 6, fig. 5a-b (not fig. 4a-c).
?Lytoceras (Gaudryceras) kayei (Forbes), Anderson, 1958, p. 182.
Lytoceras (Gaudryceras) coalingense Anderson, 1958, p.184, Pl. 68,
?Lytoceras (Gaudryceras) birkhaueseri Anderson, 1958, p. 185, P. 68, figs. 4-4a.

_Gaudryceras_ (Vertebrites) _kayei_ (Forbes), Matsumoto, 1959a, p. 146-147.
_Vertebrites kayei_ (Forbes), Collignon, 1971, p. 2, Pl. DCXL, fig. 2362.
_Vertebrites kayei_ (Forbes), Kennedy and Klinger, 1979, p.160-63, Fig. 5; Pl. 14, figs. 2a-c.

_Holotype—_British Museum C51050 (in Forbes, 1846, Pl. 8, fig. 3), from the Valudayur Group of Southern India. By monotypy.

_Material—_Two specimens very well preserved.

_Supplementary description—_Evolute species with whorl section more wide than high. Flanks rounded and venter broad; umbilical wall almost vertical but not as deeply incised as in _Saghalinites_. Available specimens composed of eight whorls. Ornamentation composed of very fine lyrae that are prorsiradiate near the umbilicus, but after a curve, become almost rectiradiate and more numerous near the venter. Last whorl has five constrictions which follow the pattern of the lyrae.

_Measurements—_

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
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<tbody>
<tr>
<td>BZ-1</td>
<td>3.95</td>
<td>1.30</td>
<td>1.40</td>
<td>1.08</td>
<td>2.05</td>
<td>52</td>
</tr>
<tr>
<td>H-1</td>
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<td>1.00</td>
<td>1.23</td>
<td>1.23</td>
<td>1.21</td>
<td>42</td>
</tr>
</tbody>
</table>

_Indian specimens_

<p>| | | | | | | |</p>
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<td>1.04</td>
<td>1.39</td>
<td>1.62</td>
<td>55</td>
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</tbody>
</table>

_Remarks—_This species was misidentified as _Anagaudryceras tennenti_
Henderson (in Macellari and Zinsmeister, 1983). However, there is no obvious change towards more compressed whorl sections in the latter stages of the shell. These specimens are identical to the original material from India, in ornamentation, cross section, and degree of involution, however, no body chambers are preserved in the Seymour Island specimens.

Vertebrites murdochii Marshall (i.e. Henderson, 1970, p.22, Pl. 3, fig. 1) has a more depressed cross section at corresponding growth stages, and apparently has a smaller number of whorls.

Localities—Seymour Island, Loc. H., the other specimen was collected on Seymour Island, but the exact procedence is not known. Additional specimens were found during the second expedition in stations 400 and N-83. Also Brandy Bay, James Ross Island (Malagnino et al., 1978)

Stratigraphic distribution—Lopez de Bertodano Formation, Baculites bailyi Zone (possibly lower Campanian) to Pachydiscus riccardi Zone. This species has been found in numerous Campanian and Maastrichtian localities of the world. In Quiriquina Island, Chile, it was found together with Eubaculites lyelli (d'Orbigny) (Hunicken and Covacevich, 1975), indicative of a Maastrichtian age.

Subfamily TETRAGONITINAE Hyatt, 1900
Genus Pseudophyllites Kossmat, 1895

Type species—Ammonites indra Forbes, 1846, by original designation
of Kossmat, 1895, p. 137.

**Pseudophyllites loryi** (Kilian and Reboul)

(Plate 7, Figs. 1-6)

?**Pseudophyllites indra** (Forbes), Kilian and Reboul, 1909, p. 14.

**Desmoceras (Latidorsella) loryi** Kilian and Reboul, 1909, p. 18, Pl. I, figs. 4-5.

**Pseudophyllites peregrinus** Spath, 1953, p. 7, Pl. 1, figs. 6, 7a-b, 8a-b, 9a-c.

**Pseudophyllites peregrinus** Spath, Collignon, 1956, p. 92, text-fig. 12.

**Pseudophyllites peregrinus** Spath, Hunicken, 1965, p. 53-55, Pl. 1, figs. 5-7, Pl. 7, figs. 3-4.

**Pseudophyllites peregrinus** Spath, Olivero, 1975, p. 26-28, Pl. 1, fig. 1a-c.

**Phyllopachyceras forbesianum** (d'Orbigny), Del Valle and Fourcade, 1976, p. 14-15, Pl. 3, fig. c.

**Lectotype**—**Desmoceras (Latidorsella) loryi** Kilian and Reboul, 1909, Pl. I, fig. 4-5. (Naturhistoriska Riksmuseet, Mo=1262), herein.

**Material**—six juvenile specimens very well preserved and one mature specimen imbeded in a concretion.

**Supplementary description**—**Pseudophyllites** of rounded to weakly subquadrate whorl section (mean W/H=0.99) and very involute. Umbilical slope steep, more so in the adults. Umbilicus narrow and deep. Shell
surface almost smooth with the exception of barely distinguishable very
delicate radial lirae, more distinct in adult specimens.

Measurements--

<table>
<thead>
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<th>Spec. N.</th>
<th>D</th>
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<td>1.02</td>
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<td>0.96</td>
<td>0.34</td>
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<td>2.11</td>
<td>2.32</td>
<td>1.10</td>
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\[ X = 0.99 \]
\[ X = 18 \]
\[ S = 0.09 \]
\[ S = 3 \]

Other measurements:

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<td>3.98</td>
<td>1.14</td>
<td>1.05</td>
<td>16</td>
</tr>
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</table>

*=lectotype
+=Spath's type of P. peregrinus.

Remarks--A revision of the original material of Kilian and Reboul
identified as Desmoceras (Latidorsella) loryi did not show a ventral
carinae as described by these authors (1909, p. 180), and this specimen
as well as another large one preserved in Stockholm belong to
Pseudophyllites. Pseudophyllites peregrinus Spath, from James Ross
Island and Humps Islet is considered a junior synonym of P. loryi.

This species is closely related, but more involute than either
Pseudophyllites latus (Marshall) (in Henderson, 1970, Pl. 1, fig. 10;
Pl. 2, fig. 3) from New Zealand, and P. skouli Birkeland (in Birkeland,
1965, Pl. 3, figs. 2-6) from the late Cretaceous of Greenland.

Most of the specimens from Seymour Island are juveniles where the
living chamber is also preserved. The unfigured specimen of
Pseudophyllites indra (Forbes)(in Kilian and Reboul, 1909, p. 14) was
not observed in the collection from the Swedish Expedition, but it is
assumed that it belongs to _P. loryi_ as the rest of the Antarctic specimens. Spath, 1953, differentiated this species from _P. indra_ because it has a more evenly rounded whorl section, a broader venter, and a vertical (not inclined) umbilical wall.

**Localities**—Seymour Island, BZ-458 (six specimens); 148; 340; 357; 360; Snow Hill Island (Kilian and Reboul, 1909); Dagger Peak, Lachman Crags South (James Ross Island), and Humps Islet (Spath, 1953).

**Stratigraphic distribution**—This species as it is the case with other species of this genus, has an extended stratigraphic range. The lowermost occurrence is in the _Baculites bailyi_ Zone (possibly lower Campanian) and the uppermost occurrence is in the _Pachydiscus riccardi_ Zone (possibly late Maastrichtian).

Superfamily TURRILITACEAE Meek, 1876

Family DIPLOMOCERATIDAE Spath, 1926

Genus Diplomoceras Hyatt, 1900

**Type species**—_Baculites cylindracea_ Defrance, 1816, by original designation, Hyatt, 1900 in Zittel, 1900, p. 571.

**Diplomoceras lambi** Spath

(Plate 8, Fig. 4, Text-figs. 163-164)

_?Hamites elatior_ Forbes?, White, 1890, p. 13, figs. 1-2.

_?Hamites elatior_ Forbes?, Weller, 1903, p. 418, Pl. II, fig. 3.

_?Hamites_ sp., Weller, 1903, p. 418, Pl. II, fig. 4.
Anisoceras notabile Whiteaves, Kilian and Reboul, 1909, p. 15, Pl. II, fig. 1, Pl. III, Pl. IV.

Diplomoceras lambi Spath, 1953, p. 17, Pl. 2, figs. 1-3, Pl. 3, fig. 1.


Diplomoceras lambi Spath, Del Valle and Rinaldi, 1976, p. 6-9, Pls. 1-10

Holotype—Diplomoceras lambi Spath, 1953, Pl. 3, fig. 1
(8M.C41400), from The Naze, James Ross Island.

Material—25 individual fragments, some more than 35 cm long, and usually with the original shell preserved.

Supplementary description—Shell of almost circular cross-section. Ornamentation composed of regularly spaced ribs that vary from straight to strongly oblique. The number of ribs at a distance on the flank equal to a diameter, varies from 10 to 16. Suture line with E relatively narrow; first lateral lobe (L) deep, bifid, and extended laterally. Antisifonal lobe less incised than L. The internal saddles are fused at the base to form a narrow stemmed saddle (Fig. 163).

Measurements—

<table>
<thead>
<tr>
<th>Spec.</th>
<th>N.</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>N. of ribs</th>
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<td>--</td>
</tr>
<tr>
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<tr>
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<td>1.00</td>
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</tr>
<tr>
<td>V-1</td>
<td></td>
<td>6.55</td>
<td>6.60</td>
<td>1.01</td>
<td>11</td>
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</tbody>
</table>

\[ X=0.99 \]
\[ S=0.02 \]
Figure 163-- Suture line of *Diplomoceras lambi* Spath (specimen H-1).

Figure 164-- Cross-sections of *Diplomoceras lambi* Spath.
Remarks—This species is directly related to Diplomoceras notabile Whiteaves, from Vancouver, Canada, and originally this material was included by Kilian and Reboul (1909) in this species. However, they differ in the shape of the cross-section (circular in D. lambi (Fig. 164), and slightly oval in D. notabile). Also the suture line in D. lambi has less finely divided terminations, particularly the terminations of the saddles which are broadly rounded and expanded in this species and much more pointed in D. notabile. This is particularly clear when comparing the suture line figured here with that figured by Jones (1963, Fig. 15).

The differences between D. notabile and D. cylindraceum (Defrance) from the Maastrichtian of Europe (i.e. Schluter, 1871-72, Pl. 31, fig. 10-11) are not clear and they might be synonyms (Whiteaves, 1903, p. 336). Diplomoceras australe Hunicken (Hunicken 1965, p. 67-70, Pl. 4, fig. 1) (as it was observed in a cast preserved in the British Museum), and D. notabile (in Laehen and Charrrier, 1972, Pl. 2, figs. 1-2) appear to be deformed, and they may represent flattened specimens of D. lambi. The status of D. lambi in relation to D. cylindraceum (Defrance) is not clear. If D. cylindraceum has also a circular cross-section (as implied by Birkeland, 1965, p. 67), then the antarctic specimens should be included in this species, which would be a senior synonym. The other difference mentioned between these two species by Spath (1953), was the smaller number of ribs in the European species (11 in a length equal to a diameter) but the new material here studied shows a ribbing pattern very similar to that of D. cylindraceum.
Localities—Seymour Island: 37-60; 41; 65; 99; 101; 160; 179; Loc. C; Loc. D; BZ(float); 322; 336; 338; 340; 347; 394; 400; 410; St. 5; St. 6; Vega Island: V-9; V-4, and also The Naze and Dagger Peak (James Ross Island)(Spath, 1953), and Snow Hill Island (Kilian and Reboul, 1909).

Stratigraphic distribution—Diplomoceras cylindraceous (the type species of the genus) was found in the Maastrichtian of Europe and its occurrence extends to the uppermost beds of the Maastrichtian chalk of Denmark (Birkelund, 1979). In Alaska, D. notabile was found in the Pachydiscus kamishakensis Zone of Jones (1963), believed to represent a lower Maastrichtian age. In the James Ross Basin this species has a long stratigraphic range, extending from the Gunnarites antarcticus Zone (Olivero, 1981) to the Pachydiscus ultimus Zone, and is abundant in the highest ammonite bearing horizon of Seymour Island.

Superfamily DESMOCRATAEAE Zittel, 1895
Family DESMOCRATIDAE Zittel, 1895
Subfamily PUZOSIINAE Spath, 1922
Genus Kitchinites Spath, 1922
Type species—Kitchinites pondicherryanus (Kossmat), by original designation of Spath, 1922.

Kitchinites (Kitchinites) darwini (Steinmann)

(Plate 7, Figs. 9-11; Plate 8, Figs. 1-3; Text-Figs. 165-168)

Puzosia darwini Philippi MS; Steinmann, 1895, pp. 73-74, pl. 5, fig.
Kitchinites-darwiní (Steinmann), Howarth, 1966, p. 59-61, Figs. 2 a-b, 3b, 4.

Kitchinites darwiní (Steinmann), Del Valle, Fourcade and Rinaldi, 1976, pp. 5-7 (in part), Pl. I; Pl. IV a,b; Pl. V,a.

Lectotype—Puzosia darwiní Steinmann, 1895, Pl. 5, figs. 3a,b, by subsequent designation of Howarth, 1966 p.60.

Material—18 specimens, mostly well preserved.

Supplementary description—Moderately evolute species with a compressed whorl section. Ribs incised in the ventral portion of the shell but disappearing towards the umbilicus. Ribs slightly prorsiradiate to rectiradiate in the ventral portion of the flank, but becoming strongly projected forward when crossing the venter. Approximately five deep constrictions are observed in the last whorl. The constrictions (which cut two or three previous ribs) are prorsiradiate but become much more so near the center of the flank. Suture complicated, with E/L saddle almost symmetrically bifid; L deep but not as deep as in Maorites. There is only a slight reduction in size from E/L to L/U, but after this saddle the umbilical elements become much smaller (Figs. 165, 166).

Measurements—

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
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<th>W/H</th>
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<th>U/D</th>
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<td>2.00</td>
<td>0.64</td>
<td>3.16</td>
<td>38</td>
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</tbody>
</table>
Figure 165-- Suture line of *Kitchinites darwini* (Steinmann). Spec. H-1.

Figure 166-- Suture line of *Kitchinites darwini*. Spec. 143-1.

Figure 167-- Cross-sections of *Kitchinites darwini* and *K. laurae*, n. sp.
<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
</tr>
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</tr>
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<td>0.79</td>
<td>5.10</td>
<td>37</td>
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<td>4.87</td>
<td>36</td>
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<tr>
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<td>3.79</td>
<td>2.20</td>
<td>0.58</td>
<td>3.44</td>
<td>34</td>
</tr>
<tr>
<td>Q. 536</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>3.89</td>
<td>37</td>
</tr>
<tr>
<td>Q-P</td>
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<td>2.68</td>
<td>0.58</td>
<td>4.00</td>
<td>35</td>
</tr>
</tbody>
</table>

+= phragmacone.
^= living chamber
BM= British Museum
Q= Quiriquina (Universidad de Concepcion)

Remarks.—The presence of *K. darwini* in the James Ross area was first reported by Howarth (1966) (Vega Island) and then by Del Valle, et al. (1976)(Seymour Island). Howarth (1966, p. 60) pointed out that the original specimens of *K. darwini* from Quiriquina, described by Steinmann (1895) could not be located in Europe or in Chile. I obtained several photographs and a cast of this species from the type locality (Fig. 167, QP), and except for a slightly more compressed section, other features of the shell are identical to those of the Antarctic specimens.

One of the specimens from Vega Island described by Howarth (1966, Fig. 3b and Fig. 4)(see Fig. 8a, BM C72791) has a more inflated whorl
section, particularly near the dorsal part of the shell. Additionally, the ribs are less incised than what is normally found in this species. Moreover, the ribs are continued throughout the flanks up to the umbilicus, particularly in the living chamber. The other specimen from Vega Island (Howarth, 1966, Fig. 2 a,b) is identical to the Seymour Island specimens.

*K. (K.) darwini* is similar to *K. (K.) angustus* (Marshall) from the Mata Series of New Zealand. According to Henderson (1970, p. 34-35) *K. (K.) angustus* differs from *K. (K.) darwini* by the prorsiradiate inclination of the constrictions as they cross the dorsal flanks, by the presence of umbilical tubercles and by having more compressed whorls at corresponding stages of growth. *K. (K.) darwini* differs from *K. (K.) angolaensis* Howarth from the Campanian of Equito, Angola (in Howarth, 1965, p. 386-87, Pl. II, fig. 4-6), by the presence of a larger umbilicus and much stronger constrictions. *K. (K.) angolaensis* is also described by Olivero (in press) for the lowermost portion of the Lopez de Bertodano Formation in James Ross Island. *K. (K.) pondicherrianus* (Kossmat) from the late Cretaceous of India (in Kossmat, 1897, Pl 6 (17), figs. 6a-c) can be distinguished from this species because its ribs are continuous throughout the flank. Also the constrictions are more rectiradiate than in *K. (K.) darwini*, but the suture and degree of compression are nearly identical. *K. (K.) brevicostatus* (Marshall) from the upper Cretaceous of New Zealand has a more inflated whorl section and ribs that do not disappear in the middle of the flank.
Localities—E; F; H; 47; 49; 107; 142; 143; 173; 174; 175; 382; 383; 384; 385; 394; 423; 427; 428; 429; 432; K-84; L-84; M-84. Also present in Vega Island (Howarth, 1966; Del Valle et al., 1982).

Stratigraphic distribution—Lopez de Bertodano Formation; in Vega Island it is found in the Gunnarites antarcticus Zone (of Olivero, 1981), and in Seymour Island in the Pachydiscus ootacodensis Zone, indicating an age extending possibly from the middle Campanian to the early Maastrichtian.

Kitchinites (Kitchinites) laurae n. sp.

(Plate 9, Figs. 1-4; Text-Figs. 167, 168, 169)

Kitchinites darwini (Steinmann), Del Valle, et al. (1976), pp. 5-7 (in part), Pl. II, Fig. a,b; V, Fig. b; VII, a,b.

Holotype—Specimen 190-1

Material—Three specimens. One of which is very well preserved as an internal mould with remains of the original iridescentshell.

Origin of name—Dedicated to my wife Laura for all her help and understanding in the completion of this work.

Diagnosis—Whorl section rounded. Radial ornamentation absent in the umbilical region. Venter wide, ornamented with relatively weak radial ribs.

Description—Moderately evolute shell with slightly inflated whorl section. Flanks parallel, somewhat arched and continued in an even,
Figure 168-- Graph showing relation between whorl height/whorl width vs. diameter in several specimens of *Kitchinites darwini* and *K. laurae*.

Figure 169-- Suture line of *Kitchinites laurae* n. sp.
broad venter. Umbilical portion of the shell smooth. Ornamentation in
the upper third of the flank composed of strongly prorsiradiated,
closely spaced ribs that continue rectiradiate and less developed across
the venter. Shell crossed by constrictions which start rectiradiate at
the umbilicus but swing forward, slightly above the middle of the flank.
A rounded elevation, more subdued than in K. *darwinii*, precedes and
follows the shape of the constrictions. Three to five constrictions per
whorl, apparently more frequent in the adult. Suture very similar to K.
(K.) *darwinii* (Figure 169).

**Measurements**—

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
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<td>0.68</td>
<td>3.17</td>
<td>36</td>
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<td>--</td>
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</table>

\[ \begin{align*}
X &= 0.71 \\
S &= 0.03
\end{align*} \]

\[ \begin{align*}
X &= 35 \\
S &= 0.5
\end{align*} \]

+= phragmacone
^ = living chamber

**Remarks**—This species differs from K. (K.) *darwinii* by its more
rounded flanks, much wider venter, and by the presence of fainter and
closely spaced ribs that almost disappear when crossing the ventral
margin. It is closely related to K. (K.) *brevicostatus* (Marshall) from
the Mata Series of New Zealand, but differs because in theantarctic
species the ribs are absent in the umbilical portion, and no nodes are
observed at the termination of the ribs. This species differs from
K. (K.) *hearni* (Anderson) from the upper Turonian of the western U.S.
(Anderson, 1958, Pl. 38, Fig. 1, la,1b), because the latter has ribs
that are continued into the umbilical region of the flank, and because
the constrictions do not show a marked inflection in the middle of the flank as it is the case in K. (K.) laurae.

Localities—Seymour Island, stations 150; 153; 190; 325; 326; 356; 377; D-83; E-83; St.5?.

Stratigraphic distribution—Lopez de Bertodano Formation, Pachydiscus riccardi to P. ultimus Zone (middle to late Maastrichtian).

Family KOSSMATICERATIDAE Spath, 1922

Genus Maorites Marshall, 1926


Maorites densicostatus (Kilian and Reboul)

(Plate 10, Figs. 4-9; Plate 13, Fig. 4; Text-figs. 170 b-c, 171)

Kossmaticeras (Madrasites) bhavani Stoliczka sp. var. densicostata

Kilian and Reboul, 1909, p. 30, Pl. 15, fig. 4, not Pl.18, fig. 1.

Maorites densicostatus (Kilian and Reboul), Spath, 1953, p. 23, Pl. 2, figs. 7-9, not Pl. 7, fig. 6.

Maorites densicostatus (Kilian and Reboul); Hunicken, 1965, p. 70, Pl. 1, figs. 12-15.

Maorites densicostatus (Kilian and Reboul); Howarth, 1966, p. 58, figs 2d, e, 3c,d.
Lectotype—Kossmaticeras (Madrasites) bhavani Stoliczka sp. var. densicostata Kilian and Reboul, 1909, pl. 15, Fig. 4. Housed in the Naturhistoriska Riksmuseet (Stockholm), Mo 1721), herein.

Material—11 specimens, generally with an excellent degree of preservation.

Supplementary description—Involute shell, relatively small (usually 8 to 12 cm in diameter, but specimens reaching 30 cm in diameter were recently collected). Flanks almost flat, meeting at an evenly rounded ventral margin, defining a compressed whorl section. Phragmacone ornamented with numerous fine ribs (10 to 12 ribs in one cm at h=3 cm) that are moderately prorsiradiate near the umbilicus. The number of ribs decreases markedly from the juvenile to the adult stage. After a marked inflection near the center of the flank, the ribs are continued radially towards the ventral margin. Most ribs bifurcate near this inflection. Umbilicus flanked by small flattened nodes formed when two and eventually three ribs meet at the umbilical margin. Four to five deep prorsiradiate constrictions which intersect four to six previous ribs present in the last whorl of the shell. Constrictions show a slight inflection near the center of the flank. After the constrictions the new ribs grow parallel to the previous depression.

Suture complex (Fig. 170b). First lateral saddle asymmetrically bifid. Lateral lobe (L) deep and asymmetric. Second lateral saddle much smaller than the first. Auxiliar elements gradually decreasing in size
Figure 170—A= Suture line of *Maorites seymourianus* (Kilian and Reboul) (Spec. 46-1); B= Suture line of *M. densicostatus* (Kilian and Reboul) (Spec. 158-1). C= Cross-section of *M. densicostatus* (Spec. J-1); D= Cross-section of *M. seymourianus* (Spec. 107-2).
towards the umbilical wall.

Measurements--

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
<th>Number of ribs at 3cm; at 2cm</th>
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X= 0.59  X= 23
S= 0.02  S= 3

+= phragmacone
 ^= living chamber
 *= measured at 1.5 cm.

Remarks--Spath (1953, p. 23-24) mentioned the confusion originated, probably as a typographical error, because Kilian and Reboul (1909) included their specimen of Pl. 15, Fig. 4 in both M. seymourianus and M. densicostatus (Kilian and Reboul, 1909, p. 29-30). Howarth (1958, p. 12) designed Kilian and Reboul specimen of Pl. 18, Fig. 1 as the lectotype of M. densicostatus. However, after revising the much larger collection now available from Seymour Island (where Kilian and Reboul material was collected), I conclude that Kilian and Reboul's specimen should be classified as M. seymourianus. In conclusion, we are left with the more involute form (U= 20) from the Plate 15, fig. 4 as the lectotype of this species.
This species closely resembles *M. tenuicostatus* Marshall from the Mata Series of New Zealand. It is interesting to note that Howarth (1966) and Henderson (1970) have both included the type of *M. suturalis* Marshall in the synonymy of *M. densicostatus* and *M. tenuicostatus* respectively. Marshall (1926) distinguished *M. tenuicostatus* from *M. densicostatus* by the "fineness of the costation, the gradual slope into the umbilicus, the indistinct constrictions and the small size of the umbilical tubercles" (Marshall, 1926, p.177).

In order to evaluate quantitatively the term "finely ribbed" I measured the number of ribs along one cm close to the ventral border and at whorl heights (WH) of 2 and 3 cm. It was found that at 2 cm. of WH the number of ribs per cm varied from 12 to 15, whereas at 3 cm varied from 10 to 12, a number consistently lower than that observed in specimens assigned to *M. tenuicostatus*. On the other hand, *M. seymourianus* (Kilian and Reboul) has in general a smaller number of ribs per cm (5 to 10 ribs at H=3 cm), although there is some overlap in this character. Kilian and Reboul specimen of *Kossmaticeras* (Madrascites) bhavani Stol. sp. var. *densicostata* (Plate 18, fig. 1) is more evolute than any of the specimens observed of *M. densicostatus*, (observation confirmed after examining the original specimen) and can be included in *M. seymourianus* (see Fig. 171). The specimens from Seymour Island are identical to those figured by Howarth (1966, Fig. 2 d-e, 3 c-d) from Cape Lamb (Vega Island). Howarth considered *M. suturalis* to be a synonym of *M. densicostatus*, but I have a large number of specimens that closely resemble *M. densicostatus* in their degree of involution but have
a more coarse ornamentation, and on this basis I propose to maintain the two species separated. A similar approach was followed by Hunicken (1965).

_M. densicostatus_ differs from _M. seymourianus_ by its more involute character (Fig. 171), less developed umbilical tubercles, generally finer and more flexuose ribs, particularly in the adult shells, and more compressed whorl section. Collignon (1977) differentiated this species from _M. subtilistriatus_ Collignon from the lower Campanian of Madagascar, because the latter is thicker, has a larger umbilicus, and the constrictions are larger and deeper.

_Macrites densicostatus_ is a typical species, easy to be identified when it is well preserved. However in isolated fragments it is usually very difficult and in many cases impossible to distinguish this species from _M. seymourianus_ or other kossaicriterid genera such as _Natalites_. Furthermore, up to four-five cm in diameter this species is very similar to _Jacobites_ (Cf. Spath, 1953, p. 27) as well as to different species of _Natalites_, _Karapadites_ (Cf. Riccardi, 1983) and possibly _Caledonites_. The problem in the identification of this species has lead to confusion regarding the stratigraphic position of this species (Cf. Macellari, in press). Also the "densicostate" character is variable, and is not an unequivocal character to distinguish between _M. seymourianus_, _M. tenuicostatus_ and _M. densicostatus_ as has been assumed by several authors.
For these reasons, *M. densicostatus* in Lahsen and Charrier (1972, Pl. 3, Figs. 3,4,5) should in my opinion be classified as *Maorites* sp. Also *M. densicostatus* in Cecioni (1955b, Pl. I, fig. 1) is deformed but its degree of involution seems to be comparable with that of *M. seymourianus*, and not with that of *M. densicostatus*. *M. cf. densicostatus* from Tierra del Fuego (described by Leanza, 1964, Pl. I, figs. 6-7) differs from *M. densicostatus* by the different degree of curvature observed in the ribs, by its more evolute character, and by the presence of closely spaced and conspicuous umbilical tubercles, which resemble those of *M. tuberculatus* Howarth (even though the constrictions are not as well defined as in this species). The specimens of *Maorites densicostatus* from New Caledonia described by Collignon, 1977 (Pl. 1, Fig. 3; Pl. 5, Fig. 1) are too poorly preserved and deformed to make a detailed comparison, but the degree of involution of the specimen of Pl. 1, Fig. 1 is closer to that of *M. seymourianus*.

Spath's (1953), specimen of Plate 7, fig. 6 a-d was included in *M. densicostatus* in the p. 23 of that work, but in *Maorites* sp. juv. in the caption of figure 7. However this specimen is much more inflated than *M. densicostatus* and its umbilical tubercles are much more prominent. Because of these characteristics it resembles *M. tuberculatus* Howarth (in Howarth, 1958).

**Localities**—Seymour Island, stations 47; 61b; 116; 117; 151; 158; 189; Loc. J. During the second expedition was found at stations: 317; 319; 321; 325; 329; 330; 331; 332; 336; 340; 341; 342; 347; 357; 359; 361; 362; 364; 366; 371; 377; 378; St. 5; St. 6; C-83; E-83; N-83; 0-83.
Stratigraphic occurrence—(in Seymour Island): Lopez de Bertodano Formation. Upper part of the Pachydiscus ootacodensis Zone to the P. ultimus Zone (lower to upper Maastrichtian).

Maorites tenuicostatus (Marshall)
(Plate 10., Figs. 1-3; Plate 11, Fig. 1)


Maorites tenuicostatus (Marshall); Marshall, (1926), p. 177, pl. 23. fig. 1; 1a; pl. 42, figs. 1, 2; pl. 45, fig. 1.

Maorites tenuicostatus (Marshall); Henderson, 1970, p. 50 (in part)
Plate 9, fig. 3, 4; Pl. 10, fig. 2.


Material—20 excellent specimens, most of them are juveniles, and several preserve a beautiful iridescence from the original shell material.

Supplementary description—Involute phragmocone of compressed whorl section and flat flanks. Ornamentation composed of very densely disposed ribs (16 to 18 ribs in one cm at H of 2 cm, and 12 to 14 ribs in one cm at 3 cm of H). The ribs are prorsiradiate, and display an inflection near the middle of the flank. Later ribs became slightly biconvex. In the proximity of the inflection new ribs bifurcate from previous ones. When two or three ribs meet in the umbilical portion of
the shell, a small flat node is developed which tend to become less apparent adorally in the adult portions of the shell; up to 40 faint nodes present in one whorl. Three to five faint constrictions are present in the last whorl, intersecting four to seven previous ribs. Constrictions very inconspicuous, giving the appearance that the ornamentation is exclusively composed of radial ribs. After 90 mm of diameter the constrictions become more evident, and the ribs are more widely spaced and almost parallel to the constriction. Suture not observed.

Measurements--

<table>
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<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
<th>Number of ribs at 3cm; at 2cm</th>
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<td>0.63</td>
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</table>

\[ \bar{X} = 0.48 \quad \bar{S} = 0.05 \]

+= Phragmacone
 ~= Living chamber

Remarks—The low width to height ratio is in part a reflection of the fact that many specimens are slightly to severely crushed.

Henderson (1970) included under this name the three species of Maorites described by Marshall (1926) from the upper Cretaceous of New Zealand (M. densicostatus; M. tenuicostatus and M. suturalis). Henderson (1970) found transitional specimens among these three species, and considered that the size and spacing of the ribs was not a significant taxonomic
The excellently preserved material now available from Seymour Island leads me to believe that they are in fact different species. The three species have almost identical degree of involution (Fig. 171) (but _M. tenuistriatus_ is slightly more involute) and form a transitional series from those with the ribs closely spaced (_M. tenuicostatus_) to intermediately spaced (_M. densicostatus_) to relatively more widely spaced (_M. suturalis_). However these three species can be differentiated also on other morphological criteria. _M. tenuicostatus_ differs from _M. densicostatus_ by the presence of faint and inconspicuous constrictions, the larger number of ribs per unit area, and the more faintly developed umbilical ribs. Judging from Marshall's figure (1926, Pl. 23, Fig. 1), _M. tenuicostatus_ has a suture similar in outline but much more complicated in detail than _M. densicostatus._

_M. tenuicostatus_ from New Caledonia (in Collignon, 1977, Pl. V, Figs. 2-3) is included with some doubts into the synonymy of this species because Collignon's specimens are fragmentary and it is not possible to determine the degree of involution of those shells.

**Localities**—Seymour Island, 63; 66; 154; 189; 190; 195; B-458; 329, and C-83.

**Stratigraphic occurrence**—Lopez de Bertodano Formation, _Pachydiscus riccardi_ Zone (possibly middle to upper Maastrichtian).
Maorites seymourianus (Kilian and Reboul)
(Plate 11, Fig. 2; Plate 12, Figs. 1-2; Plate 13, Figs. 1-3; Plate 14, Figs. 1-3; Text-figs. 170a, d)

Kossmaticeras (Madrasites) bhavani Stoliczka var. seymouriana, Kilian and Reboul, 1909, p. 29-30, Pl XIV, fig. 3; Pl XIX, Fig. 1.

Kossmaticeras (Madrasites) bhavani Stoliczka var. densicostata, Kilian and Reboul, 1909, p. Pl. XVIII, Fig. 1.

Kossmaticeras (Madrasites) bhavani Stoliczka, Kilian and Reboul, 1909, p. 29, Pl. XIX, Fig. 2.

Maorites seymourianus (Kilian and Reboul), Collignon, 1977, p. 12, Pl. IV, fig. 2.

Caledonites crassecostatus Collignon, 1977, p. 17, Pl. I, Fig. 6.

Lectotype—Kossmaticeras (Madrasites) bhavani Stoliczka var. seymouriana, Kilian and Reboul, 1909, Pl. XIX, Fig. 1, (preserved in the Naturhistoriska Riksmuseet, Mo= 1719), by subsequent designation of Howarth, 1958, p. 12.

Material—A total of 35 specimens with a degree of preservation ranging from fair to excellent.

Supplementary description—Moderately evolute shell with somewhat rounded flanks that meet in an evenly rounded whorl section. Ornamentation composed of radially oriented ribs (5 to 10 ribs in one cm at W= 3 cm) that are slightly prosoiradiate but after an inflection near
Figure 171-- Graph showing the relation of Umbilical Diameter vs. Diameter in Moorites seymourianus, M. densicostatus; M. tenuicostatus; and M. suturalis.
the center of the flank, adopt a more rursiradiate pattern. Eventually
the ribs display a biconvex shape. Bifurcations and intercalations of
new ribs occur close to the middle flank inflection. Deep constrictions
which are more clearly defined in the younger stages are prorsiradiate,
and intercept five to three previous ribs. Approximately four
constrictions per whorl are observed. Pronounced knobs are formed when
two to four ribs meet together at the umbilical margin. Two types of
living chambers observed. The first type (here interpreted as a
microconch) usually starts at a diameter of 9 to 12.8 cm, develops
strong, thick radial costae. The second type, which is less frequent
(here interpreted as a macroconch) develops at larger diameters, and
continues with the thin, closely spaced radial ribs, identical to those
of the phragmacone.

Suture line almost identical to that of M. densicostatus (Fig.
170a). E/L saddle asymmetrically bifid; I relatively wide and very deep;
U narrow and much shorter than L.

**Measurements**

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<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
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\[X=0.62\] \[X=32\]
\[S=0.06\] \[S=2\]

**Parameters:**
- Phragmacone
- Living chamber
- Microconch
- Macroconch

**Remarks:** A wide range of variation was found among the individual studied. The ribbing spacing and shape are relatively constant in the phragmacone. In most specimens the living chamber starts at a diameter of 9 to 12.8 cm. However, there is a smaller group which occur at the same stratigraphic interval where the phragmacone reaches diameters of up to at least 16.38 cm. Even though no living chamber of the larger specimens was observed in conjunction with an entire shell, I have two large fragments where the living chamber is preserved. However, the ornamentation in these fragments is composed of regularly spaced, thin radial ribs, and not of coarse costae as it is the case in the smaller forms. These differences are here interpreted as a sexual dimorphic
character. The specimen of Plate 14 is similar to *M. tuberculatus* Howarth because the ribs swing forward from the middle portion of the flank towards the venter. However it clearly differs from this species because it lacks the coarse tubercles, the constrictions are much less pronounced, and the section is much less inflated.

*Maurites menabensis* (in Collignon, 1955, pl. XI, fig. 2, 2a, 2b) has a similar ornamentation but differs because it is much more inflated than the antarctic species. After studying at the material described by Spath as *Maurites seymourianus* (1953, Pl. IV, Fig. 1a,b), it is concluded that this specimen has much more pointed tubercles, and that the bifurcation of the ribs in the middle of the flank is much more pronounced than in *M. seymourianus*. Probably this specimen could be a *Gunnarites bhavani* where the crenulation in the ribs was not preserved.

*Maurites pseudobhavani* Spath (in Spath, 1953, Pl. VI, Fig. 7-9; Pl. XI, Fig. 2-3) from Lachman Crags was included by Howarth (1966, p. 67) in *Gunnarites kalika* (Stolickzka). After a revision of the original specimens I agree with Howarth's conclusion that this is not a *Maurites*, but probably these specimens could be better classified as *G. bhavaniformis* (Kilian and Reboul).

**Localities**—Seymour Island, 42; 43; 49; 104; 107; 143; 172; 175; Locs. B; E; F; H; H' ; BZ; 383; 385; 394; 422; 423; 426; 427; 428; 432; K-84; L-84; M-84.

**Stratigraphic distribution**—Lopez de Bertodano Formation.
Maorites suturalis Marshall

(Plate 15, Figs. 1-4)

Maorites suturalis Marshall, 1926, p. 179, Pl. 23, Fig. 3; Pl. 43, Fig. 1; Pl. 45, Fig. 5.
Maorites suturalis Marshall, Matsumoto, 1955, p. 128, Fig. 5 a,b.
Maorites suturalis Marshall, Hunicken, 1965, p. 72, Pl. I, Fig. 10-11;
Pl. V, Figs. 1-4.

Material—10 specimens very well preserved.

Supplementary description—Involute shell with a compressed whorl section with flat and extended flanks. Ornamentation composed of moderately spaced, and pronouncedly marked ribs (6-7 ribs in one cm at H= 3cm). Ribs start in a prorsiradial fashion at the umbilicus and when reaching approximately 2/5 of the flanks, bend backwards to proceed to the ventral margin. A moderately pronounced flat tubercle is formed when 2-3 ribs meet. Adorally the nodes tend to disappear completely.

Four to five pronouncedly incised prorsiradial constrictions that intercept five to six previous ribs are found in the last whorl. In the adult, constrictions become more spaced and the ribs become broader and flat, separated by narrow interspaces. Suture line not observed.

Measurements—

<table>
<thead>
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<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
<th>Number of ribs</th>
</tr>
</thead>
</table>
Remarks—Howarth (1966) considered *Maorites suturalis* as a synonym of *M. densicostatus*. Henderson (1970) in turn, revised Marshall's collection, and together with new specimens from the Mata Series of New Zealand, included *M. suturalis* into *M. tenuicostatus*. In my collection from Seymour Island, there are numerous specimens that coincide with the description of Marshall (1926) of *M. suturalis* and which clearly differ from either *M. tenuicostatus* and from *M. densicostatus*, as discussed previously. With *M. tenuicostatus* it shows obvious differences: the smaller number of ribs per cm, the much more pronounced constriction lines and more prominent umbilical tubercles in the juvenile specimens. With *M. densicostatus* the same differences hold true, but with a difference of degree. There seems to be a discrete morphological transition from *M. suturalis* to *M. densicostatus* to *M. tenuicostatus*, but this is not reflected in the stratigraphic distribution of this species, which occur approximately at the same level. *Maorites* sp. juv. aff. *M. suturalis* (in Spath, 1953, Pl. V, Fig. 6-7) is quite similar to some of my specimens.

Localities—Seymour Island, 56; 61; 114; 150; 153; 195; 337; 397; 399.

Stratigraphic distribution—Lopez de Bertodano Formation, upper part of the *Pachydiscus ootacodensis* Zone to the lower part of the *P. ultimus* Zone.
Maorites tuberculatus Howarth

(Plate 17; figs. 4,5,6)

Maorites tuberculatus Howarth, 1958, p. 11-12, Pl. II, figs. 1-3

Maorites aff. tuberculatus Howarth, Olivero, 1975, p. 32, Pl.1, figs. 2a-c.

Holotype—Maorites tuberculatus Howarth, 1958, Pl. II, fig. 1; British Museum N° C.49073, by original designation.

Material—Twelve fragmentary individuals.

Measurements—

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
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<tbody>
<tr>
<td>G-83-1</td>
<td>5.25</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.72</td>
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<td>G-83-3</td>
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<td>G-83-4</td>
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<td>2.90</td>
<td>1.95</td>
<td>0.67</td>
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</table>

Remarks—Typical of this species are the prominent umbilical tubercles (up to 16 per whorl), which are much more pronounced up to a diameter of 3.5 cm. An important difference with other species of Maorites is that the radial ribs do not intercept the preceding deep constrictions. The constrictions are abundant (up to 9 per whorl) and deep. The radial ribs after crossing the middle of the flank become more prorsiradial than the ribs of other species of Maorites found on Seymour Island. All specimens observed are medium sized (up to 85 mm in diameter).

The specimens described here are identical to those of Howarth (1958) from Seymour Island, and to a small specimen described by
Olivero (1975) from Snow Hill Island. Detailed collecting on Seymour Island showed that *M. tuberculatus* is restricted to the lower beds of the Lopez de Bertodano Formation (units 3-5), and only is abundant near to Cape Bodman.

**Localities and stratigraphic distribution**—Stations 22, 112; G-83; G-83 and 433, Seymour Island; present also on Snow Hill Island, and possibly in James Ross Island, (undescribed specimen preserved in the collection of the Swedish Expedition in Stockholm). Its occurrence is restricted to beds that are considered here as upper Campanian.

**Genus Kossmaticeras De Grossouvre, 1901**

**Subgenus K. (Natalites) Collignon, 1955**

**Type species**—*Madrasites natalensis* Spath, by original designation of Collignon, 1955, p. 13.

**Kossmaticeras (Natalites) weddelliensis** n. sp.

(Plate 16, Figs. 1-5)

**Holotype**—Specimen H (Plate 16, Figs. 2,3,4)

**Material**—Three specimens, two of them very well preserved.

**Origin of name**—After the nearby Weddell Sea.

**Diagnosis**—Umbilical wall almost vertical. Ornamentation composed of slightly prorsiradial, widely spaced ribs (four ribs in one cm at H=3cm). Prominent tubercles forming at the conjunction of two ribs in the
umbilical margin. Deep straight constrictions intersect two to four previous ribs.

**Description**—Medium sized shell, moderately involute (U/D = 32-33), of moderately inflated whorl section (W/H = 0.70 to 0.77), with flat flanks and arched venter. Umbilical wall almost vertical. Ornamentation composed of widely spaced ribs that are slightly prosriradiate on the dorsal flank but rectiradiate on the ventral flank and venter. Ribs bifurcate in the middle of the flank. A prominent tubercle is formed at the conjunction of two ribs in the umbilical margin. Approximately 11 tubercles are present in the last whorl. Ribs become more prominent, wider and more spaced in the living chamber. Five deep constrictions are observed in the last whorl. These constrictions intersect two to four previous ribs, and the adapical border of the constriction is thicker and more elevated than the adoral border. Suture line not visible.

**Measurements**—

<table>
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<tr>
<th>Spec. N.</th>
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<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
<th>Number of ribs at H = 3cm</th>
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<tr>
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<td>2.82</td>
<td>0.70</td>
<td>--</td>
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</table>

+= Phragmacone
^= Living chamber

**Remarks**—The subgenus K. (Natalites) Collignon is characterized by its strong umbilical tubercles, and almost straight and prominent ribs which are continuous throughout the flank (Cf. Collignon, 1955, p.13;
Matsumoto, 1955, p. 142 (under Kaiparaites), and Riccardi, 1983). These specimens fit well into the description of the subgenus. Exception is that the ribs are not as strong as in the type species, forming a transition between Maorites and K. (Natalites).

This species is almost identical in lateral view to K. (Natalites) sulcatum (Marshall) (in Henderson, 1970, p. 37–38, Pl. 5, Fig. 1a–b). It differs however, in the degree of inflation (B/H= 0.85 to 0.94 in K. (Natalites) sulcatum, and B/H= 0.70 to 0.77 in K. (Natalites) n.sp.). The Antarctic specimens are also much larger, but the difference in inflation is also maintained at smaller diameters. K. (Natalites) natalensis (Spath) (in Spath, 1922, p. 34, Pl. 5, Fig. 3) from the Umzamba Beds of Pondoland, South Africa, has a similar degree of involution and ribbing pattern. However, the ribs of K. (N.) natalensis are more conspicuous and slightly more prorsiradial, and the constrictions instead of being straight are strongly projected forward. Moreover, the umbilical tubercles are somewhat more prominent and the whorl section is slightly more inflated than in K. (N.) weddelliensis (W/H= 0.81 vs. 0.70 to 0.77).

K. (Natalites) multisulcatum (Marshall) and K. (Natalites) regularis (Marshall) from the late Cretaceous of New Zealand (in Henderson, 1970, Pl. 5, Figs. 2 and 3 respectively) are more evolute, their whorl section is more inflated, and the umbilical tubercles are more numerous. K. (Natalites) bensonii Henderson, from New Zealand, and K. (Natalites) rossensis (Olivero), from James Ross Island have both
strongly projected ribs across the venter (Henderson, 1970; Olivero, in press). K. (Natalites) acuticostatus (Spath) from south Africa (in Spath, 1922, Pl. 8, Fig. 2) has more spaced and marked ribs. K. (Natalites) weddelliensis is similar to M. seymourianus but can be differentiated by the straight and less numerous ribs, more prominent umbilical tubercles and more incised constrictions.

**Localities**—Seymour Island, 143; 174; loc. H`, 423, and M-84.

**Stratigraphic distribution**—Lopez de Bertodano Formation, Pachydiscus ootacodensis Zone (possibly lower Maastrichtian).

**Genus** Gunnarites, Kilian and Reboul, 1909

**Type species**—Gunnarites antarcticus Weller, by original designation of Kilian and Reboul, 1909, p. 31

**Gunnarites kalika** (Stoliczka)

(Plate 17, Fig. 7)

*Ammonites kalika* Stoliczka, 1865, p. 140, Pl. 70, Fig. 5a–b.

*Gunnarites kalika* (Stoliczka), Spath, 1953, p. 33–34, Pl. X, Figs. 1–6.

*Gunnarites kalika* (Stoliczka), Lahsen and Charrier, 1972, p. 529–30, Pl. 2, Figs. 3–6.

**Material**—One cast of a fragment (1–1).
Supplementary description—Finely ribbed specimen with the ribs strongly flexuose and crenulated, particularly in the ventral portion of the flank. Elongated and prominent umbilical tubercles are continued in four to five ribs which are first prorsiradial, then change to rectiradial near the middle of the flank and finally become prorsiradial in the ventral portion of the flank.

Remarks—This specimen is identical to those of Spath (1953, Pl. X, Figs. 1a, 3a, and 5a), particularly in the shape of the umbilical tubercles, the flexuosity of the ribs and in the abundant ribs. The presence of faint crenulations in the ribs is a typical characteristic of Gunnarites.

Locality—Seymour Island, Station 1. This species is also present in James Ross Island (The Naze, Dagger Peak, Lachman Crags, south); Humps Islet and Snow Hill Island.

Stratigraphic occurrence—Lopez de Bertodano Formation; lowermost beds of Seymour Island (possibly upper Campanian).

Genus Grossouvrites Kilian and Reboul, 1909

Type species—Grossouvrites gemmatus (Huppe), by monotypy.

Grossouvrites gemmatus (Huppe)

(Plate 17, Figs. 1-3; Text-fig. 172)

Ammonites gemmatus Huppe, 1854, p. 35, Pl. I, figs. 3-3a.

?Holcodiscus gemmatus (Huppe) Steinmann, 1895, p. 68, Pl. VI, figs. 1-2.
Kossmaticeras (Grossouvreites) gemmatum (Huppe), Kilian and Reboul, 1909, p. 38, Pl. XVII, figs. 1, 2a-b, 3a-b.

Grossouvreites gemmatum (Huppe), Spath, 1953, p. 29, Pl. V, Fig. 1.

Grossouvreites gemmatum (Huppe), Howarth, 1958, p. 12, Pl. II, Fig. 4 a-b.

Grossouvreites gemmatum (Huppe), Hunicken, 1965, p. 77, Pl. VI, Fig. 1-2; Pl. VII, Figs. 8-9.

Material—15 specimens usually with the original shell still preserved.

Supplementary description—Moderately evolute shell, medium to large size. Whorl section with vertical umbilical walls, flat flanks almost parallel, and broadly rounded venter. Ornamentation composed of prominent, flat, umbilical tubercles (20–23 in the last whorl) from where usually two and sometimes three rectiradiate, straight ribs emerge. Intercalary ribs appear near the center of the flank and they, as well as the primary ribs, cross the venter without interruption or decrease in surface expression. Constrictions only present in the young portion of the shell (up to 2–3 cm in diameter), give the appearance of young Gunnarites. Ornamentation in the living chamber similar than in the phragmacone, but with more pronounced ribs and tubercles. Suture line extremely complicated (Fig. 172) with E very deep and L narrow and very incised. E/L saddle assymetrically bifid with the branch closer to E larger but very similar than that closer to L.

Measurements—

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<td>3.62</td>
<td>0.78</td>
<td>2.16</td>
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</table>

\[ X = 0.75 \]
\[ S = 0.04 \]
\[ X = 24 \]
\[ S = 1 \]

+= Phragmacone
\(^{\sim}\)= Living chamber

**Remarks**—After observing specimens of this species from the type locality (I. Quiriquina), it is concluded that they are identical in whorl shape and ornamentation to the material here described. Steinmann's figure of this species (1895, Pl. 6, Fig. 1a,b) is however different from other specimens from Quiriquina and Antarctica in the presence of prosriradiate ribs, many of them with a flexuosity in the middle of the flank. It also differs in its whorl cross-section because the flanks are less flat and more convergent. It is possible that the noted differences are more due to artistic license in the illustration of this specimen than to real differences. *Grossouwrites gemmatus* from Brandy Bay (in Olivero, in press) probably does not belong to this species because the ribs are much more flexuose, and the constrictions much more prominent.

**Localities**—Seymour Island, stations 51; 56; 61+; 107; 114; 116; 149; 153; 156; 157; 160; 173; 177; 178; 187; 189; 191; 195; H\(^{\sim}\), and J. During the second expedition was also found in stations: 325; 326; 331; 332; 337; 338; 340; 341; 347; 356; 357; 359; 360; 364; 366; 368; 371;
372; 377; 397; 399; 423; C-83; O-83, and St.6. Also present in Vega
Island (Howarth, 1966; Del Valle et al., 1982) and Snow Hill Island
(Olivero, 1975).

Stratigraphic occurrence—Lopez de Bertodano Formation, most
characteristic in the Maastrichtian of Seymour Island, but apparently
also present in lower levels of this formation.

Family PACHYDISCIDAe Spath, 1922

Genus Pachydiscus Zittel, 1884

Type species—Ammonites neubergicus Hauer, 1858 (by subsequent
designation of De Grossouvre, 1894, p. 177)

Pachydiscus (Pachydiscus) ultimus n. sp.

(Plate 18, Figs. 1-4; Plate 19, Figs. 1-2 )

Holotype—S.I.-1 (Plate 18, Figs. 1-2)

Material—Ten specimens in excellent degree of preservation, most
of them still preserving the original shell.

Origin of name: ultimus, indicating the last ammonite.

Diagnosis—Shell very involute. Compressed whorl section with
maximum width near umbilicus, decreasing progressively towards the
venter. Shell almost smooth with the exception of slightly
prosiradial ribs which disappear in the middle of the flank,
reappearing very faintly in ventral margin. Thickened umbilical ribs
forwardly projected.
Figure 172-- Suture line of *Grossouvreites gemmatus* (Huppe). (Spec. 51-1).

Figure 173-- Suture line of *Pachydiscus* (Pachydiscus) *riccardi* n.sp. (Spec. 61+1-1).

Figure 174-- Cross-section of *Pachydiscus* (Pachydiscus) *ootacodensis* (Stoliczka).
Description—Shell of compressed whorl section with a lanceolate outline. Umbilical wall vertical, flanks straight and subparallel converging to a narrowly curved venter. Shell strongly involute with a small umbilicus that maintains a constant relationship with the total diameter of the shell (U/D = 15 to 17). Large sizes (over 20 cm) are commonly attained. Ornamentation consisting of thickened pro-sirradiate umbilical ribs (27 to 31 per whorl) which are continued by slightly pro-sirradiate and more abundant lyræ that disappear after crossing the center of the flank. Some medium sized specimens, and all large specimens, with flank devoid of ornamentation. Subdued ribs reappear in the ventral portion of the flank and cross the venter uninterrupted, becoming even less defined in the adult stage. Suture line very incised.

Measurements—

<table>
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<th>W/H</th>
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<td>--</td>
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</table>

X=0.56  X=16
S=0.04  S=1

(all phragmacones)

Remarks—This species belongs to the "Typical subgroup" of Matsumoto (1959b, p. 41), together with P. (P.) egertoni (Forbes), P. (P.) subcompressus Matsumoto, and P. (P.) gollevillensis (d'Orbigny)
among others. In this subgroup, Matsumoto (1959b) included the compressed and high-whorled species ornamented with separate short umbilical and ventrolateral ribs. P. (P.) ultimus is clearly distinguished from P. (P.) gollevillensis (d’Orbigny) by its smaller umbilicus, the shape of the umbilical ribs (more expanded and forming a small tubercle in P. gollevillensis) as well as by the presence in this new species of less conspicuous ventral ribs.

It differs from P. (P.) excelsus Matsumoto (in Matsumoto et al., 1979) by its narrower umbilicus (more involute) and by its more compressed whorl section, and more vertical umbilical wall. Additionally the umbilical ribs in the Japanese specimens are in some cases connected with the ventrolateral ribs. P. (P.) ultimus differs from P. (P.) flexuosus Matsumoto (in Matsumoto et al., 1979) by the gentle flexuosity of the ribs and lirae on this last species. P. (P.) ultimus is closely associated to P. (P.) subcompressus (Matsumoto) (Matsumoto, 1954, Matsumoto et al., 1979, Fig. 5) from the Maastrichtian of south Sakhalin (Japan), from which apparently differs by its more involute character. More detailed comparison with this species is not possible because most specimens from Japan are secondarily compressed and can not be measured with precision (Matsumoto, written communication, 1983). P. (P.) compressus Spath (in Collignon, 1951, Pl. 12, fig. 4, 4a,b) has a wider umbilicus, a less triangular whorl section (more compressed near the umbilicus) and much stronger ventral ribs. P. (P.) egertonii (Forbes) (in Forbes, 1856, Pl. 9, Fig. 1a-c) and P. (P.) neubergicus (V. Hauer)(i.e. Grossouvre, 1893, Pl. 30, fig. 4,4a) are
much more evolute and have much more prominent and widely spaced umbilical tubercles that are continued in an elevated radial rib. Besides, *P. (P.) neubergicus* is a much more flattened form.

**Localities**—Seymour Island, Stations 68; 116; BZ; 341; 342; 347; 368; 371; 372; 398; 399; 400; St. 7.

**Stratigraphic occurrence**—Upper part of the Unit 9 of the Lopez de Bertodano Formation, *Pachydiscus ultimus* Zone (uppermost Maastrichtian).

**Pachydiscus (Pachydiscus) riccardi** n.sp

(Plate 17, Fig. 4; Plate 19, Figs. 3-4; Plate 20, Figs. 1-3; Text-fig. 173)

*Pachydiscus (Parapachydiscus) aff. gollevillensis* (d'Orbigny), Kilian and Reboul, 1909, p. 43, Pl. 19. fig. 3; Pl. 20, fig. 1.

**Holotype**—*Pachydiscus (Parapachydiscus) aff. gollevillensis* (d'Orbigny), Kilian and Reboul, 1909, Pl. 19, fig. 3; Pl. 20, fig. 1 (Naturhistoriska Riksmuseet, Mø= 1905a).

**Material**—Ten specimens very well preserved.

**Origin of name**—Species dedicated to Dr. Alberto C. Riccardi, from the Museo de La Plata, Argentina.

**Diagnosis**—Shell involute with whorl section inflated to moderately compressed. Umbilical wall vertical. Ornamentation composed of slightly prorsiradiate radial ribs which are continuous across the flank
in juvenile specimens. Umbilicus bordered by slightly elongated, blunt, rectiradiate nodes. Venter crossed by weak but clearly defined and evenly spaced radial ribs.

Description—Shell large, (diameters of more than 30 cm common), involute. Whorl section moderately inflated to moderately compressed (mean W/H: 0.74); umbilical wall vertical, flanks slightly convex near the umbilicus, then become straight. Maximum width observed near the umbilicus. Venter broad and rounded. Ornamentation in the juvenile portion of the shell with well developed prorsiradiate ribs, continuous throughout the flank, and slightly thickened near the umbilicus. Adult shell with the middle flank almost smooth, and short, rectiradiate umbilical tubercles (approximately 18 per whorl). Ventral portion of the flank and venter with closely spaced, weak, and slightly prorsiradiate ribs, less developed and more spaced in the adult. Suture line typical pachydiscid with the lobes narrow and symmetric (Fig. 173).

Measurements—

<table>
<thead>
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<th>Spec. N.</th>
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<th>W/H</th>
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<td>4.82</td>
<td>0.69</td>
<td>2.20</td>
<td>16</td>
</tr>
<tr>
<td>190-2</td>
<td>16.82</td>
<td>8.43</td>
<td>6.05</td>
<td>0.72</td>
<td>2.91</td>
<td>17</td>
</tr>
<tr>
<td>BZ-v</td>
<td>19.12</td>
<td>9.44</td>
<td>7.6</td>
<td>0.81</td>
<td>3.71</td>
<td>19</td>
</tr>
</tbody>
</table>

X=0.74       X=18
S=0.04       S=2

(all phragmacones).

Remarks—This species is similar to P. ultimus, and it is clearly related in the degree of involution and general shape of the
oration. However, it can be easily distinguished by its more inflated section (W/H: 0.74 in P. riccardi, vs. 0.56 in P. ultimus), by its more developed and incised ribs, and particularly by the shape and number of the umbilical tubercles, which are blunt, short, rectiradiate, and less numerous (approx. 18 per whorl) in P. riccardi, and elongated, strongly prorsiradiate, and more abundant (up to 31 per whorl) in P. ultimus. This species has been compared with P. gollevillensis (d'Orbigny) (Kilian and Reboul, 1909), but clearly differs from this species by its more inflated section and by the presence of more numerous and less defined radial ribs in the umbilical region. P. (P.) quiriquinae Steinmann (in Steinmann, 1895, Pl.6, figs. 3a-b) has a similar but slightly stronger ornamentation in the flank and a similar degree of involution, however, the ribs are more incised in the venter and the whorl section is much more inflated.

**Localities**--Seymour Island, 61+; 151; 153; 188; 189; 190; 325; 326; 327; 329; 337; 338; 356; 357; 360; 378; 397; D-83; 0-83; St. 6.

**Stratigraphic occurrence**--Lopez de Bertodano Formation, P. riccardi Zone ("middle" to late Maastrichtian).

**Pachydiscus (Pachydiscus) ootacodensis** (Stoliczka)

(Plate 21. Figs. 1-4; Text-fig. 174)

**Ammonites ootacodensis** Stoliczka, 1865, p. 109, Pl. 54, figs. 3,4; Pl. 56 (not Pl. 57).

**Pachydiscus ootacodensis** (Stoliczka), Kossmat, 1898, P 98, Pl. 16, figs.
Pachydiscus ootacodensis (Stoliczka), Whiteaves, 1903, p. 340, Pl. 46, fig. 1, text-fig. 20.

Parapachydiscus aff. ootacodensis (Stoliczka), Spath, 1922, p. 132, Pl. 7, fig. 6.

not Pachydiscus ootacodensis (Stoliczka), Wetzel, 1930, p. 85, Pl. 13, fig. 3a-b.

Pachydiscus ootacodensis (Stoliczka), Usher, 1952, p. 85, Pl. 17, figs. 1-5; Pl. 18, 19, and 20.

Pachydiscus (Pachydiscus) ootacodensis (Stoliczka), Jones, 1963, p. 38, Pl. 29, figs. 1-3, 13-16; Pls. 30, 31, and 32, fig. 1.

Pachydiscus (Pachydiscus) hornbyense Jones, 1963, p. 38-40, Pl. 32, figs. 2-6, Pl. 33; text-fig. 19.

Pachydiscus ootacodensis (Stoliczka), Collignon, 1971, p. 40, Pl. DCLVI, fig. 2419.

Material—Three specimens from Seymour Island; one is complete and well preserved, the other two are fragmentary.

Supplementary description—Involute shell with a very narrow umbilicus and inflated whorl section. Umbilical walls rounded; venter broad and evenly rounded. Ornamentation composed of bullae or protruded radial ribs, that appear slightly displaced from the umbilicus. Nine of these tubercles are observed in one whorl of the only complete available specimen. Usually two radial ribs start from these tubercles, but disappear in the center of the flank, to reappear later in the ventral
portion of the flank where they become more prominent and raised. Very delicate and numerous radial striations present throughout the shell.

Suture line not observed.

**Measurements—**

<table>
<thead>
<tr>
<th>Spec. N.</th>
<th>D</th>
<th>H</th>
<th>W</th>
<th>W/H</th>
<th>U</th>
<th>U/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>BZ-38-3</td>
<td>7.48</td>
<td>4.08</td>
<td>4.40</td>
<td>1.08</td>
<td>1.48</td>
<td>20</td>
</tr>
<tr>
<td>BZ-37-20</td>
<td>6.90</td>
<td>6.65</td>
<td>0.96</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>H'-1</td>
<td>8.60</td>
<td>8.90</td>
<td>1.03</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Remarks—**This species should have attained very large sizes because even in the larger fragment the whorls are still septate. Jones (1963) created a new species (*P. (Pachydiscus) hornbyense*) to include the specimens from Hornby Island (British Columbia) that were previously identified by Whiteaves (1903) and Usher (1952) as *P. (P.) ootacodensis*. According to Jones (1963) *P. (P.) hornbyense* differs from *P. (P.) ootacodensis* (Stoliczka) by the presence of well developed umbilical tubercles as well as of primary and secondary ribs on the early whorls. However these differences are not clearly defined, particularly the presence of umbilical tubercles, which are very easy to be eroded away. Such is possibly the case of the specimen from Hornby Island figured by Usher (1952, Pl.19), and Whiteaves (1903, Pl. 46, fig.1), where the umbilical tubercles are hardly visible, even in the inner whorls. As Jones (1963, p. 38) discussed, *P. (P.) ootacodensis* as originally established by Stoliczka, included smooth specimens, fairly coarsely ribbed specimens with umbilical tubercles, and specimens on which ornamentation was restricted to short ventral ribs. Later Kossmat (1898, p. 98-101) (as commented by Jones, 1963) restricted this species
to specimens that were either smooth or had ventral and lateral ribs on which the umbilical ornamentation was obsolete. Jones (1963) interpreted this statement as complete lack of umbilical tubercles. The antarctic specimens have umbilical tubercles that are slightly displaced on the flanks. In this way, the inner umbilical region is entirely smooth. With all these ambiguities in mind it is preferred here to include P. (P.) hornbyense into the synonymy of P. (P.) ootacodensis until the original as well as new material from India can be revised.

The specimens figured here are remarkably similar to those figured by Jones (1963) from the Lambert Formation of the Nanaimo Group, Hornby Island, British Columbia. Particularly similar is his Figure 1 of Plate 33 to my Figure 1, Plate 21, however the presence of secondary ribs is not apparent in the Seymour Island material, and the ribs are more separated.

P. (P.) ambatyensis Collignon (in Collignon, 1951, Pl. 12, figs. 1-3) from the lower Maastrichtian of Madagascar, and Quiriquina (Chile) (in Wetzel, 1930, Pl. 14, fig. 1a-b), have more closely spaced ribs that do not disappear or become weaker when crossing the flanks.


Stratigraphic occurrence—Lopez de Bertodano Formation, Pachydiscus ootacodensis Zone (possibly, lower Maastrichtian).
CLASS BIVALVIA

Family NUCULIDAE Gray, 1758

Genus Nucula Lamarck, 1799

Subgenus Nucula (Leionucula) Quenstedt, 1930

Type species—Nucula albensis d' Orbigny, by original designation of Quenstedt, 1930, p. 110-112.

Nucula (Leionucula) suboblonga (Wilckens)

(Plate 22, Figs. 1-5)

Nucula suboblonga Wilckens, 1907, p. 53

Nucula suboblonga Wilckens, 1910, p. 22-24, Pl. 2, fig. 1a-b; 2.

Nuculoma (Palaeonucula) poyaensis Freneix, 1956, p. 157-158, Pl. 1, fig. 1a-b.

Leionucula poyaensis (Freneix), Freneix, 1980, p. 75-77, Pl. 1, figs. 1-4.

Lectotype—Nucula suboblonga Wilckens, Wilckens, 1910, Pl. 2, Fig. 1a-b. (Naturistoriska Riksmuseet Mo 1424a), herein.

Type locality—Ultima Esperanza Region, southern Chile.

Material—41 complete specimens, mostly preserved as internal moulds.

Supplementary description—Shell suboval, moderately small (up to 4.9 cm long) but large for the group. Equivalve, inequilateral with the opistogyrated umbones, placed in the posterior of the shell. Anterior
margin oval shaped; ventral margin rounded; posterior margin truncated and relatively produced. Ornamentation composed of delicate concentric lirae with superimposed closely spaced fine radial threads, giving rise to a cancellate pattern. Hinge not completely preserved in specimens observed. Internal margin smooth; anterior and particularly posterior retractor strongly incised. Anterior adductor scar larger than the posterior; additionally, three well defined circular muscle scars, a round larger medial muscle scar, and a large, elongated dorso-medial muscle scar. These 5 muscle scars form a 90° angle. (Plate 22, Figs. 2,4).

**Measurements**

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI-1</td>
<td>4.38</td>
<td>3.22</td>
<td>3.28</td>
<td>1.36</td>
<td>0.75</td>
<td>2.23</td>
</tr>
<tr>
<td>42-1</td>
<td>*4.15</td>
<td>3.10</td>
<td>*3.15</td>
<td>1.34</td>
<td>0.76</td>
<td>2.35</td>
</tr>
<tr>
<td>E-1</td>
<td>3.70</td>
<td>2.83</td>
<td>*2.85</td>
<td>1.31</td>
<td>0.77</td>
<td>2.30</td>
</tr>
<tr>
<td>72-1</td>
<td>3.87</td>
<td>2.76</td>
<td>2.97</td>
<td>1.40</td>
<td>0.77</td>
<td>2.34</td>
</tr>
<tr>
<td>143-1</td>
<td>4.90</td>
<td>*3.50</td>
<td>*3.70</td>
<td>1.40</td>
<td>0.75</td>
<td>*2.60</td>
</tr>
<tr>
<td>143-2</td>
<td>*4.81</td>
<td>3.34</td>
<td>3.46</td>
<td>1.44</td>
<td>0.72</td>
<td>*2.60</td>
</tr>
</tbody>
</table>

X=4.30       X=1.37   X=0.75   X=2.40
S=0.49       S=0.05   S=0.02   S=0.16

* = measurement estimated.

**Discussion**—This species was first mentioned by Wilckens (1907, p. 33) but it was figured latter in 1910 from material collected on Seymour Island. The measurements of the Seymour Island specimens are identical to those of *Leionucula poyaensis* (Freneix) described by Freneix (1956, 1980) from New Caledonia. This, together with similarities in shape and ornamentation lead me to consider *Nucula (Leionucula) suboblonga*, and *N. (L.) poyaensis* as conspecific.
Nucula (Leionucula) grandis Malumian (Malumian et al, 1978, pl. 4, figs 3a-b; 5) from the Eocene-Lower Oligocene "Magallanense" of Tierra del Fuego (Argentina) is almost identical to this species. The main difference that can be observed is the absence of the radial ornamentation in N. (L.) grandis.

Nucula oblonga Wilckens (in Wilckens, 1907) from the Cerro Cazador Formation in southern Argentina, is less expanded posteriorly and generally smaller. Nucula frenguelii Feruglio (Feruglio, 1936, Pl. 23, fig. 11) from the Danian of Patagonia is also very similar but it is more elongated and expanded posteriorly.

Localities—Seymour Island, Stations B, E; F; SI (Float); 37; 39; 41; 43; 71; 72; 105; 143; 350; 352; 353; 404; 405; 406; 407; 423; 426; 428; 429.

Stratigraphic distribution—This species is abundant in the uppermost Unit 6, lower part of Unit 7, and in Unit 10 of the Lopez de Bertodano Formation, and extends to the base of the Sobral Formation.

Family MALLETIIDAE Adams & Adams, 1858
Genus Malletia des Moulins, 1832
Subgenus Malletia (Malletia)
Type species—Malletia chilensis by monotypy.

Malletia (Malletia) gracilis Wilckens
(Plate 22, Figs. 6,7)
Malletia gracilis Wilckens, 1907, p. 35, Pl. 5, fig. 10.

Malletia gracilis Wilckens, Wilckens, 1910, p. 25, Pl. 2, fig. 4.

Lectotype—Malletia gracilis Wilckens 1907, Pl. 5, Fig. 10 (Museo de La Plata), by this designation.

Type locality—Cerro Cazador (Argentina, Chile).

Material—Six complete specimens, three of them preserved as internal moulds.

Supplementary description—Shell subelliptical, elongate, equivalve, inequilateral of moderately small size (up to 4.5 cm). Beaks mesogyrous located in an anterior position with respect to a median line. Anterior margin subelliptical; ventral margin extended, slightly curved, continued into a straight posterior margin. Posterior margin more rounded. Dorso-posterior margin straight with a slight concavity. Posterior area poorly defined. Shell thins rapidly in a posterodorsal direction. Deep pallial sinus, well preserved in internal moulds. External ornamentation composed of very delicate concentric lines.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-1-1</td>
<td>4.19</td>
<td>2.38</td>
<td>1.53</td>
<td>1.76</td>
<td>0.36</td>
<td>1.60</td>
</tr>
<tr>
<td>9-1-2</td>
<td>4.48</td>
<td>2.20</td>
<td>1.50</td>
<td>2.04</td>
<td>0.33</td>
<td>*1.55</td>
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<tr>
<td>9-1-3</td>
<td>--</td>
<td>2.38</td>
<td>1.48</td>
<td>--</td>
<td>--</td>
<td>*1.66</td>
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<tr>
<td>9-1-4</td>
<td>3.92</td>
<td>2.18</td>
<td>1.13</td>
<td>1.79</td>
<td>0.29</td>
<td>1.40</td>
</tr>
</tbody>
</table>

X=4.20
S=0.28

* = measurement estimated

Remarks—This species, is not abundant and is restricted to the Sobral Formation.
Localities—Seymour Island, WZ-9; 80.

Subclass CRYPTOCONA Neumayr, 1884

Order SOLEYOIDA Dall, 1889

Family SOLEYIDAE Adams & Adams, 1857

Genus Solemy Lamarck, 1818

Subgenus Solemy (Solemy)

Type species—Solemya mediterranea (≡Tellina togata Poli, 1795) by subsequent designation, Children, 1823.

Solemya (Solemy) rossiana (Wilckens)

(Plate 22, Figs. 8-11; Text-Fig. 175)

Solenomya rossiana Wilckens, 1910, P. 65-67; Pl. 3, fig. 9.

Holotype—Solenomya rossiana Wilckens, 1910, Pl. 3, fig. 9
(Naturistoriska Riksmusset Mo 1602), by monotypy.

Material—10 complete specimens; some still preserving the original coloration of the periostracum.

Supplementary description—Shell thin, elongate, oval, compressed. Umbones situated posteriorly; ligament posterior to umbones. Shell height increases anteriorly. Shell almost smooth except in the anterior portion where there are low diagonal ondulations that increase in width towards the anterovental margin. Periostracum, where preserved, showing concentric lamellae with superimposed radial riblets. Periostracum dark brown to tan colloured with darker bands parallel to the ventral border.
Figure 175 -- A- Graph showing the relation of Anterior Length vs. Length in *Solemya (Solemya) rossiana*. B- Graph showing the relation of Length vs. Height in *Solemya (Solemya) rossiana*. 

*Solemya (Solemya) rossiana*
Large anterior muscle scar observed in some specimens.

**Measurements**

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-1</td>
<td>7.67</td>
<td>2.62</td>
<td>5.76</td>
<td>2.93</td>
<td>0.75</td>
</tr>
<tr>
<td>E-3</td>
<td>7.85</td>
<td>2.81</td>
<td>6.00</td>
<td>2.79</td>
<td>0.76</td>
</tr>
<tr>
<td>E-2</td>
<td>7.50</td>
<td>2.52</td>
<td>5.68</td>
<td>2.67</td>
<td>0.76</td>
</tr>
<tr>
<td>E-4</td>
<td>5.34</td>
<td>2.45</td>
<td>3.73</td>
<td>2.18</td>
<td>0.70</td>
</tr>
<tr>
<td>459-1</td>
<td>3.95</td>
<td>1.58</td>
<td>2.92</td>
<td>2.50</td>
<td>0.74</td>
</tr>
<tr>
<td>459-2</td>
<td>3.72</td>
<td>1.48</td>
<td>2.82</td>
<td>2.51</td>
<td>0.76</td>
</tr>
<tr>
<td>459-3</td>
<td>3.20</td>
<td>1.45</td>
<td>2.50</td>
<td>2.21</td>
<td>0.78</td>
</tr>
<tr>
<td>459-4</td>
<td>3.67</td>
<td>*1.50</td>
<td>2.95</td>
<td>2.53</td>
<td>0.80</td>
</tr>
<tr>
<td>459-5</td>
<td>*3.22</td>
<td>1.54</td>
<td>2.34</td>
<td>2.09</td>
<td>0.73</td>
</tr>
<tr>
<td>459-6</td>
<td>3.46</td>
<td>1.45</td>
<td>2.54</td>
<td>2.39</td>
<td>0.73</td>
</tr>
</tbody>
</table>

**Remarks**—Specimens from Locality E are much larger than those of Wilckens (1910) or those from Station 459 (Fig. 175). The measurements of specimens from Locality 459 coincide with those of Wilckens (1910, p. 66). Moreover, specimens from Locality E, differ by their more extended and acute posterior margin and may belong to a a different, new species. Until further material is available for study, they are temporarily considered as conspecific with *Solemya rossiana*.

**Localities**—Seymour Island, E (four specimens); 459 (six specimens). Additionally several specimens were found during the second expedition, in locality N-84

**Stratigraphic distribution**—Lopez de Bertodano Formation.

Subclass PTERIOMORPHA Beurlen, 1944

Order ARCOIDA Stoliczka, 1871

Family PARALLELODONTIDAE Dall, 1898

Subfamily GRAMMATODONTINAE Branson, 1942

Genus *Indogrammatodon* Cox, 1937
Type species—Cucullaea virgata J. C. de Sowerby, 1840, by original designation of Cox, 1937, p. 194.

Remarks—Cox (1937) established the genus Indogrammatodon as a subgenus of Nanonavis Stewart (1930). Newell (1969) considered Indogrammatodon as a subgenus of Grammatodon Meek and Hayden; later Tashiro (1976, p. 44) concluded that the hinge structure of Nanonavis and Indogrammatodon are identical and thus these two taxa are synonyms. He retained the senior name (Nanonavis) for them. Freneix (1980, p. 17) discussed the affinities of the taxon Indogrammatodon and concluded that it should be treated as an independent genus, following an earlier opinion by Ichikawa and Haeda (1958, p. 70-71). According to Freneix (1980) the difference between Indogrammatodon and Nanonavis lies in the presence of a radial ornamentation slightly different in both valves. Differences with Grammatodon are based on dentition and absence of radial ornamentation.

Indogrammatodon and Nordenskjoldia Wilckens (1910) are distinguished by the presence of a characteristic radial ornamentation in Indogrammatodon, and by the presence of an anterior pseudolateral tooth in Nordenskjoldia, which converges towards the umbo (Cf. Freneix, 1980, p. 18).

Indogrammatodon cf. lormandi Freneix
(Plate 22, Figs. 13,14; Plate 23, Figs. 1-5)

Nordenskjoldia nordenskjoldi Wilckens, 1910, pp. 26-30 (in part), Pl. 2,
fig. 10 (only).

*Indogrammatodon lormandi* Freneix, 1958, p. 20-22, Pl. 1, fig. 3.

*Indogrammatodon lormandi* Freneix, 1980, p. 16-17, Pl. 2, fig. 1-2.

Holotype—*Indogrammatodon lormandi* Freneix, 1958, Pl. 1, Fig. 3.

Type locality—Noumea Basin, New Caledonia.

Material—five complete specimens; two right valves.

Supplementary description—Shell subquadrate, moderately elongated (mean L/H=1.31), equivale, and inequilateral. Anterior margin evenly rounded. Ventral margin rounded and oblique, expanding in a posterior direction. Umbonal carina absent. Ventral and posterior margin meet at a rounded edge. Posterior margin truncated. Umbones mesogyrous to slightly prosogyrous and relatively thin, located anteriorly with respect to the middle of the shell. Ligamental area with chevron-shaped sulci (up to eight were found in Specimen 43-1). Hinge composed of five slightly bended downward anterior pseudolaterals, and four subhorizontal posterior pseudolaterals. Ventral margin crenulated.

External ornamentation composed of well-developed radial ribs that become more closely spaced in a posterior direction. Two or three secondary riblets are present in between primary ribs, and finely concentric ornamentation is superimposed on this pattern. The ribs of the left valve are wider apart and less raised than those of the right.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation(lv.)</th>
</tr>
</thead>
</table>

Remarks--This is the first record of Indogrammatodon in the Late Cretaceous sequence of Antarctica. I have also here some specimens collected in the Rio Baguales area (southern Chile) which should also be included in this genus. The antarctic specimens are apparently identical to I. lormandi, figured by Freneix (1980, P. 2, fig. 1). The general description as well as the measurements fit very closely with the new material under study. However, Freneix's material is fragmentary, making it difficult a more precise comparison.

The presence of the conspicuous radial ribs, as well as the differential ornamentation between the two valves, are typical characteristics of the genus Indogrammatodon.

Localities--Seymour Island, localities E, F, and K-43.

Stratigraphic distribution--Units 6 and 7 of the Lopez de Bertodano Formation.

Genus Nordenskjoldia Wilckens, 1910

Type species--Arca disparilis d'Orbigny, 1846, by original designation of Wilckens, 1910, p.30.

Remarks--Newell (1969, N.258) treated Nordenskjoldia as a subgenus of Grammatodon Meek and Hyden. However, the differences in the hinge structure, particularly the pseudolaterals converging towards the umbo.
in Nordenskjoldia and diverging towards the umbo in Grammatodon, separate the two taxa at the generic level, as originally described by Wilckens (1910, p. 30).

**Nordenskjoldia nordenskjoldi** Wilckens

(Plate 23, Figs. 6-12)

*Nordenskjoldia nordenskjoldi* Wilckens, 1910, p. 26-30 (in part), Pl. 2, Fig. 8a-c, 9a-b, 11.

*Lectotype*—*Nordenskjoldia nordenskjoldi* Wilckens, 1910, Pl. 2, Fig. 8a (Naturhistoriska Riksmuseet Mo 1552a,b), herein.

*Type locality*—Seymour Island.

*Material*—Eight right valves, five left valves; four complete specimens; one internal mould.

*Supplementary description*—Shell medium sized (mean length = 6.5 cm), subquadrate, elongated. Anterior margin rounded. Ventral margin usually straight but occasionally more rounded, subparallel to the dorsal margin. Umbonal carina well defined near the dorsal margin but disappearing towards the ventro-posterior margin. Posterior margin straight, subparallel to the anterior margin. Umbones very broad and depressed, located anteriorly of the median line. Ligamental area narrow with 7 to 15 chevron-shaped sulci. Hinge composed of four oblique anterior pseudolaterals and five subhorizontal posterior pseudolaterals, all of them showing a clear crenulation. Internal
margin crenulated. External ornamentation composed of fine concentric growth lines and flat, poorly developed radial ribs. Myophoric buttresses present in thicker specimens.

**Measurements**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation(l.v)</th>
<th>Sulci</th>
</tr>
</thead>
<tbody>
<tr>
<td>47+--1</td>
<td>6.68</td>
<td>4.97</td>
<td>1.88</td>
<td>1.34</td>
<td>0.28</td>
<td>2.60</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>37-10</td>
<td>6.74</td>
<td>4.79</td>
<td>1.96</td>
<td>1.41</td>
<td>0.29</td>
<td>2.22</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>47+--2</td>
<td>6.40</td>
<td>4.35</td>
<td>1.73</td>
<td>1.47</td>
<td>0.27</td>
<td>2.56</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>145-1</td>
<td>6.08</td>
<td>4.47</td>
<td>--</td>
<td>1.36</td>
<td>--</td>
<td>2.15</td>
<td>--</td>
<td>11</td>
</tr>
<tr>
<td>143-1</td>
<td>6.20</td>
<td>4.96</td>
<td>*1.60</td>
<td>1.25</td>
<td>0.26</td>
<td>2.32</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>143-2</td>
<td>6.18</td>
<td>4.20</td>
<td>1.65</td>
<td>1.47</td>
<td>0.27</td>
<td>1.98</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>SI-1</td>
<td>7.16</td>
<td>--</td>
<td>2.19</td>
<td>--</td>
<td>0.31</td>
<td>2.13</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>49-1</td>
<td>7.12</td>
<td>4.86</td>
<td>*1.84</td>
<td>1.47</td>
<td>0.26</td>
<td>*2.50</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>47+-3</td>
<td>6.36</td>
<td>4.38</td>
<td>1.92</td>
<td>1.45</td>
<td>0.30</td>
<td>2.53</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

X=6.55  
S=0.40

**Remarks**—This species is closely related to *Nordenskjoldia besairei* Collignon from the Maastrichtian of Madagascar. They differ however by the more massive hinge and smaller number of posterior pseudolaterals parallel to the hinge margin, and larger size of the Madagascar species (cf. Collignon, 1951, p. 55). *Nordenskjoldia moindouensis* Freneix from the Campanian of New Caledonia was created on the basis of a poorly preserved specimen (Freneix, 1980), but the hinge seems to be very similar to that of *N. nordenskjoldi*.

**Localities**—Seymour Island, stations F, H, 12, 47+; 49; 143; 144; 145; 37-10, and Snow Hill Island.

**Stratigraphic distribution**—Units 6 and 7 of the Lopez de Bertodano Formation.
Genus Cucullaea Lamarck, 1801

Type species—Arca labiata Solander (1786, p. 185)(=Cucullaea
auriculifera Lamarck, 1801, p. 116), by subsequent designation of

Generic characteristics—"Shell trapezoidal or sub-quadrangular,
ever pronouncedly inequilateral, posteriorly carinate, well inflated;
valve margins closed (byssus vestigial). Cardinal area of moderate
width and bearing a variable number of chevron-shaped ligamental
grooves. Dentition consisting in the adult shell of a median series of
short teeth perpendicular to the hinge-margin, and of two lateral series
each formed by from two to five elongate teeth which are more or less
parallel to the hinge margin. Posterior adductor usually, but not
invariably, attached in front to a thin, raised septum" Cox, 1940, p.
55.

Discussion—Newell (1969) followed Gillet (1924, p. 16) in dividing
the genus Cucullaea into two subgenera: C. (Cucullaea), only Cenozoic,
and C. (Idonearca) for specimens of Mesozoic age. However Cox (1940, p.
55) could not find significant differences between these two groups, and
considered C. (Cucullaea) and C. (Idonearca) as synonyms. This
criterion was followed by Speden (1970, p. 49), and is also accepted
here.

Cucullaea antarctica Wilckens

(Plate, 24, Figs. 1-10; Plate 25, Figs. 1,2; Text-Fig. 176)

Cucullaea antarctica Wilckens, 1907, p. 36-37, Pl. 6, fig. 5a-b; 6.

Lectotype—Cucullaea antarctica Wilckens, 1907, Pl. 6, Fig. 5a,b.
Herein.
Type locality—Sierra de los Baguales (Chile).

Material—Five left valves, nine right valves, eight complete specimens.

Supplementary description—Shell moderately large (5.8 to 7.6 cm), subquadrangular, inflated and équant (mean L/H = 1.13) Umbones mesogyrous located in a medial position and relatively elevated with respect to the cardinal area. Anterior and ventral margins evenly rounded, but in larger specimens the ventral margin tends to be flat. Posterior margin moderately truncated meeting with the ventral margin in a narrow curve.

Ligamental area moderately narrow in smaller specimens, crossed by widely spaced chevron-shaped sulci. In larger specimens ligament area composed of a zone of widely spaced sulci and a zone proximal to the commissural plane where sulci are more compressed. Number of sulci ranging from five to more than ten.

Ornamentation composed of concentric growth lines intercepted by less conspicuous (except when weathered) radial ribs. Hinge composed of four anterior and five posterior subhorizontal pseudolateral teeth and an irregular series of vertically arranged medial denticles. Internal margin denticulated. Myophoric ridge prominent.

Measurements—

<table>
<thead>
<tr>
<th>Specimen</th>
<th>N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation(1v)</th>
<th>Sulci</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-J-1</td>
<td>6.50</td>
<td>5.57</td>
<td></td>
<td>2.93</td>
<td>1.16</td>
<td>0.45</td>
<td>2.60</td>
<td>--</td>
</tr>
<tr>
<td>L-42-1</td>
<td>6.60</td>
<td>5.96</td>
<td></td>
<td>2.86</td>
<td>1.11</td>
<td>0.43</td>
<td>2.73</td>
<td>5a,5p</td>
</tr>
<tr>
<td>L-S1</td>
<td>5.93</td>
<td>5.15</td>
<td></td>
<td>*2.84</td>
<td>1.16</td>
<td>0.48</td>
<td>*2.30</td>
<td>--</td>
</tr>
<tr>
<td>L-153-1</td>
<td>6.65</td>
<td>5.90</td>
<td></td>
<td>2.83</td>
<td>1.13</td>
<td>0.43</td>
<td>2.92</td>
<td>8a,8p</td>
</tr>
<tr>
<td>L-186-1</td>
<td>7.41</td>
<td>6.84</td>
<td></td>
<td>3.00</td>
<td>1.08</td>
<td>0.40</td>
<td>3.55</td>
<td>--</td>
</tr>
<tr>
<td>L-J-2</td>
<td>7.67</td>
<td>--</td>
<td></td>
<td>3.35</td>
<td>--</td>
<td>--</td>
<td>3.26</td>
<td>10a,10p</td>
</tr>
</tbody>
</table>
L-B-1 7.07 6.00 2.87 1.18 0.41 -- -- 398
R-42-1 -- 5.69 2.84 -- -- 2.67 5a,5p
R-153-2 *6.38 5.65 2.73 1.13 0.43 2.79 8a,8p
R-179-1 *6.20 5.92 3.05 1.05 0.49 2.83 --
R-105-1 *5.85 5.75 2.85 1.02 0.49 2.84 8a,8p
R-J-3 6.89 5.54 2.73 1.24 0.40 3.11 >10
R-186-2 7.30 6.69 3.09 1.12 0.41 3.52 >10
R-J-2 7.60 6.40 *3.00 1.19 0.39 3.30 >10

X(LV)=6.83 X(LV)=1.13 X=2.95
S=0.59 S=3.72 S=0.37
X(RV)=6.74 X(RV)=1.12
S=0.71 S=0.08
X(t)=6.79 X(t)=1.13
S=0.62 S=0.06

L= left valve
R= right valve
*= measurement estimated

Remarks—This species is similar to the specimens described by Feruglio (1936, Pl. 12, figs. 4-5) as Cucullaea argentina Feruglio. After observing the original specimens which are preserved in the University of Bologne (Italy), it is clear that these two internal moulds are too fragmentary to create a new species and should be classified as Cucullaea sp. Cucullaea grahamensis Wilckens is not well represented in Seymour Island, but several undescribed well-preserved specimens are present in the bivalve collection of the British Museum (Natural History) and they differ from C. antarctica by being more quadrate with a well developed posterior carina.

Localities—Seymour Island, B, E, F, H, J, SI (Float); 42; 105; 151; 153; 179; 186. Additionally it was observed in stations 322; 330; 331; 332; 342; 356; 360; 361; 398; B-83; C-83; D-83; E-83.

Stratigraphic distribution—Lopez de Bertodano Formation, Units 6 to 9.
Figure 176-- Graph showing the relation of Length vs. Height in *Cucullaea antarctica* Wilckens and *Cucullaea ellioti* n.sp.

*Pinna anderssoni*

Figure 177-- Cross-sections of *Pinna anderssoni* Wilckens.
Cucullaea ellioti n. sp.

(Plate 25, Figs. 3-12; Text-Fig. 176)

Holotype—Plate 25, Figs 7,8; Specimen 9-13.

Material—14 left valves and 11 right valves; one complete specimen.

Origin of name—Species dedicated to Dr. David Elliot of the Institute of Polar Studies, The Ohio State University.

Diagnosis—Cucullaea of small size, elongate with depressed and broad umbos. Myophoric flange usually absent.

Description—Shell hardly exceeding 5.0 cm in length, swollen, moderately elongated (mean L/H=1.33); subquadract, sub-oval in outline. Inflation increases greatly in adult specimens. The anterior margin forms an almost rect angle with the cardinal area. Downward from the cardinal area a short straight border is continued in an evenly rounded fashion until it meets with the ventral margin. Ventral margin slightly curved forming a gently curvature where it continues into the posterior margin which is obliquely truncated.

Umbones low with respect to the cardinal area, placed in the anterior portion of the shell. Ligamental area relatively narrow, and having a variable number of sulci usually less than seven.

Ornamentation composed of concentric growth lines intercepted by radial ribs, conforming a cancellate pattern. Radial ribs absent in the postero-dorsal portion of the shell. Hinge composed of three or four
subhorizontal pseudolaterals and smaller denticles in a medial position.  
Internal margin crenulated; myophoric flange absent.

**Measurements**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>N. Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation(lv)</th>
<th>Sulci</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-9-1</td>
<td>4.85</td>
<td>3.59</td>
<td>1.72</td>
<td>1.35</td>
<td>0.35</td>
<td>1.67</td>
<td>--</td>
</tr>
<tr>
<td>L-9-2</td>
<td>3.75</td>
<td>3.13</td>
<td>1.37</td>
<td>1.20</td>
<td>0.37</td>
<td>1.03</td>
<td>--</td>
</tr>
<tr>
<td>L-9-3</td>
<td>4.64</td>
<td>3.40</td>
<td>1.51</td>
<td>1.36</td>
<td>0.33</td>
<td>1.70</td>
<td>--</td>
</tr>
<tr>
<td>L-9-4</td>
<td>*4.75</td>
<td>3.47</td>
<td>1.65</td>
<td>1.37</td>
<td>0.35</td>
<td>1.68</td>
<td>6a,4p</td>
</tr>
<tr>
<td>L-9-5</td>
<td>4.97</td>
<td>3.55</td>
<td>1.73</td>
<td>1.40</td>
<td>0.35</td>
<td>1.74</td>
<td>--</td>
</tr>
<tr>
<td>L-9-6</td>
<td>*5.55</td>
<td>4.33</td>
<td>1.80</td>
<td>1.28</td>
<td>0.32</td>
<td>2.07</td>
<td>--</td>
</tr>
<tr>
<td>L-9-7</td>
<td>4.86</td>
<td>3.67</td>
<td>1.73</td>
<td>1.32</td>
<td>0.36</td>
<td>1.70</td>
<td>--</td>
</tr>
<tr>
<td>L-9-8</td>
<td>--</td>
<td>3.23</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.40</td>
<td>--</td>
</tr>
<tr>
<td>L-9-9</td>
<td>4.78</td>
<td>3.57</td>
<td>1.81</td>
<td>1.34</td>
<td>0.38</td>
<td>1.74</td>
<td>7a,6p</td>
</tr>
<tr>
<td>L-9-10</td>
<td>4.88</td>
<td>3.51</td>
<td>1.63</td>
<td>1.39</td>
<td>0.33</td>
<td>1.68</td>
<td>--</td>
</tr>
<tr>
<td>L-9-11</td>
<td>*4.22</td>
<td>--</td>
<td>1.42</td>
<td>--</td>
<td>0.34</td>
<td>1.40</td>
<td>4a,4p</td>
</tr>
<tr>
<td>R-9-12</td>
<td>4.81</td>
<td>3.48</td>
<td>1.78</td>
<td>1.38</td>
<td>0.37</td>
<td>1.68</td>
<td>5a--</td>
</tr>
<tr>
<td>R-9-13</td>
<td>5.05</td>
<td>3.75</td>
<td>1.64</td>
<td>1.35</td>
<td>0.32</td>
<td>1.57</td>
<td>5a,4p</td>
</tr>
<tr>
<td>R-9-14</td>
<td>4.69</td>
<td>3.78</td>
<td>1.74</td>
<td>1.24</td>
<td>0.37</td>
<td>1.78</td>
<td>--</td>
</tr>
<tr>
<td>R-9-15</td>
<td>4.79</td>
<td>3.88</td>
<td>1.66</td>
<td>1.23</td>
<td>0.35</td>
<td>1.76</td>
<td>--</td>
</tr>
<tr>
<td>R-9-16</td>
<td>*4.95</td>
<td>3.62</td>
<td>1.88</td>
<td>1.37</td>
<td>0.38</td>
<td>1.54</td>
<td>--</td>
</tr>
<tr>
<td>R-9-17</td>
<td>4.61</td>
<td>3.31</td>
<td>1.64</td>
<td>1.39</td>
<td>0.36</td>
<td>1.57</td>
<td>--</td>
</tr>
<tr>
<td>R-9-18</td>
<td>4.77</td>
<td>3.63</td>
<td>1.65</td>
<td>1.31</td>
<td>0.35</td>
<td>1.60</td>
<td>--</td>
</tr>
</tbody>
</table>

\[
X(L)=4.72 \quad X(L)=1.33 \\
S=0.47 \quad S=0.06 \\
X(R)=4.81 \quad X(R)=1.32 \\
S=0.15 \quad S=0.07 \\
X(t)=4.76 \quad X(t)=1.33 \\
S=0.37 \quad S=0.06
\]

L= left valve  \quad t=right and left valves combined  
R= right valve  \quad *= measurement estimated

**Remarks**—This species clearly differs from *Cucullaea antarctica* by its smaller size, greater elongation, and by its depressed and broad umbones (Fig. 176). The absence of a myophoric flange is uncommon among species of *Cucullaea*. However Kauffman (written communication, 1979) after observing a large population preserved in the Smithsonian Institution of the living *Cucullaea cucullus* Gmelin, the Danian

*Cucullaea gigantea* Conrad, and *Idonearca capax* Conrad from the
Maastrichtian Coon Creek Tongue of the Ripley Formation in Tennessee, concluded that whereas **Idonearca** consistently has massive muscle platforms, Cenozoic and Recent species of **Cucullaea** have both large variations, ontogenetic and preservational in the posterior myophore.

"In ontogeny, the posterior buttress is at best a low thin rib in juveniles and a low, very thin and fragile plate or ridge in specimens up to about 5 cm; the posterior buttress then grows rapidly in medium size to large adults. On many Recent and fossil specimens in the 1-10 cm size range, the thin plate of the inner side of the myophore is broken off in part, or entirely, leaving only the rough base exposed" (Kauffmann, 1979, written communication). Most of the material under study here show clear signs of transport, and thus the absence of the myophoric ridge could alternatively be an artifact of preservation. Worn-out shells of this species give the impression of having much stronger radial costae than what they actually have.

**Localities**—Seymour Island, 70; 118; 119, and IPS-9. Additionally was found in stations 350; 351; 353; 373; 374; 350; 351; 353.

**Stratigraphic distribution**—Unit 19 of the Lopez de Bertodano Formation, extending to the base of the Sobral Formation.

**Family** LIMOPSIDAE Dall, 1895  
**Genus** Limopsis Sassi, 1827  
**Type species**—*Arca aurita* Brocchi, 1814, by original designation of Sassi, 1827, p. 476.

**Subgenus** Limopsis (Limopsis)

**Limopsis (Limopsis) antarctica** Wilckens

(Plate 26, Fig. 8)
**Limopsis antarctica** Wilckens, 1910, p. 31-34, Pl. 2, figs. 14, 15.

**Material**—One left valve.

**Supplementary description**—Shell small, ovoid, higher than wide, expanded posteriorly. Anterior margin extended and evenly curved, continued into a short ovoid ventral margin. Posterior and postero-dorsal margins slightly truncated. Umbones pointed. Ornamentation composed of evenly spaced thin concentric growth lines.

**Measurements**—

<table>
<thead>
<tr>
<th>Specimen</th>
<th>N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>St.5-1</td>
<td></td>
<td>1.32</td>
<td>1.45</td>
<td>0.37</td>
<td>0.91</td>
<td>0.28</td>
</tr>
</tbody>
</table>

**Remarks**—Although the hinge could not be observed in the available valve, its shape is identical to Wilckens' specimen (1910, Plate 2, fig. 14). The only noted difference is that the specimen figured here does not preserve the delicate radial ornamentation displayed in the original material.

**Locality**—Station St. 5, Seymour Island, Lopez de Bertodano Formation, Unit 9.

Order **MYTILOIDA** Ferussac, 1822

Family **PINNIDAE** Leach, 1819

Genus **Pinna** Linne, 1758

Subgenus **Pinna** (Pinna)

**Type species**—**Pinna rudis** Linne by subsequent designation of Children, 1823.

**Pinna (Pinna) anderssoni** Wilckens
Pinna anderssoni Wilckens, 1910, p. 11-14, Pl. 1, figs. 5,6.

Lectotype—Pinna anderssoni Wilckens, 1910, Pl. 1, fig. 6,
Naturhistoriska Riksmusset (Stockholm) Mo.1610. Herein.

Type locality—Snow Hill Island.

Material—seven specimens.

Supplementary description—Shell triangular, large (up to 21.5 cm) with median ridge well defined. Anterior end forming an apical angle ranging from 19° to 32°. Dorsal margin straight; ventral margin straight with minor sinuositites. Ventral portion of shell more inflated and more rounded in the younger portions. Ornamentation of the dorsal half of the shell composed of seven to eight longitudinal ribs which are crossed by thin perpendicular growth lines. Ventral portion with two types of ornamentation; the half closer to the median ridge has approximately 4–6 longitudinal ribs similar to those of the dorsal portion. The lower half of the shell bears oblique ribs which eventually develop as minor folds in the shell flank.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Max. Height</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-1</td>
<td>17.5</td>
<td>7.62</td>
<td>26</td>
</tr>
<tr>
<td>F-2</td>
<td>12.7</td>
<td>6.30</td>
<td>21</td>
</tr>
<tr>
<td>B-1</td>
<td>10.5</td>
<td>6.25</td>
<td>23</td>
</tr>
<tr>
<td>216-1</td>
<td>11.5</td>
<td>6.30</td>
<td>28</td>
</tr>
<tr>
<td>116-1</td>
<td>--</td>
<td>--</td>
<td>23</td>
</tr>
<tr>
<td>V-4</td>
<td>21.5</td>
<td>7.90</td>
<td>19</td>
</tr>
</tbody>
</table>

Wilckens 1910, Pl. 1, Fig. 6 32

Remarks—Wilckens, 1910 (p. 13) separated P. anderssoni from P.
morenoi Wilckens, on the basis of a more rapid increase in the width of the former species. However, this rate of expansion, as measured by the apical angle, was found to be very variable in the studied specimens, enough to overlap with values found in P. morenoi. The only difference that can be observed between these two species is that the ventral longitudinal ribs are not truncated by the oblique ribs in P. anderssoni. New material from Patagonia might prove the equivalence of these two species.

Pinna arata Forbes from the Trichinopoly Group of India, has a similar ornamentation and shape (apical angle= 25°)(Stoliczka, 1871, p. 384), but appear to have a larger number of longitudinal ribs (i.e. Stoliczka, 1871, Pl. 25, Fig. 1) due to the presence of intercalary ribs. Pinna noesmoeni Freneix (Freneix, 1958, Pl. 1, Fig. 7a-b) is very similar to P. anderssoni, differing by its large apical angle (35°) and by the presence of intercalary ribs. Pinna sp. B described by Willey 1975 (p. 127) from Alexander Island, Antarctica, differs by its larger apical angle.

Localities--Seymour Island, stations B, F; 72; 75; 116; 143; 157; 333; 334; 340; 342; 360; 361; 420; 423; 427; 428; G-83; Snow Hill Island, 216; Vega Island, V-4; also observed in Cockburn Island (Wilckens, 1910).

Order PTERIOIDA Newell, 1965

Family BAKEVELLIIDAE King, 1850

Genus Phelopteria Stephenson, 1952

Type species--Pteria? dalli Stephenson, by original designation.
Phelopteria sp.
(Plate 26, Figs. 5, 6, 7)

Material—19 specimens in a concretion.

Description—Shell small, subovate, expanded in a postero-ventral direction. Anterior auricle small and pointed. Posterior wing relatively short but clearly developed, and having a weak marginal sinus. Anterior and posterior margins subparallel, meeting in a moderately acute angle in the postero-ventral margin. Dorsal margin straight and extended. Beaks prosogyrous, pointed, and elevated above dorsal margin. Ligamental area composed of two shallow ligamental pits. Shell exterior almost smooth with the exception of thin concentric growth lines and ondulations. Left valve slightly more inflated than right.

Remarks—All specimens were found at the same locality, concentrated around a large specimen of the gastropod Amberleya
spinigera Wilckens. One specimen (Plate 26, Fig.6) developed around one spine of the gastropod, resulting in the formation of a circular scar. The presence of ligamental pits distinguish these specimens from specimens of the genus Pteria Scopoli, 1777, which also have a hinge with one or two toothlike processes. Phelopteria sp. is closely related to P. linguaeformis (Evans & Schumard) from the Maastrichtian Fox Hill Formation of South Dakota (i.e. Speden, 1970, Pl. 12, figs. 3-10).

Localities and stratigraphic distribution—Station 398, Unit 9 of the Lopez de Bertodano Formation.
Family PULVINITIDAE Stephenson, 1941
Genus Pulvinites DeFrance, 1824

Pulvinites antarctica Zinsmeister
(Plate 26, Figs. 1-4)


Material—Two well preserved specimens.

Remarks—This species has been recently described by Zinsmeister (1978) from the Lopez de Bertodano Formation of Seymour Island. The newly collected material closely agrees with the type material, also collected on Seymour Island.

Localities—Seymour Island, stations 322; 340.

Stratigraphic distribution—Units 8 and 9 of the Lopez de Bertodano Formation (upper Maastrichtian).

Family ENTOLIIDAE Korobkov, 1960
Genus Entolium Meek, 1865

Type species—Pecten demissus Phillips, by original designation

Subgenus Entolium (Entolium)

Entolium (Entolium) sp.
(Plate 26, Figs. 9-11)

Material—Six valves moderately to poorly preserved, mostly as casts.
Description—Shell thin, flat, subcircular. Umbonal angle varying from 95° to 117°. Anterior auricle well developed extending above hinge margin, and without a notch; anterior portion of the auricle convex. Ventral margin evenly rounded, more expanded in a posterior direction. Ornamentation composed of weak concentric growth lines. One mould of a left valve preserves five weak radial groves close to the center of the shell.

Measurements

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Length</th>
<th>Height</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>377-1</td>
<td>4.7</td>
<td>5.2</td>
<td>117</td>
</tr>
<tr>
<td>377-2</td>
<td>4.0</td>
<td>4.7</td>
<td>106</td>
</tr>
<tr>
<td>377-3</td>
<td>5.7</td>
<td>5.7</td>
<td>95</td>
</tr>
</tbody>
</table>

Remarks—These specimens are identical to _Pecten ex aff. membranaceus_ Mills. (in Wilckens, 1910, p. 17, Pl. 1, Fig. 9). The fact that in all observed specimens the posterior wing is broken, makes it difficult or impossible to make a precise determination of this material, and so a specific identification is not attempted.

_Syncyclonema membranaceus_ (Mills) (in Woods, 1917, p. 25, Pl. 11, figs. 3-5) is also very similar to my specimens. However, the extension of the auricles above the hinge margin in Woods’ as well as in the Seymour Island specimens, is more typical of the genus _Entolium_ than of _Syncyclonema._

Localities—Seymour Island, stations 377; C-83; O-83.

Stratigraphic distribution—Unit 9 of the Lopez de Bertodano Formation (upper Maastrichtian).
Family LIMIDAE Rafinesque, 1815

Genus *Acesta* Adams & Adams, 1858

Subgenus *Acesta* (*Acesta*)

Type species--*Lima* (*Callolima*) *rathbuni* Bartsch, 1913

*Acesta* (*Acesta*) *snowhillensis* (Wilckens)

(Plate 27, Fig. 7)

*Lima* (*Acesta*) *snowhillensis* Wilckens, 1910, p.14-16; Pl. 1, figs. 7a,b.

*Lectotype*--*Lima* (*Acesta*) *snowhillensis* Wilckens, 1910, Pl. 1, fig. 7a. Naturhistoriska Riksmuseet, Mo 1633 (cast), herein.

**Material**--One well preserved specimen, several casts.

**Supplementary description**--Shell large, equivelv, inequilateral. Umbones protruding above margin and pointed. Posterior margin with a broad, subcircular auricle, but anterior auricle absent. Ventro-posterior margin subparallel to the anterior margin, which is straight. Ornamentation composed of delicate concentric growth lines crossed by radial ribs, which are much better defined in the anterior and posterior areas of the shell.

**Measurements**--

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Length</th>
<th>Height</th>
<th>L/H</th>
</tr>
</thead>
<tbody>
<tr>
<td>37-17-1</td>
<td>8.3</td>
<td>9.2</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Localities**--Seymour Island, 337; 368; N-84; Snow Hill Island (Wilckens, 1910).

**Stratigraphic distribution**--Unit 9, Lopez de Bertodano Formation,
but also present in older beds in Snow Hill Island.

_Acesta (Acesta) webbi_ n.sp.

(Plate 27, Figs. 4-6)

_Holotype_—Specimen 72-1, (Plate 27, Figs. 4,5), Sobral Formation, Seymour Island.

_Material_—Two complete specimens.

_Origin of name_—Species dedicated to Dr. Peter N. Webb, Department of Geology and Mineralogy, The Ohio State University.

_Description_—Shell moderately large, mytiliform, equi-valve, inequilateral. Umbones very pointed, situated anteriorly, prosogyrous. Anterior auricle poorly defined. Posterior auricle well developed, straight. Anterior margin straight, concave; ventral margin ovoid. Posterior margin subrounded. Shell flank almost smooth. Ornamentation composed of delicate, concentric growth lines. Minute radial threads are preserved in the anterior margin of the holotype.

_Measurements_

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>L/H</th>
<th>Inflation (2v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>72-1</td>
<td>5.58</td>
<td>7.58</td>
<td>0.75</td>
<td>2.92</td>
</tr>
<tr>
<td>72-2</td>
<td>3.92</td>
<td>5.96</td>
<td>0.66</td>
<td>2.24</td>
</tr>
</tbody>
</table>

_Remarks_—The almost absence of radial ornamentation is uncommon among members of the family Limidae. Even though the material is well preserved, it is possible that the radial ornamentation was confined to a thin outer layer that could have been eroded away. _Acesta snowhillensis_ (Wilckens) is more inflated, and more expanded
posteriorly, resulting in a more rounded outline. Also, its anterior margin is not as straight as in Acesta webbi. "Lima" cf. latens Feruglio from the Maastrichtian of Lago Argentino in Patagonia (Feruglio, 1936, Pl. 14, figs. 10-11) is very close to Acesta webbi. However they differ because this new species has a more expanded posterior auricle and a more compressed outline.

Acesta marlbumensis (Woods) from New Zealand (Woods, 1917, Pl. 3, fig. 3) has a general similar shape but the posterior auricle is much more rounded, and the radial ornamentation much better defined. The ornamentation of Acesta webbi is very similar to that of Lima (Plagiostoma?) derby White from the Cretaceous of Brasil (White, 1888, Pl. 3, fig. 1) but it differs by its more developed anterior auricle.

Localities—Seymour Island, Station 72, Sobral Formation.

Genus Limatula Wood, 1839

Subgenus Limatula (Limatula) Fleming, 1978

Type species—Lima subauriculata (Montagu) by subsequent designation of Gray, 1847, p. 200.

Limatula (Limatula) antarctica (Wilckens)

(Plate 27, Figs. 1-3)

Lima (Limatula) antarctica Wilckens, 1910, p. 16-17, Pl. 1, Fig. 8.

Limatula (Limatula) antarctica (Wilckens), Fleming, 1978, p. 52, Fig. 26.

Limatula (Limatula) parisii Freneix, 1980, p. 93-94, figs. 3-4.

Holotype—Lima (Limatula) antarctica Wilckens, 1910, Pl. 1, Fig. 8,
by monotypy (Naturhistoriska Riksmuseet, Mol636).

Type locality—Seymour Island.

Material—Three complete specimens and four single valves.

Supplementary description—Shell small, opisthocline, with a convex, rounded posterior margin and a more compressed anterior margin. Auricles very small. Ornamentation composed of five to eight radial ribs located in the medial portion of the flank or somewhat anteriorly. Anterior and posterior portions of flank smooth.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Oblique length</th>
<th>Oblique width</th>
</tr>
</thead>
<tbody>
<tr>
<td>180−1</td>
<td>1.56</td>
<td>1.00</td>
</tr>
<tr>
<td>458−1</td>
<td>2.79</td>
<td>1.53</td>
</tr>
<tr>
<td>195−1</td>
<td>0.89</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Remarks—A much wider range in sizes is observed in the present collection from Seymour Island than that afforded by the single specimen figured by Wilckens (1910). According to Fleming (1978, p. 52), the differences between *L. (Limatula) antarctica* and *L. (Limatula) sp. indet* (=*Lima (Limatula) huttoni* Woods, 1917, Pl. 12, fig. 15) are the larger size, the more opisthocline character and the more convex posterior margin of the former. The last two characters are still valid differences.

*L. (Limatula) parisi* Freneix (in Freneix, 1980, Pl. 3, Fig. 3−4) is identical to *L. (Limatula) antarctica*, and its size is comparable to some of the small specimens found in Seymour Island.

Localities—Seymour Island, 458; 175; 180; 195; 337; 340; 342; 360;
398. Snow Hill Island (Wilckens, 1910).

**Stratigraphic distribution**—On Seymour Island, present in Unit 7 but more abundant in Unit 9 of the Lopez de Bertodano Formation.

Order TRIGONIOIDA Dall, 1889

Family TRIGONIIDAE Lamarck, 1819

Subfamily NOTOTRIGONIINAE Skwarko, 1963

Genus *Laevitrugia* Lebkuchner, 1932

Subgenus *Laevitrugia* (Eselaevitrugia) Kobayashi and Mori, 1954

**Type Species**—*Trigonia meridiana* Woods, 1917, by original designation.

*Laevitrugia* (Eselaevitrugia) ecplecta (Wilckens)

(Plate, 27, Fig. 10; Plate 28, Figs. 1-7; Text-fig. 178)

*Trigonia* ecplecta Wilckens, 1907, pp. 37-39, Pl. 7, fig. 2

*Trigonia* cf. ecplecta Wilckens, 1907, pp. 39-40, Pl. 7, fig. 5a-b.

*Trigonia regina* Wilckens, 1910, pp. 41, Pl. 2, figs. 22-26.

*Trigonia regina* Wilckens, Feruglio, 1936, pp. 103-104, Pl. 12, Fig. 9.

*Eselaevitrugia regina* (Wilckens), Medina, 1980, p. 109-110, Pl. 2, figs. 3-4; Pl. 3, figs. 1-3.

**Lectotype**—*Trigonia ecplecta* Wilckens, 1907, Pl. 7, Fig. 2, (Museo de La Plata N. 9005) herein.

**Type locality**—Sierra de los Baguales, southern Chile.

**Material**—20 left valves, 14 right valves, 2 complete specimens and
10 internal moulds. Also a left valve from Cerro Cazador (Argentina).

**Supplementary description**—Shell moderately large, equant to moderately elongate, of subtrigonal to oval outline. Beaks located anteriorly, pointed, and slightly ophistogyre. Anterior border evenly rounded, continued without break into the ventral margin. Ventral and dorsoventral margin meeting in a rounded edge. Dorsal margin straight and oblique, meeting the dorsal-ventral margin at a wide angle. Marginal carina absent in adult stages; insinuated in younger stages. Estucheon carina ill defined. Area rounded and inflated, difficult to differentiate from the flank. Interior margin smooth. Flank ornamentation with unevenly concentric costae, more spaced and rised in the later stages. Some costae oblique and locally coalesce with other costae. Anterior portion of the shell the costae usually discontinuous and with a kink. A very faint radial ornamentation observed in the area of the younger portion of some specimens.

**Measurements**--

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>A2/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-E-2</td>
<td>4.31</td>
<td>3.65</td>
<td>1.25</td>
<td>1.18</td>
<td>0.29</td>
</tr>
<tr>
<td>L-116</td>
<td>5.64</td>
<td>4.92</td>
<td>1.38</td>
<td>1.15</td>
<td>0.24</td>
</tr>
<tr>
<td>L-37-19-5</td>
<td>5.25</td>
<td>4.05</td>
<td>1.57</td>
<td>1.30</td>
<td>0.30</td>
</tr>
<tr>
<td>L-37-19-6</td>
<td>5.57</td>
<td>4.83</td>
<td>1.60</td>
<td>1.15</td>
<td>0.29</td>
</tr>
<tr>
<td>L-J</td>
<td>6.00</td>
<td>4.20</td>
<td>1.62</td>
<td>1.43</td>
<td>0.27</td>
</tr>
<tr>
<td>L-37-19-7</td>
<td>7.39</td>
<td>—</td>
<td>1.64</td>
<td>—</td>
<td>0.22</td>
</tr>
<tr>
<td>L-81</td>
<td>5.80</td>
<td>4.60</td>
<td>1.54</td>
<td>1.26</td>
<td>0.26</td>
</tr>
<tr>
<td>R-37-19</td>
<td>5.64</td>
<td>4.97</td>
<td>1.55</td>
<td>1.13</td>
<td>0.27</td>
</tr>
<tr>
<td>R-116-1</td>
<td>5.50</td>
<td>5.16</td>
<td>1.30</td>
<td>1.07</td>
<td>0.24</td>
</tr>
<tr>
<td>R-37-19-2</td>
<td>4.72</td>
<td>4.20</td>
<td>1.14</td>
<td>1.12</td>
<td>0.24</td>
</tr>
<tr>
<td>R-37-19-3</td>
<td>5.16</td>
<td>4.21</td>
<td>1.27</td>
<td>1.23</td>
<td>0.25</td>
</tr>
<tr>
<td>R-37-19-4</td>
<td>5.44</td>
<td>4.50</td>
<td>1.27</td>
<td>1.21</td>
<td>0.23</td>
</tr>
<tr>
<td>R-E-1</td>
<td>4.12</td>
<td>3.42</td>
<td>1.09</td>
<td>1.20</td>
<td>0.26</td>
</tr>
<tr>
<td>R-179-1</td>
<td>5.74</td>
<td>5.29</td>
<td>1.50</td>
<td>1.08</td>
<td>0.26</td>
</tr>
</tbody>
</table>
Figure 178-- Graph showing the relation of Length vs. Height in *Laevitrigonia (Eselaevitrigonia) eclecta* (Wilckens) and in *Linotrigonia (Oistotrigonia) pygoscélum* (Wilckens).
| R-186-1 | 4.21 | *3.32 | 1.11 | 1.27 | 0.26 |
| R-181-1 | *6.36 | *5.18 | 1.87 | 1.23 | 0.29 |
| R-181-2 | 4.78 | — | 1.37 | — | — |
| R-SI    | *6.00 | 5.18 | 1.69 | 1.16 | 0.28 |

X=5.42  
S=0.81  

X=1.20  
S=0.09

* = measurement estimated  
L= left valve  
R= right valve

Remarks—This species was originally described by Wilckens (1907) from southern Patagonia on the basis of a poorly preserved right valve. From the same area Wilckens also described one specimen as *Trigonia* cf. *ecplecta*, being the main difference between these two specimens the presence of a kink in the anterior ornamentation in the former (Wilckens, 1907, p. 39). Latter, when describing "*Trigonia*" *regina* from Seymour and Snow Hill islands, Wilckens (1910, p. 46) concluded that "*Trigonia*" cf. *ecplecta* was identical to the antarctic species. The measurements of "*Trigonia*" cf. *ecplecta* fall well into the observed range of variation of the specimens described here from Seymour Island (Fig. 178). The availability of a new large collection allows to observe a range of variation of different characters. Most of the specimens from Seymour Island show the same upward swing in the anterior ornamentation as in the holotype of *L. (Eselaevitrigonia) ecplecta*. Wilckens (1910) compared "*Trigonia*" *regina* with "*Trigonia*" cf. *ecplecta* but did not summarize the differences between "*Trigonia*" *ecplecta* and "*Trigonia*" *regina*. Looking at the figures it seems that the differences between "*T.*" *ecplecta* and "*T.*" *regina* are related to the larger size and to the presence of wider costae in the former. The specimens from Seymour Island show a large variation in the development of the kink in
the anterior concentric ornamentation, with cases where it is very difficult to distinguish to cases where it is pronouncedly marked. The concentric ornamentation is also variable in size and shape, with cases where the costae are as separated as in the lectotype of "T." ecplecta and others, more frequent, where the costae are more closely spaced. It is concluded in the light of a larger collection that "Trigonia" ecplecta and "Trigonia" regina are synonyms to which the senior name should apply. Medina (1980, p. 110) was of the opinion that "T." regina Wilckens (in Feruglio, 1936, Pl. 12, fig. 9) differed from the typical "T." regina by its irregularities in the concentric ornamentation. However these irregularities are common in many antarctic specimens.

The generic status of this species has been a matter of debate. This species has been alternatively included in the genus Rutitrionia (Cox, 1952, p. 59); Pacitrionia (Cox, 1952, p. 63; Nakano, 1961, p. 86; Perez and Reyes, 1978, p. 13); Nototritonia (Reyes and Perez, 1979, p. 24); and Laevitrionia (Eselaevitrionia)(Medina, 1980, p. 110). Nakano (1970, p. 103-106) believes that "Trigonia" regina could be an immature form of "Trigonia" ecplecta and included this species in the genus Nototritonia. As also pointed out by Medina (1980, p. 110), this species lacks the antecarinal depression, typical of both Nototritonia and Pacitrionia, which also have an oblique ornamentation in the flank, as opposed to a concentric ornamentation in Laevitrionia (Eselaevitrionia) ecplecta. The area of this species is, however, more rounded and lacks the depression insinued in Laevitrionia (Eselaevitrionia) meridiana (Woods), and could alternatively be
considered as a member of the genus *Rutitrigonia*, which in some specimens lack the antecarinal depression and display a very similar ornamentation.

Localities—Seymour Island, 37; 42; 47+; 37-60; 116; 143; 151; 153; 157; 160; 178; 179; 181; 182; 186; 189; 191; 319; 330; 337; 340; 357; 361; 366; 368; 398; 423; 428; 429; Locs. B, E, F, J, SI (Float); L-84; M-84; D-83, and WZ-37-19. Other localities: Snow Hill Island, Humps Islet, Cape Lamb, Sierra Contreras, Chile; Sierra de los Baguales, Chile; Cerro Cazador (Argentina, Chile).

Stratigraphic distribution—On Seymour Island: Units 6 to 9 of the Lopez de Bertodano Formation.

Subfamily *MYOPHORELLINAE* Kobayashi and Tamura, 1955

Genus *Linotrigonia* Van Hoepen, 1929

Subgenus *Linotrigonia* (*Oistotrigonia*) Cox, 1952

Type Species—*Trigonia spinosa* Parkinson, 1811, by original designation.

*Linotrigonia* (*Oistotrigonia*) *pygoscelium* (Wilckens)

(plate, 28, Figs. 8-15; Text-fig. 178)

*Trigonia pygoscelium* Wilckens, 1910, p. 39-41, Pl. 2, fig. 21a-b.


Holotype—*Trigonia pygoscelium* Wilckens, 1910, Pl. 2, fig. 21a-b
(Naturistoriska Riksmuseet, Stockholm Mo 1500a,b), by monotypy.

**Type locality**—Seymour Island.

**Material**—12 left valves; 13 right valves.

**Supplementary description**—Shell small, equant ($L/H=1.02-1.07$) of subtriangular to trapezoidal shape. Umbones prominent and pointed, located in an anterior position and very slightly opistogyre. Anterior margin moderately straight to convex. Ventral margin subrounded but becoming more straight in larger specimens; meets the straight dorso-ventral margin forming a wide angle. Dorsal margin straight and oblique, with a slight concavity in the center. Marginal carina present but poorly developed; estucheon carina better defined. Flank ornamentation cancellate, originated by the intersection of straight radial ribs which become slightly bended in the anterior region, and evenly spaced commarginal grooves. Nodes develop at the intersection of these two trends. A similar pattern of ornamentation is observed in the area. Ornamentation of the area and flank meet very close to the marginal carina, forming a chevron-shaped pattern. Interior margin denticulated, except in the posteroventral margin.

**Measurements**

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-39-1</td>
<td>3.28</td>
<td>3.03</td>
<td>1.15</td>
<td>1.08</td>
<td>0.35</td>
</tr>
<tr>
<td>L-SI-1</td>
<td>1.57</td>
<td>1.43</td>
<td>0.50</td>
<td>1.10</td>
<td>0.32</td>
</tr>
<tr>
<td>L-SI-2</td>
<td>1.38</td>
<td>1.35</td>
<td>0.40</td>
<td>1.02</td>
<td>0.29</td>
</tr>
<tr>
<td>L-46-1</td>
<td>1.82</td>
<td>1.75</td>
<td>0.56</td>
<td>1.04</td>
<td>0.31</td>
</tr>
<tr>
<td>L-SI-3</td>
<td>2.98</td>
<td>2.32</td>
<td>0.61</td>
<td>0.78</td>
<td>0.20</td>
</tr>
<tr>
<td>L-SI-4</td>
<td>1.77</td>
<td>1.63</td>
<td>0.49</td>
<td>1.09</td>
<td>0.28</td>
</tr>
<tr>
<td>L-166-1</td>
<td>1.90</td>
<td>1.97</td>
<td>0.70</td>
<td>0.96</td>
<td>0.37</td>
</tr>
<tr>
<td>L-SI-5</td>
<td>2.30</td>
<td>2.20</td>
<td>0.70</td>
<td>1.04</td>
<td>0.30</td>
</tr>
<tr>
<td>L-E-1</td>
<td>3.10</td>
<td>3.05</td>
<td>*0.80</td>
<td>1.02</td>
<td>0.26</td>
</tr>
<tr>
<td>L-E-2</td>
<td>3.16</td>
<td>3.00</td>
<td>*1.00</td>
<td>1.05</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>R-SI-6</td>
<td>R-147-1</td>
<td>R-39-2</td>
<td>R-46-1</td>
<td>R-43-1</td>
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<tr>
<td>-----</td>
<td>--------</td>
<td>---------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>X</td>
<td>3.20</td>
<td>2.39</td>
<td>2.63</td>
<td>1.90</td>
<td>2.50</td>
</tr>
<tr>
<td>S</td>
<td>2.93</td>
<td>2.33</td>
<td>2.50</td>
<td>1.84</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>0.91</td>
<td>0.64</td>
<td>0.71</td>
<td>0.60</td>
<td>0.83</td>
</tr>
<tr>
<td>X</td>
<td>1.09</td>
<td>1.03</td>
<td>1.05</td>
<td>1.03</td>
<td>1.18</td>
</tr>
<tr>
<td>S</td>
<td>0.28</td>
<td>0.27</td>
<td>0.27</td>
<td>0.32</td>
<td>0.33</td>
</tr>
</tbody>
</table>

X=2.34  X=1.04  X=0.30  S=0.64  S=0.08  S=0.04

*= measurement estimated
L= left valve
R= right valve

Discussion—There is a tendency in smaller specimens to be more inflated than larger ones. This species differs from the closely related species L. (Oistotrigonia) antarctica (Wilckens) from Snow Hill Island, because the latter has a more rounded outline, mostly because the ventro-posterior and the ventral margin meet transitionally and not in a sharp angle like in L. (Oistotrigonia) pygoscelium.

Localities—Seymour Island, 37; 39; 41; 43; 46; 144; 147; 166; 315; 359; 426; 428; SI (float), and loc. E.

Stratigraphic distribution—Lopez de Bertodano Formation, Units 6 to 9.

Subclass HETERODONTA Neumayr, 1884
Order VENEROIDA H. & A. Adams, 1856
Family LUCINIDAE Fleming, 1828
Genus Lucina Bruguiere, 1797
Type species—Venus jamaicensis Spengler, 1784

Lucina? scotti (Wilckens)
Phacoides scotti Wilckens, 1910, p. 57, Pl. 3, fig. 2a-b.

Lectotype—Phacoides scotti Wilckens, 1910, Pl. 3, fig. 2a-b (Naturhistoriska Riksmuseet Mo 1563).

Phacoides scotti Wilckens, 1910, p. 57, Pl. 3, fig. 2a-b.

Lectotype—Phacoides scotti Wilckens, 1910, Pl. 3, fig. 2a-b (Naturhistoriska Riksmuseet Mo 1563).

Material—One complete specimen.

Supplementary description—Shell small somewhat elongated for a lucinid, and prosocline. Beaks low, prosogyrous; lunule incised, small and elongated; estucheon extending along the entire postero-dorsal margin. Ornamentation composed of strong, concentric lamellae that become more irregular ventrally. Anterior margin oval; ventral margin subrounded but forming a wide angle when crossing the median line. Posterior margin short and truncated.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation(2v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>459-1</td>
<td>2.67</td>
<td>2.21</td>
<td>1.27</td>
<td>1.21</td>
<td>0.48</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Discussion—The generic identification of this species is difficult to confirm without the possibility of observing internal features such as dentition and shape of the pallial line. The external shape and the large nymph resemble that of Nymphalucina occidentalis (Morton) from the
Maastrichtian of South Dakota (Speden, 1970, Pl. 22, figs. 12-14; Pl 23; Pl 24, figs. 1-2; 4-7). Also this species resembles externally to "Phacoides" (Callucina) bermudensis Dall (Dall, 1901, Pl. 39, fig. 5).

Specimen 459-1 differs slightly in lateral outline with Lucina scotti (Wilckens, 1910, Pl.3, fig. 2) because it is more rounded and has a larger posterior margin, but an observation of the original material of Wilckens confirms the identity of this two specimens.

Localities—Seymour Island, Stations WZ-459; 429; B-83, N-84, Lopez de Bertodano Formation.

Family THYASIRIDAE Dall, 1901
Genus Thyasira Leach in Lamarck, 1818
Subgenus Thyasira (Conchocele) Gabb, 1866
Type species—Lucina bisecta Conrad, 1849 (=L. disjuncta Gabb 1866) by original designation of Gabb, 1866.

Thyasira (Conchocele) townsendi (White)
(Plate 31, Figs. 1, 2)

Lucina? townsendi White, 1890, p. 14, Pl. 3, figs 1-2
Lucina? townsendi White, Weller, 1903, p. 415, Pl. 1, figs. 2-3
Thyasira townsendi (White) Wilckens, 1910, p. 53, Pl. 2, fis. 31a-c; Pl. 3, fig. 1.

Holotype—Lucina? townsendi White, 1890, p. 14, Pl. 3, figs. 1-2,
by monotypy.

**Material**—Three complete and well preserved specimens, one internal mould.

**Supplementary description**—Shell medium to large sized, suboval, inflated, and enlarged posteriorly. Umbones prominent, pointed, and prosogyrous. Apical angle varying from 90° to 110°. Primary sulcus of the valve exterior (Kauffman, 1969, p. 184) extremely incised. Submarginal sulcus present but less incised. Anterior margin subrounded, extended. Ventral margin moderately rounded. Posterior margin starts with a deep marginal notch and continues gently curved. Lunule slightly concave, poorly developed. Estuchon narrow and elongate. External ornamentation composed of irregular concentric growth lines. Internal ornamentation composed of delicate radial ribs.

**Measurements**—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation (2v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>459-1</td>
<td>5.08</td>
<td>5.26</td>
<td>1.69</td>
<td>0.97</td>
<td>0.33</td>
<td>2.63</td>
</tr>
<tr>
<td>E-1</td>
<td>5.05</td>
<td>5.50</td>
<td>1.71</td>
<td>0.92</td>
<td>0.34</td>
<td>2.76</td>
</tr>
<tr>
<td>E-2</td>
<td>7.50</td>
<td>8.00</td>
<td>*2.40</td>
<td>0.94</td>
<td>0.32</td>
<td>5.78</td>
</tr>
</tbody>
</table>

* measurement estimated.

**Discussion**—The posteriorly elongated shape of these specimens is typical of the subgenus *Thyasira* (*Conchocele*), which until now was regarded to have a range from the Oligocene to the Recent. This species is very close to the recent *Thyasira* (*Conchocele*) *bisepta* Conrad (in Dall, 1901, Pl. 42, Fig. 5; Abbott, 1974, p. 463, fig. 5336), but differs by its more incised posterior marginal notch. *T. collignoni* Freneix (Freneix, 1980, Pl. 5, Fig. 1a-b) is also similar but less
expanded posteriorly than the antarctic species.

Localities—Seymour Island, Loc. E; B-83; N-84; WZ-459; Snow Hill Island, Lopez de Bertodano Formation.

Family ASTARTIDAE d'Orbigny, 1844
Subfamily ERIPHYLINAE Chavan, 1952
Genus Eriphyila Gabb, 1867
Subgenus Eriphyila (Eriphyila)

Type species—Eriphyila umbonata Gabb, 1864, by original designation.

Eriphyila (Eriphyila) drygalskiana Wilckens
(Plate 30, Figs. 1-4)

Holotype—Eriphyila drygalskiana Wilckens, 1910, Pl. 3, Figs. 3a-3b, Naturhistoriska Riksmuseet, Mø1510, by monotypy.

Material—Four right and seven left valves, very well preserved.

Supplementary description—Shell moderately inflated, suborbicular, with maximum height slightly larger than the length (mean elongation = 0.95). Anterior and ventral margins evenly rounded; posterior margin more straight. Posterior and ventral margin meet forming a small inflection. Beaks very prosogyrous and acute. Lunule strongly incised, heart shaped. Estucheon narrow, deep. External ornamentation of fine concentric growth lines. Pallial sinus shallow.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>3.44</td>
<td>3.54</td>
<td>1.65</td>
<td>0.97</td>
<td>0.48</td>
</tr>
<tr>
<td>R-2</td>
<td>4.04</td>
<td>4.06</td>
<td>1.85</td>
<td>0.99</td>
<td>0.46</td>
</tr>
<tr>
<td>R-3</td>
<td>3.11</td>
<td>3.16</td>
<td>1.54</td>
<td>0.98</td>
<td>0.49</td>
</tr>
<tr>
<td>R-4</td>
<td>3.62</td>
<td>3.77</td>
<td>1.76</td>
<td>0.96</td>
<td>0.49</td>
</tr>
<tr>
<td>L-5</td>
<td>3.42</td>
<td>3.67</td>
<td>1.58</td>
<td>0.93</td>
<td>0.46</td>
</tr>
<tr>
<td>L-6</td>
<td>--</td>
<td>3.88</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>L-7</td>
<td>3.26</td>
<td>3.51</td>
<td>1.50</td>
<td>0.92</td>
<td>0.46</td>
</tr>
<tr>
<td>L-8</td>
<td>4.00</td>
<td>--</td>
<td>1.99</td>
<td>--</td>
<td>0.50</td>
</tr>
<tr>
<td>L-9</td>
<td>3.18</td>
<td>3.27</td>
<td>1.46</td>
<td>0.97</td>
<td>0.46</td>
</tr>
<tr>
<td>L-10</td>
<td>3.45</td>
<td>3.84</td>
<td>1.74</td>
<td>0.90</td>
<td>0.50</td>
</tr>
</tbody>
</table>

R= right valve  
L= left valve

Remarks—The only specimen of *Eriphyla drygaslkiana* figured by Wilckens (1910) has a prominent angularity in the middle of the ventral margin. An inspection of the original material preserved in Stockholm (Naturhistoriska Riksmuseet, Mo 1510) reveals that this angularity is due to secondary deformation. In fact this specimen has several cracks along which the shell was slightly displaced, but they were not represented in the artistic reconstruction of Plate 3, Figs. 3a-b (Wilckens, 1910). The new material from Seymour Island is identical to Wilckens's specimen, considering that the later is deformed. *Eriphyla meridiana* (Woods) from the Cretaceous of New Zealand is a junior synonym of *E. drygaslkiana*.

*Eriphyla diversa* Stoliczka, *E. lenticularis* Goldfuss and *E. forbesiana* Stoliczka from the Cretaceous of India (in Stoliczka, 1871, Pl. 6, Figs. 6; 7b and 14-16 respectively) are more compressed and have less extended umbones than *E. drygaslkiana*. *Eriphyla camachoii* Del Valle (Del Valle et al., 1982) from Vega Island has not been described or figured and thus is an invalid name.
Localities—Seymour Island, 42 and WZ 37-10. Lopez de Bertodano Formation.

Family LAHILLIDAE Finlay and Marwick, 1937
Genus Lahilla Cossmann, 1899
Subgenus Lahilla (Lahilla)

Type species—Amathusia angulata Philippi, 1887, by subsequent designation of Finlay and Marwick, 1937.

Lahilla (Lahilla) larseni (Sharman and Newton)
(Plate 29, Figs. 1-6; Text-fig. 179)

Cyprina larseni Sharman and Newton, 1898, p. 59-60, Pl. 1
Lahilla luisa (Wilckens), Wilckens, 1910, p. 58-63; Pl. 3, Figs. 4,5,6,7a-c,11.

Hypotype—Lahilla luisa (Wilckens), Wilckens, 1910, Pl. 3, Fig. 11. Naturhistoriska Riksmuseet (Stockholm) No. 1278), herein.

Type locality—Seymour Island.

Material—35 complete specimens, mostly well preserved.

Supplementary description—Shell large (X = 9.18 cm) of subquadrate outline; inflated, equi valve, subequilateral. Umbones rounded, prosogyrous, situated medially. Anterior portion of shell rounded, slightly compressed and produced. Ventral margin evenly rounded. A faint marginal carina marks the beginning of the posterior margin which
Figure 179-- Graph showing the relation of Length vs. Height in *Lahilla (Lahilla) larseni* (Sharman and Newton).
is more truncated. Posterior area slightly flatter than the rest of
flank. Ligament opisthodetic, wide and long (preserved in some
specimens), situated on a large nymph. Hinge massive with a broad hinge
plate. Ornamentation composed of widely spaced concentric ribs.

**Measurements—**

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation (2v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.80</td>
<td>8.82</td>
<td>*5.40</td>
<td>1.11</td>
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</tr>
<tr>
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</tr>
<tr>
<td>3</td>
<td>10.42</td>
<td>*8.75</td>
<td>*5.30</td>
<td>1.19</td>
<td>0.51</td>
<td>6.65</td>
</tr>
<tr>
<td>4</td>
<td>9.45</td>
<td>8.61</td>
<td>*5.03</td>
<td>1.10</td>
<td>0.53</td>
<td>6.82</td>
</tr>
<tr>
<td>5</td>
<td>*7.35</td>
<td>*6.70</td>
<td>*3.65</td>
<td>1.10</td>
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<td>4.88</td>
</tr>
<tr>
<td>6</td>
<td>8.50</td>
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<td>*4.05</td>
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<td>5.54</td>
</tr>
<tr>
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<td>0.44</td>
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<tr>
<td>8</td>
<td>8.52</td>
<td>8.15</td>
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<td>0.53</td>
<td>6.05</td>
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<tr>
<td>9</td>
<td>9.37</td>
<td>8.44</td>
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<td>6.40</td>
</tr>
<tr>
<td>10</td>
<td>*9.75</td>
<td>8.60</td>
<td>4.35</td>
<td>1.13</td>
<td>0.45</td>
<td>6.03</td>
</tr>
<tr>
<td>11</td>
<td>9.00</td>
<td>8.22</td>
<td>*4.74</td>
<td>1.09</td>
<td>0.53</td>
<td>5.95</td>
</tr>
<tr>
<td>12</td>
<td>8.58</td>
<td>7.85</td>
<td>*4.01</td>
<td>1.09</td>
<td>0.47</td>
<td>5.52</td>
</tr>
<tr>
<td>13</td>
<td>9.74</td>
<td>8.30</td>
<td>5.10</td>
<td>1.17</td>
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<td>6.22</td>
</tr>
<tr>
<td>14</td>
<td>10.54</td>
<td>9.11</td>
<td>5.40</td>
<td>1.16</td>
<td>0.51</td>
<td>6.88</td>
</tr>
<tr>
<td>15</td>
<td>9.34</td>
<td>8.58</td>
<td>4.75</td>
<td>1.09</td>
<td>0.51</td>
<td>6.50</td>
</tr>
<tr>
<td>16</td>
<td>9.10</td>
<td>8.13</td>
<td>4.65</td>
<td>1.12</td>
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</tr>
<tr>
<td>17</td>
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<td>9.47</td>
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<td>1.11</td>
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<td>7.16</td>
</tr>
<tr>
<td>18</td>
<td>7.00</td>
<td>6.22</td>
<td>3.50</td>
<td>1.13</td>
<td>0.50</td>
<td>4.46</td>
</tr>
<tr>
<td>19</td>
<td>9.47</td>
<td>8.80</td>
<td>*4.62</td>
<td>1.08</td>
<td>0.49</td>
<td>6.76</td>
</tr>
</tbody>
</table>

X=9.18  X=1.12  X=0.50
S=0.95  S=0.04  S=0.03

*= measurements estimated.

**Remarks—** The systematic affinities of this species are currently
being studied by Zinsmeister. Lahilla larsenl differs from Lahilla
luisa (Wilckens) from the late Cretaceous of Patagonia by its more
inflated shell, its produced anterior, generally larger size, and much
more massive hinge at comparable sizes. Lahilla gigantea Feruglio
(Feruglio, 1936, Pl. 14, Fig. 12) differs from L. larseni because it
lacks the marginal carina and a defined posterior area; additionally it
is not produced anteriorly and attains a larger size.
Localities—Seymour Island, 55; 69; 70; 71; 72; 75; 118; 119; 156; 157; 160; 181; 190; 332; 334; 340; 341; 342; 343; 347; 350; 351; 352; 353; 358; 360; 361; 362; 364; 366; 368; 372; 373; 374; 375; 376; 399; 401; 404; 405; 406; 407; C-83; N-84. Lopez de Bertodano and Sobral formations. Present also in Snow Hill Island.

Family VENERIDAE Rafinesque, 1815

Genus Cyclorisma Marwick, 1927

Type species—Cyclorisma woodsi, by original designation

Cyclorisma incognita n.sp

(Plate 30, Figs. 15-14)

Astarte cf. venatorum Wilckens, Wilckens, 1910, Pl. 2, Fig. 28a-b.

Holotype—Astarte cf. venatorum Wilckens, Wilckens, 1910, Pl. 2, Fig. 28a-b (Naturhistoriska Riksmuseet, Stockholm Mo 1504), herein.

Material—13 complete specimens; one right valve; one left valve.

Description—Shell small, trigonally suboval, moderately inflated. Umbones acute, elevated, prosogyrous, situated slightly anteriorly from a median line. Anterior and ventral margins evenly rounded. A very poorly developed, rounded carina defines the initiation of the posterior margin, which is subrounded. Estucheon narrow. Lunule oval, poorly defined. Pallial sinus subhorizontal, moderately deep. Hinge composed of three cardinals, 3a radiates from the umbo. 3b strong, bifid. A narrow socket for a posterior lateral of left valve behind 3b. Anterior
laterals absent. Ornamentation composed of widely spaced concentric growth lines which become more crowded near the ventral margin.

**Measurements**

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation (2v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.55</td>
<td>2.24</td>
<td>0.73</td>
<td>1.14</td>
<td>0.29</td>
<td>1.39</td>
</tr>
<tr>
<td>2</td>
<td>2.22</td>
<td>2.05</td>
<td>0.63</td>
<td>1.08</td>
<td>0.28</td>
<td>1.09</td>
</tr>
<tr>
<td>3</td>
<td>2.83</td>
<td>2.62</td>
<td>0.75</td>
<td>1.08</td>
<td>0.27</td>
<td>1.55</td>
</tr>
<tr>
<td>4</td>
<td>2.29</td>
<td>1.96</td>
<td>0.67</td>
<td>1.17</td>
<td>0.29</td>
<td>1.15</td>
</tr>
<tr>
<td>5</td>
<td>3.07</td>
<td>2.82</td>
<td>0.85</td>
<td>1.09</td>
<td>0.28</td>
<td>1.62</td>
</tr>
<tr>
<td>119-1</td>
<td>3.24</td>
<td>2.82</td>
<td>0.90</td>
<td>1.15</td>
<td>0.28</td>
<td>1.76</td>
</tr>
</tbody>
</table>

\[ X = 2.70 \]
\[ S = 0.42 \]

\[ X = 1.12 \]
\[ X = 0.28 \]

\[ S = 0.04 \]
\[ S = 0.01 \]

**Remarks**—I have collected several specimens of *Astarte venatorum* Wilckens in the Cerro Cazador (Argentina-Chile). These specimens do not have a well developed pallial sinus, and have a typical astartid dentition, and are clearly different from the siphonate antarctic species.

*Cyclorisma incognita* is similar in external shape to *Aphrodina* (Tikia) wilckensi (Woods) (Woods, 1917, p. 31, Pl. 16, figs. 10a–b, 11) (Marwick, 1927, fig. 57) but differs primarily in the lack of anterior laterals and secondarily because of its more extended anterior and more concave antero-dorsal margin. *Aphrodina* (Tikia) sp. from Cape Lamb, Vega Island (in Del Valle and Medina, 1980) is possibly identical to *Cyclorisma* n. sp., but it is difficult to make a definite statement because the hinge structure of those specimens was not described.

**Localities**—Seymour Island, 66; 119; 160; 332; 356; 377; 404; 405; N-83. Also present in Snow Hill Island (Wilckens, 1910, p. 50). Lopez de Bertodano and Sobral formations.
Subclass ANOMALODESMATA Dall, 1889

Order PHOLADOMYOIDA Newell, 1965

Family THRACIIDAE Stoliczka, 1870

Genus Thracia Sowerby, 1823

Subgenus Thracia (Thracia)

Type species--Thracia pubescens Lamarck (=Mya pubescens Pulteney, 1799) by subsequent designation of Anton, 1839.

Thracia (Thracia) n. sp.

(Plate 30, Figs. 15-18)

Thracia (Thracia) sp. Del Valle and Medina, p. 54-55, Pl. 3, Figs 1-2.

Holotype--Thracia (Thracia) sp., Del Valle and Medina, Pl. 3, fig. 1. CPCEN 3733.

Material--One complete specimen; two casts; one internal mould.

Diagnosis--Shell small to medium sized; oblong, inequilateral, inequivalve (right valve slightly larger than left valve). Umbones located medially, slightly opistogyres and low, touching each other. Anterior portion of shell subelliptical. Antero-ventral margin convex, postero-ventral margin stright to concave. Posterior truncated, defined by a strong marginal carina. Posterodorsal margin almost straight; ligament external, opisthodetic. Estucheon short and narrow. A shallow depression is found just on the anterior side of the marginal carina. Ornamentation composed of delicate concentric striae.

Measurements--

<table>
<thead>
<tr>
<th>Specimen</th>
<th>N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior</th>
<th>L</th>
</tr>
</thead>
</table>
L-JR-1 3.28 2.20 1.62
L-46  3.95 3.09 2.25
L-30  3.78 2.23 1.90
L= left valve

Remarks—The specimens here available are identical to those described by Del Valle and Medina (1980, p. 54). This species is closely related to *Thracia haasti* Woods (Woods, 1917, Pl. 19, Fig. 3a-c) from the late Cretaceous of New Zealand, but differs by its less inflated outline and greater elongation.

*Thracia lenticularis* Wilckens (1907, Pl.8, Fig. 9P and *Thracia* sp. (Feruglio, 1936, Pl. 14, Fig.1) do not show the posterior truncation typical of the genus *Thracia*.

Localities—The Naze, James Ross Island, locality JR-1; Seymour Island, stations 30; 46 and 185. Also present in Vega Island (Del Valle and Medina, 1980). Lopez de Bertodano Formation.

Family PHOLADOMYIDAE Gray, 1847
Genus *Goniomya* Agassiz, 1842
Subgenus *Goniomya* (*Goniomya*)

Type species—*Mya angulifera* J Sowerby, 1819 (=*Mya intersectans* Smith, 1817) by subsequent designation of Herrmannsen, 1847).

*Goniomya* (*Goniomya*) *hyriiformis* (Wilckens)

(Plate 31, Figs. 6,7,8)

*Trigonia* *hyriiformis* Wilckens, 1910, p.47, 49; Pl.2, Fig. 27.

*Trigonia* *hyriiformis* (Wilckens) Perez and Reyes, 1978, p. 11, Pl.2,
fig. 2.

Holotype—Trigonia hyriiformis Wilckens, 1910, Pl. 2, Fig. 27. Naturhistoriska Riksmusset, No 1497), by monotypy.

Type locality—Snow Hill Island.

Material—Four complete specimens.

Supplementary description—Shell rectangular, large, very elongated and inflated. Posterior gape large; anterior gape small. Beaks situated anteriorly, mesogryres to very slightly prosogyrous. Umbones broad, depressed. Anterior margin rounded, preserved in only one specimen. Anterior portion of ventral margin forming a small concavity followed by a protuberance beneath the umbones. Posterior portion of ventral margin straight, slightly concave. Posterior margin divided by a moderately defined marginal carina. Dorsal margin straight, slightly concave. Ornamentation composed of semi-concentric ribs that meet at an acute angle beneath the umbones. This acute angle forms a well defined carina, particularly near the ventral margin. Antero-ventral portion of flank concave, with more raised ribs than in the rest of the shell, tending to coalesce beneath the umbones. Ornamentation disappears in the postero-ventral as well as in the dorso-posterior portion of the shell.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation (2v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-1</td>
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<td>5.00</td>
<td>2.83</td>
<td>2.32</td>
<td>0.24</td>
<td>4.88</td>
</tr>
<tr>
<td>B-1</td>
<td>9.57</td>
<td>5.32</td>
<td>3.40</td>
<td>1.80</td>
<td>0.56</td>
<td>4.60</td>
</tr>
<tr>
<td>41-1</td>
<td>--</td>
<td>4.63</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>4.66</td>
</tr>
<tr>
<td>42-1</td>
<td>--</td>
<td>5.09</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>4.11</td>
</tr>
</tbody>
</table>

Remarks—The new and complete specimens from Seymour Island display
conspicuous anterior and posterior gapes, which were impossible to recognize in Wilckens' (1910) only specimen. This, together with the chevron-shaped ornamentation, and the lack of any dentition (as observed by sectioning several specimens) is typical of the genus Coniomya.

Localities—Seymour Island, B, H., 41; 42; also observed in 44; 103; 344; 402; 422; 433; 427; 428; N-84. Snow Hill Island (Wilckens, 1910). Lopez de Bertodano Formation.

Order MYOIDA Stoliczka, 1870
Family HIATEGIDAE Gray, 1824
Genus Panope Menard, 1807
Subgenus Panope (Panope)

Type species—Panope faujasi (=Mya glycimeris Born, 1778) by subsequent designation of Fleming, 1818.

Panope (Panope) clausa (Wilckens)

(Plate 31, Figs. 3, 4, 5)

Panope (Pleuromya?) clausa Wilckens, 1910, p. 1, Pl. 3, Fig. 10a-b.
Panope clausa Wilckens, Woods, 1917, p. 33; Pl. 18, figs. 6a-b, 7.
Panope clausa Wilckens, Frenel, 1958, p. 43, Pl. 3, fig. 6.

Lectotype—Panope (Pleuromya?) clausa Wilckens, 1910, Pl. 3, Fig. 10a-b (Naturistoriska Riksmusset, Mo 1608), herein.
Material—15 complete and well preserved specimens.

Supplementary description—Shell medium to small, subrectangular in outline, elongate. Umbones flat, mesogyrous, situated anteriorly. Anterior portion of umbo higher than the posterior. Posterior gape present. Anterior margin almost straight, slightly oblique, meets the straight ventral margin in a sharp bend, which extends to the anterior portion of the umbo, forming a well developed carina and anterior area. Posterior margin subparallel to the anterior, meets the ventral margin in a narrow curve, forming a carina not as well defined as the anterior. Postero-dorsal margin straight. Hinge composed of one cardinal in each valve. External ornamentation composed of concentric ribs wider than the interrib areas. Maximum inflation observed in the anterior one third of the specimens.

Measurements—

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>Anterior L</th>
<th>L/H</th>
<th>AL/L</th>
<th>Inflation (2v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-1</td>
<td>5.57</td>
<td>3.08</td>
<td>2.10</td>
<td>1.81</td>
<td>0.38</td>
<td>2.52</td>
</tr>
<tr>
<td>175-1</td>
<td>5.14</td>
<td>2.93</td>
<td>1.80</td>
<td>1.75</td>
<td>0.35</td>
<td>2.44</td>
</tr>
</tbody>
</table>

Remarks—This is a typical species that has been reported from Patagonia, New Zealand, and New Caledonia besides its type locality in Antarctica.

Localities—Seymour Island, stations 42; 46; 56; 175; 177; 182; 185; 195; 356; 361; 402; 429; locs. E; F; G-83; N-84.

Stratigraphic distribution—Units 6 to 9 of the Lopez de Bertodano Formation.
Suborder OSTREINA Ferusal, 1822

Family GRYPHAEIDAE Vialov, 1936

Subfamily PYCNODONTEINAE Stenzel, 1959

Genus Pycnodonte Fisher Von Waldheim, 1835

Subgenus Pycnodonte (Phygraea) Vialov, 1936

Type species—Phygraea frauscheri Vialov, 1936, by original designation.

Pycnodonte (Phygraea) seymourianus (Wilckens)

(Plate 31, Figs. 9,10; Plate 33, Figs. 1-6)

Ostrea seymouriensis Wilckens, 1910, p.19-21, Pl. 1, Figs. 11, 12a-b.

Ostrea ex aff. lesueuri d'Orbigny, Wilckens, 1910, p. 18,19; Pl. 11 Fig. 10a,b.

Lectotype—Ostrea seymourianus Wilckens, 1910, Pl. 1, Fig. 12a-b (Naturhistoriska Riksmuseet, Mo 1645), by this designation.

Material—27 left valves; 5 right valves. Material moderately to very well preserved.

Supplementary description—Shell of medium size (mean length of left valve=6.29cm), suborbicular in outline. Left valve larger than right, inflated, relatively thin, convex, with vermicular chomata developed only near to the dorsal margin. Posterior aductor scar oval to subcircular, situated closer to the dorsal margin. Anterior and posterior auricles variably developed from typical pycnodontid in few
cases (i.e. anterior and posterior auricles forming an extended straight dorsal margin, only slightly below the umbo), to poorly developed (more common), giving rise in the last case to a more triangular-shaped shell. Hinge generally small, flat, variable in size. Umbonal cavities very small to absent. External shell ornamentation smooth with concentric irregular lamellae, and in some individuals with very faint radial ornamentation.

Right valve flat to concave, with a circular to oval (compressed anteroposteriorly) outline. Chomata also present in this valve.

Posterior muscle scar oval, slightly pointed postero-dorsally. Scar with several step-like concentric lamellae. External ornamentation composed of concentric irregular lamellae.

**Measurements**

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>L/H</th>
<th>Maximum</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-37-16-1</td>
<td>6.50</td>
<td>6.22</td>
<td>1.05</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>L-37-16-2</td>
<td>6.42</td>
<td>7.16</td>
<td>0.90</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>L-H'-1</td>
<td>6.33</td>
<td>6.95</td>
<td>0.91</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>L-A-1</td>
<td>6.10</td>
<td>6.29</td>
<td>0.97</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>L-47-1</td>
<td>6.10</td>
<td>7.07</td>
<td>0.86</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>R-47+2</td>
<td>4.87</td>
<td>6.30</td>
<td>0.77</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>R-37-16-3</td>
<td>5.35</td>
<td>5.70</td>
<td>0.94</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>R-37-16-4</td>
<td>4.84</td>
<td>5.60</td>
<td>0.86</td>
<td>0.55</td>
<td></td>
</tr>
</tbody>
</table>

X(L)=6.29  
X(R)=5.02

L=left valve  
R=right valve

**Remarks**—This species displays a large variability in shape. This is particularly due to the uneven development of the auricles, but this may be an artifact of preservation and not a true feature. Usually
smaller specimens are much more inflated and circular in outline.  

**Pycnodonte seymourianus** is possibly identical to **P. vesicularis** (Lamarck), but it is preferred to maintain the Seymour Island specimens in a different species, until a detailed study of the present collection is conducted. **Pycnodonte vesicularis** (Lamarck) displays a well known polymorphism (Woods, 1913; Muller, 1970; Freneix, 1972; Pugaczewska, 1977) ranging from gryphaeoid to more flat forms. Different criteria exist in relating this species to the closely associated species **P. vesiculosa** (Sowerby) and **P. subvesiculosa** (Renngarten). Freneix (1972, p. 101) included all these forms into **P. vesicularis** with the rank of subspecies. The typical subspecies **P. vesicularis vesicularis** has a less pointed umbo with a larger attachment surface and has a larger size than **P. vesicularis vesiculosa**. Moreover, the area in the former species is lower, and usually the height of the shell is relatively small in proportion to the length (Woods, 1913, p. 375). **P. seymourianus** lacks however, the typical radial ornamentation on the right valve, clearly displayed in Woods' (1913) and Pugaczewska's (1977) specimens.

**Localities**—Seymour Island, stations 41; 47+; 104; 106; 116; 173; 195; 37-16; 422; 423; 427; 428; A; B; H; H'. Lopez de Bertodano Formation.

**Pycnodonte (Phygraea) cf. vesiculosa** (Sowerby)

(Plate 32, Figs. 1-2)
Gryphaea cf. vesicularis Lamarck, Wilckens, 1910, p. 21-22, Pl. 1, figs. 14a,b, 15,

Material—35 left valves; 8 right valves.

Supplementary description—Shell small to medium size (mean length = 4.01 cm) gryphaeoid, arcuate. Left valve inflated, generally very thick in the zone of maximum convexity. Lacking auricles. Beak pointed, projected and generally twisted at its end. Chomata present in the one fourth portion of the anterior and posterior margins closer to the hinge. Posterior adductor scar almost circular. External portion of shell smooth, with concentric lamellae. Very delicate radial ornamentation preserved in few specimens.

Right valve concave, particularly in its ventral portion, usually compressed, ophistocline and much thinner than the left. Chomata well developed; posterior adductor scar subrounded. External ornamentation composed of concentric lamellae.

Measurements---

<table>
<thead>
<tr>
<th>Specimen N.</th>
<th>Length</th>
<th>Height</th>
<th>L/H</th>
<th>Maximum thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>68-1</td>
<td>4.43</td>
<td>5.06</td>
<td>0.88</td>
<td>1.70</td>
</tr>
<tr>
<td>68-2</td>
<td>4.33</td>
<td>5.16</td>
<td>0.84</td>
<td>1.27</td>
</tr>
<tr>
<td>SI-1</td>
<td>5.88</td>
<td>5.50</td>
<td>1.07</td>
<td>1.90</td>
</tr>
<tr>
<td>68-3</td>
<td>4.10</td>
<td>4.79</td>
<td>0.86</td>
<td>0.98</td>
</tr>
<tr>
<td>B-1</td>
<td>4.00</td>
<td>4.95</td>
<td>0.81</td>
<td>—</td>
</tr>
<tr>
<td>160-1</td>
<td>3.06</td>
<td>3.83</td>
<td>0.80</td>
<td>0.75</td>
</tr>
<tr>
<td>V-10-1</td>
<td>3.01</td>
<td>3.56</td>
<td>0.85</td>
<td>—</td>
</tr>
<tr>
<td>160-2</td>
<td>2.90</td>
<td>3.36</td>
<td>0.86</td>
<td>0.83</td>
</tr>
<tr>
<td>37-6-1</td>
<td>3.68</td>
<td>4.33</td>
<td>0.85</td>
<td>0.89</td>
</tr>
<tr>
<td>116-1</td>
<td>4.67</td>
<td>5.09</td>
<td>0.92</td>
<td></td>
</tr>
</tbody>
</table>

X = 4.01
S = 0.91
(all left valves)
Remarks—The material described by Wilckens (1910) as *Grypahea* cf. *vesicularis*, clearly belongs to the *Pycnodonte vesicularis* group, but are more clearly related to the grypaeoid forms which are included in *P. vesiculosa*. The Seymour Island specimens lack however the typical furrow that separates the posterior of the shell from the remainder of the valve (i.e. Woods, 1913, Pl. 55, Figs. 10–14), and thus these specimens are referred with doubts to this species. The relationship between the Seymour Island specimens here referred to *P. seymourianus* and to *P. cf. vesiculosa* will be established after a thorough biometric study of the collection available, together with a detailed study of the abundant literature available on these and related species.

**Localities**—Seymour Island, stations 37; 66; 68; 114; 116; 142; 160; 337; 340; 342; 347; 364; 366; 368; 369; 371; 397; 399; 400; 401; loc. B. Vega Island, stations V-9; V-10; The Naze, James Ross Island, Station JR-1.
Class GASTROPODA Cuvier, 1797

Order ARCHEOGASTROPODA Thiele, 1925

Family PLEUROTOMARIADE Swainson, 1840

Genus Pleurotomaria Defrance, 1826

Subgenus Pleurotomaria (Perotrochus) Fisher, 1885

Type species—Pleurotomaria quoyana Fisher and Bernard, 1865

Pleurotomaria (Perotrochus) larseniana (Wilckens)

(Plate 34; Figs.1-4)

Pleurotomaria larseniana Wilckens, 1910, p. 73, Pl. 3, fig. 24.

Holotype—Pleurotomaria larseniana Wilckens, 1910, Pl. 3 Fig. 24. Naturhistoriska Riksmusset N° Mol268, by monotypy.

Material—17 specimens mostly preserved as internal casts. Three with portion of the original shell still preserved.

Supplementary description—Shell trochiform, large (max. size: 15.5 cm in height), and thick. A maximum of six whorls were observed, but the total number must be larger. Whorl section sub-oval with the outer wall slightly convex to flat; small ridge at the base of each whorl just above the suture, which is slightly impressed. Apical angle ranging from 60° to 69°. Shell anomphalus. Slit band (selenizone) located below the middle of the whorl, as shown by the recurvation of the growth lines in this zone.
Remarks—These specimens are identical to that figured by Wilckens from the same area. They also bear close similarities with *Pleurotomaria* (*Perotrochus* maoriensis) (Wilckens) from the Upper Cretaceous of New Zealand (i.e. Warren and Speden, 1977, Fig. 25, 8), but in that species the selenizone is higher in the whorl and much more marked than in the antarctic specimens.

Localities—Seymour Island, station H, 46; 143; 37-60; 71; 73a; C-37; WZ-9, and two float specimens. During the 1983/84 expedition, this species was also found at stations 384; 423; K-84; L-84, and M-84.

Stratigraphic occurrence—Lopez de Bertodano and Sobral formations.

Family AMBERLEYIDAE Wenz, 1938

Genus *Amberleya* Morris and Lycett, 1851

Subgenus *Amberleya* (*Amberleya*)

Type species—*Amberleya bathonica* Cox and Arkell, 1950.

*Amberleya* (*Amberleya*) spingera Wilckens

(Plate 34; Figs. 9,10)

*Amberleya* spigera Wilckens, 1910, p. 74-76, Pl. 3, figs. 25-26

Holotype—*Amberleya spingera* Wilckens, 1910, Pl. 3, figs. 25-26, by monotypy (Naturhistoriska Riksmuseet, Stockholm, Mo 1269a).

Material—23 specimens, mostly very well preserved and with the original nacreous shell still preserved.
Supplementary description—Shell medium sized (7-8 cm in length), subturriculate with almost rounded whorl section. Suture moderately impressed. Keel located in the middle of the whorl, bearing strong nodes (13 to 19 per whorl). Abapical portion of the last whorl with four to five concentric folds.

Remarks—This is a typical and abundant species in the Lopez de Bertodano Formation. In two cases, this species was found inside the living chamber of the ammonite *Maurites*, possibly indicating that *Amberleya* was a carnivore or a scavenger.

Localities—41; 44; 56; 105; 106; 107; 143; 145; 149; 150; 151; 175; 177; 179; 181; 190. During the last field season, found at stations 317; 321; 326; 328; 329; 330; 332; 335; 337; 342; 356; 357; 360; 361; 362; 364; 366; 367; 368; 372; 378; 382; 384; 385; 394; 398; 399; 428; 429; C-83; D-83; E-83; F-83; K-84; N-84; St. 6.

Stratigraphic occurrence—Seymour Island, upper 500 of the Lopez de Bertodano Formation, disappearing approximately 60m below the contact with the Sobral Formation. Also mentioned from Snow Hill Island (Wilckens, 1910).

Order CTENOBANCHIA Schweggen, 1920
Superfamily STROMBACEA Rafinesque, 1815
Family APORRHAIDAe Morsh, 1852
Genus **Perissoptera** Tate, 1865

*Type species*—**Perissoptera reussi** Tate, 1865.

**Perissoptera nordenskjoldi** Wilckens

Lectotype—Perissoptera nordenskjoldi, Wilckens, 1910, Pl.4, fig. 2, (Naturhistoriska Riksmusset, No Mo 1367), herein.

Material—Sixty specimens.

Supplementary description—Shell medium sized (3-5cm) composed of nine whorls. Spire of about half the shell length. Whorls with a spiral keel formed by oblique nodes directed forward and below the keel. Outer lip forming a long, curved digit that bends upward and backward. Upper margin of outer lip thickened by a callosity. Lateral labral process well developed forming an acute, thickened, forward projected digit. Inner lip with a thick callosity; anterior process extended and slightly curved to the left in some specimens. Faint fasciole present.

Remarks—This species is closely related to Perissoptera waiparaensis (Hector) from the Amuri Bluff of New Zealand (Wilckens, 1922, p. 11). The only difference observed is the lack of the characteristic lower lobe of the wing of P. nordenskjoldi in the New Zealand species. Perissoptera monodactyla Wilckens (=Aporrahis cf. gregaria, Wilckens, Pl. 3, figs. 11-13)(Wilckens, 1922) is very closely related to the previous two species, and further taxonomic work might prove that these three species belong to only one.

Localities—37; 60; 63; 72; 75; 94; 119; 146; 147; 148; 149; 156;
157; 159; 178; 185; 331; 350; 351; 352; 353; 359; 361; 368; 373; 374; 375; 377; 378; 383; 398; 404; 405; 406; 407; 432; Locs. E; N-84.

Stratigraphic distribution—Lopez de Bertodano Formation, and lower part of Sobral Formation.

Family NATICIDAE Gray, 1840

Genus Eunaticina Fisher, 1885

Type species—Eunaticina papilla (Gmelin)

Eunaticina (Eunaticina) arctowskiana Wilckens

(Plate 34, Figs. 11,12; Plate 35, Fig. 11)

Eunaticina? arctowskiana Wilckens, 1910, p. 78-80; Pl. 3, fig. 29 a,b; Pl. 4, figs. 17, 18.

Lectotype—Eunaticina arctowskiana Wilckens, 1910, Pl. 3, fig. 29 a,b; (Naturhistoriska Riksmuseet, N° Mo 1340), herein.

Material—Fourty, usually very well preserved shells.

Supplementary description—Shell small and thick; peristome subrounded. Whorl margin evenly convex. Suture moderately impressed. Ornamentation composed of evenly spaced spiral threads.

Remarks—Wilckens, 1910, used the spelling arktowskiana for this species in pages 78-79, whereas he used the spelling arctowskiana in the figure caption of Plate 3. The latter is the correct spelling, after the polish geologist, oceanographer and meteorologist Henryk Arctowski.

Localities—Seymour Island, 41; 42; 46; 105; 179; 180; 181; 183;
Locs. D, E, F; WZ-9; Snow Hill Island; The Naze, James Ross Island (Wilckens, 1910).

Stratigraphic distribution—Lopez de Bertodano Formation, and lower part of the Sobral Formation.

Superfamily TONNACEA Peile, 1926
Family CASSIDIDAE Swainson, 1832
Genus Cassidaria Lamarck, 1812

Type species—Cassidaria echinophora (Linne)

Cassidaria mirabilis Wilckens var. papillosa Wilckens

(Plate 35, Figs. 1-3)

Cassidaria mirabilis Wilckens var. papillosa Wilckens, 1910, p. 89-91;
Pl. 4, figs. 15-16.

Lectotype—Cassidaria mirabilis var. papillosa Wilckens, 1910, pl. 4, fig. 16. Naturhistoriska Riksmusset, N° Mo 1398, herein.

Material: Approximately 30 specimens.

Supplementary description—Shell fusiform, medium sized (5-7 cm in length). Spire composed of four to five whorls. Sutures poorly defined, almost adpressed. Ornamentation composed of closely spaced spiral lines that develop into more prominent spiral ribs at regular intervals. Spiral ribs (usually one in the spire) break into pustules (approximately 16 to 18 per whorl) which grow in size abapically. Base with 4-5 rows of spirally arranged tubercles. Second row from the spire
is the most prominent.

Remarks—Cassidaria mirabilis papillosa differs from C. mirabilis Wilckens by the presence of numerous, more closely spaced pustules and tubercles, and possibly by a higher spire.

Localities—41; 46; 99; 149; 150; 151; 153; 160; 182; 191; 321; 322; 340; 356; 357; locs. B; E; F; C-83; D-83.

Order NEOGASTROPODA Thiele, 1925
Superfamily MURICACEA de Costa, 1776
Family BUCINIDAE Rafinesque, 1815
Genus Austrosphaera Camacho, 1949

Type species—Austrosphaera glabra Camacho, 1949 (in Furque and Camacho, 1949).

Austrosphaera patagonica (Feruglio)

(Plate 35, Figs. 4,5)

Cominella patagonica Feruglio, 1936, p. 75, 76; Pl. 26, fig. 11 a,b; 12; 13a-b.

Type locality—Río Chubut, Argentina (Puesto Ramírez).

Lectotype—Cominella patagonica Feruglio, 1936, Pl. 26, fig. 11a,b; herein (preserved in the University of Bologna, Italy).

Material—18 specimens moderately to poorly preserved.

Supplementary description—Shell globose, usually small (most specimens around 3 cm in length but some reaching 5.5 cm),
siphonostomatous, with the last whorl covering most of the spire; whorls adpressed. Opening oval shaped; outer lip with a thick callosity extending all along the margin. Adapical portion of inner lip with thick callosity (not well displayed in specimen of Plate 35, Fig. 5). Upper part of inner lip with a variably developed shoulder. Fasciole not observed. Anterior canal short. Shell smooth or with faint irregular spiral lines, and prosocline growth lines.

Remarks—The genus *Austrophaera* was created by Camacho (in Furque and Camacho, 1949) for specimens found in the late Cretaceous of the Atlantic coast of Tierra del Fuego. Camacho defined this genus as different from *Cominella* and *Austrocominella* because it has a shorter spire, almost completely covered by the last whorl, a thick external callossity, a poorly developed siphonal fasciole, and an almost lack of ornamentation.

*A. patagonica* differs from *A. glabra* Camacho, because it has a shorter anterior canal and a more ovoid shape. The presence of a weak concentric ornamentation in the Seymour Island specimens coincides with the description of Feruglio (1936, p. 75).

**Localities**—Seymour Island, 75; 352; IPS 9.

**Stratigraphic distribution**—On Seymour Island, this species is restricted to the unit 10 of the Lopez de Bertodano Formation, and to the Sobral Formation (lower Paleocene). In Patagonia it was found in the Salamanca Formation (Paleocene).

Genus *Cominella* Gray, 1850
Type species—Cominella testudinacea (Lamarck)

Cominella sp. cf. C. tumida (Wilckens)
(Plate 35, Figs. 9,10)

cf. Struthiolariopsis? tumida Wilckens, 1907, p. 116-117, Pl. 4, figs. 3,4

figs. 12a,b.

cf. Cominella (?) tumida (Wilckens), Feruglio, 1936, p. 163-164, Pl. 19,
fig. 4a,b.

Material—Three specimens moderately well preserved.

Description—Shell medium to small (maximum height= 3.7 cm), of
rhomboidal shape. Last whorl slightly larger than the spire, where four
whorls are preserved. Whorls forming an angle in the upper one third
defined by the presence of blunt nodes (approx. 13 per whorl). Suture
slightly impressed, coinciding with the base of the nodes. Aperture
oval shaped, relatively narrow. Inner lip covered by a thick callosity.
Anterior canal short and twisted to the left. Ornamentation composed of
collabral growth lines with superimposed evenly spaced spiral threads
(not clearly preserved in the figured specimen).

Remarks—These specimens differ from "Struthiolariopsis" tumida
(Wilckens, 1907, Pl. 4, fig. 3,4) by having a smaller number of
tubercles, a more rhomboidal outline, and a less developed spiral
ornamentation. Even though the aperture was not preserved in either
Wilckens' (1907) or in Feruglio's (1936) specimens, the ornamentation and shape of the spire are very similar to that of the new material from Seymour Island.

**Localities and stratigraphic distribution**—Seymour Island, Lopez de Bertodano Formation, stations, 153; 378; 399.

**Family FASCIOLARIIDAE** Gray, 1853

**Subfamily TAIOMINAE** Finlay and Marwick, 1937

**Genus Taioma** Finlay and Marwick, 1937

**Type species**—Taioma tricarinata Finlay and Marwick, 1937.

**Taioma charcotianus** (Wilckens)

(Plate 35, Figs. 6-8)

**Fusus charcotianus** Wilckens, 1910, p. 91-93, Pl. 4, figs. 6a, 6b, 8.

**Lectotype**—Fusus charcotianus Wilckens, 1910, Pl. 4, fig. 6a,b (Naturhistoriska Riksmuseet, Mo. 1403); herein.

**Material**—27 specimens, mostly well preserved.

**Supplementary description**—Shell fusiform, medium sized (8-10 cm). Whorls with a projected shoulder angle bearing approximately 19 tubercles in the last whorl. Shoulder slightly concave. Body whorl tricrenate with the middle keel coinciding with the line of suture. Keel decrease in size abapically with the last keel only faintly indicated, and almost devoid of nodes. Ornamentation composed of evenly
spaced fine spiral threads. Outer lip forming a sinus in the shoulder. Anterior siphonal canal extended and bended to the left and backwards.

Remarks—This species is closely related to *Taiona tricarina* Finlay and Marwick (Finlay and Marwick, 1937, p. 72, Pl. 10, figs. 5,6,7) from the lowermost Tertiary of New Zealand. *T. charcotianus* differs from the former species by having a higher spire, less pronouced and more abundant nodes, and a more extended anterior canal. The other species from this genus, *T. globus* Medina and del Valle, from the upper Cretaceous of Cape Marsh, Antarctica, has a distinctive convex shoulder (Medina and del Valle, 1980, p. 101-102, fig. 3,d,e,f).

*Localities*—Seymour Island, stations 99; 148; 151; 160; 176; 177; 180; 181; 190; 315; 328; 329; 342; 371; 372; 377; 397; 399; D-83; G-83.

*Stratigraphic distribution*—Lopez de Bertodano Formation mostly restricted to units 6 to 9.

*Family VASIDAE* Wade, 1924

*Genus Pyropsis* Conrad, 1860

*Type species*—*Pyropsis perlata* Conrad

*Pyropsis gracilis* Wilckens

*Pyropsis gracilis* Wilckens, 1907, p. 119, Pl. 3, fig. 16.

*Pyropsis gracilis* Wilckens, Wilckens, 1910, p.93-94, Pl. 4, figs. 7a,b.

*Holotype*—*Pyropsis gracilis* Wilckens, 1907, Pl. 3, fig. 16; Museo
Material—One poorly preserved specimen.

Remarks—The single specimen of *Pyropsis gracilis* was found in the Sobral Formation (Station 78, Paleocene). Even though poorly preserved, it is identical to previous figured specimens of this species. Wilckens' (1910) single specimen was also found in the Sobral Formation.

Family FASCIOLARIIDAE Gray, 1853

Genus Cryptorhytis Meek, 1876

Type species—*Cryptorhytis fusiformis* (Meek and Hayden).

*Cryptorhytis philippiana* Wilckens

(Plate 36, Figs. 1-9)

*Cryptorhytis philippiana* Wilckens, 1910, p. 94-95; Pl. 4; fig. 20-21.

Lectotype—*Cryptorhytis philippiana* Wilckens, 1910, Pl. 4, Fig. 21 (Naturhistoriska Riksmuseet, Mo 1409); herein.

Material—47 specimens.

Supplementary description—Shell medium sized (up to 10 cm), moderately fusiform. Spire high, with moderately impressed sutures. Ornamentation composed of coabral elevations with strong, superimposed, closely spaced spiral ribs. Last whorl more expanded

Remarks—Two different forms of this species were found co-occurring on Seymour Island. One form (i.e. Plate 36; Figs. 1-4) is
much wider, particularly in the last whorl, where a well marked shoulder is developed, and has a much shorter spire. It resembles *Penion asper* (Marwick) from the upper Tertiary of New Zealand (Fleming, 1966, fig. 1282). The second form is more closely coiled around the axis, resulting in a more elongated shell (Plate 36, Figs. 5, 6, 8, 9). No shoulder is observed here, and the spire is elevated. However, transitional forms between these two extremes are also observed. These differences are maintained at different sizes. Further study of the material might prove that these two forms belong to different species, but meanwhile they are considered as variations of a single taxa.

**Localities**—Seymour Island, 41; 44; 105; 146; 151; 153; 156; 160; 179; 181; 188; 340; 342; 356; 361; 363; 368; 377; 384; 394; 399; 422; 424; 426; 429; Loc. F; H; H'; D-83; G-83; O-84; M-84; N-84, St. 7.

Lopez de Bertodano Formation, Seymour Island. Also found on Snow Hill Island (Wilckens, 1910).

**Stratigraphic distribution**—Units 4 to 9 of the Lopez de Bertodano Formation.
CHAPTER X

SUMMARY

A monotonous, 1400m thick, continuous sequence of friable siltstones and occasional indurated sandstones is exposed in the southern portion of Seymour Island. This sequence, composed of the Lopez de Bertodano, Sobral, and Cross Valley formations (all belonging to the Marambio Group), is the sedimentary record of a marine depositional cycle that started during the late Campanian and ended in the Paleocene.

These sediments were sampled in detail during two field seasons. Extensive collections made during field work provide data on the stratigraphic distribution of an abundant and well preserved macrofauna. Annelids, bivalves, ammonites and gastropods have been studied in this work. Sixty three taxa are described in detail, including 11 new species and 12 new occurrences for the area. The study of the macrofauna provides valuable insight into the paleobiogeography of the Antarctic faunas, their stratigraphic distribution, and the correlation of this sequence with other late Cretaceous localities in the southern Hemisphere. In addition, the macrofauna provides valuable paleoenvironmental information for the sequence.
From a paleobiogeographic perspective, the fauna is strongly endemic. It does have close affinities, however, with other late Cretaceous faunas of the Weddellian Province, which developed along a rectilinear coast extending from Australia to southern South America. Biogeographical analysis identified taxa useful for subdividing the sequence. Two groups are stratigraphically useful: the annelids and the ammonites. The Lopez de Bertodano Formation has been divided into four *Rotularia* (Annelida) zones, locally useful for correlation within the James Ross Island Basin. The Lopez de Bertodano ammonites, however, which cluster into three zones (*Pachydiscus ootacodensis*, *P. riccardi*, and *P. ultimus* zones), allow correlation of the sequence with other localities throughout the world, including type sections in Europe. The ages of the ammonite zones range from the earliest (?) to the latest Maastrichtian. Glauconite ages obtained at four successive stratigraphic intervals, confirm the late Maastrichtian age of the upper Lopez de Bertodano Formation and the Paleocene age of the overlying Sobral and Cross Valley formations.

A major change in the macrofauna occurs at the inferred Cretaceous/Tertiary boundary. All ammonites and marine reptiles, and several species of bivalves and gastropods disappear at this horizon, although some bivalves and gastropods continue to be abundant above the boundary. Several new taxa appear in the younger beds. The sudden extinction of the ammonites contradicts previous proposals of a gradual decrease of this group during the Maastrichtian.
Macrofauna diversity increases linearly from the base of the section to the Cretaceous/Tertiary boundary, but a rapid diversity decrease occurs above this level. The lower 500 m of the Lopez de Bertodano Formation contains a sparse macrofauna, dominated by the annelid Rotularia. Diversity increases sharply in the overlying 600 m of this formation, with maximum diversity occurring at approximately 900 m above the base of the section. The macrofauna at this level is dominated by abundant epifaunal suspension feeding bivalves (Pycnodonte assemblage). Horizons containing a high diversity macrofauna are also characterized by the appearance of more streamlined ammonites, including several cosmopolitan taxa absent in the lower beds.

The Lopez de Bertodano Formation has been subdivided into 10 informal lithostratigraphic units. Units 1 to 6 are interpreted as very shallow marine deposits, influenced by major river output. Mud-rich units probably represent shallow water mud belts. Units 7 to 9 are interpreted as progressively deeper water deposits, with unit 7, 8, and 9 probably representing a middle shelf, an outer shelf/slope break, and upper slope facies, respectively. However, macrofaunal evidence suggest that even the most offshore facies was deposited in relatively shallow water (probably less than 150 m). Regression began at approximately the Cretaceous/Tertiary boundary (contact between units 9 and 10). The Sobral and Cross Valley formations were deposited as the basin was filled by the progradation of a deltaic system. A succession of prodelta facies (Unit 1, Sobral Formation), coastal barrier facies (Unit 2), and delta top facies (Cross Valley Formation) is interpreted here.
Marambio Group sandstones, which range from subarkoses to lithic arenites, were deposited in a back-arc tectonic setting. Petrographic analysis of the Seymour Island sequence indicates the development and unroofing of a magmatic arc on the nearby Antarctic Peninsula during this time. From the late Campanian to the middle Maastrichtian, both an igneous-metamorphic source and a volcanic source supplied sediments to the James Ross Basin. Active volcanism began during the late Maastrichtian, and is reflected by an increase in the abundance of clean, straight extinction quartz, an increase in the plagioclase/K-feldspar ratio, the appearance of euhedral hornblende, and the appearance of abundant angular glass shards and pumice. Volcanigenic fragments dominate sandstones from the upper part of the Lopez de Bertodano and the Sobral formations. Active volcanism probably ceased during the late Paleocene, but the newly erupted volcanic rocks provided most of the lithic fragments found in the Cross Valley Formation.
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APPENDIX A

DESCRIPTION OF MEASURED SECTIONS AND LOCALITIES

(See map at the back for location of stations and fold-out figure showing the sections measured in the Lopez de Bertodano Formation. The stratigraphic distribution of samples collected in the Sobral and Cross Valley formations is shown in Fig. 63. A color notation, obtained by comparison in the lab with a Munsell color chart is included in brackets for samples 2 to 195).

SECTION A

A = thickness; B = cumulative thickness of the formation (meters).

Lopez de Bertodano Formation

A    B
35.0 35.0-Gray-greenish fine grained, well bedded sandstone; individual beds are 5cm thick. Very abundant, randomly oriented tubes (1mm in diam.). Concretions up to 30 cm in diam. Sample 1. Gunnarites cf. kalika.

24.0 59.0-Gray greenish (5GY 5/1) fine grained well bedded sandstone. Frequent horizontal tubes. Samples 2-6. Linotrigonia (Oistotrigonia) cf. antarctica; Rotularia (A.) fallax; Gastropoda sp. indet.; fossil wood.

6.0 65.0-Friable gray sandy siltstone.

10.5 75.5-Dark gray (5GY 5/1) silty sandstone, more resistant that previous bed. Sample 7.

1.0 76.5-Medium grained grayish (5GY 6/1), mottled, bioturbated sandstone, somewhat glauconitic. Interbedded are dark, red-weathering, more resistant sandstones. Sample 8. Diplomoceras ? sp.; Pinna? sp.; Astartid sp. indet.; Cycloserris sp. (coral); echinoderm spines.

13.5 90.0-Tan to gray (5Y 5/1) clayey silt with laminations preserved. Sample 9.

1.0 91.0-Medium to fine grained gray, mottled sandstone.

14.0 105.0-Greenish to gray and tan (6/) sandy silt, with intercalations of friable sandstone (at 9 and 14m). Sample 10.

12.0 117.0-Greenish gray sandy silt to clayey silt. On top a 20 cm of

3.0 120.0—Dark gray (5Y 5/2) sandy clayey silt. Sample 12.

18.0 138.0—Poorly exposed. Gray (2.5Y 5/2) mudstone with red colored concretions. Sample 13.

15.0 153.0—Fine grained clayey silt (2.5Y 5/4) with reddish concretionary levels. Sample 14.

25.5 178.5—Mostly covered. Very friable mudstone (5GY 6/1), with rounded concretionary levels. Sample 14bis (at 13.5 m); Sample 15. Rotularia (A.) fallax.

14.0 192.5—Poorly exposed mudstone. At the top, the rock is more consolidated. Sample 16. Rotularia (A.) fallax.

19.5 212.0—Friable mudstone alternating with more resistant 30-40 cm thick beds of dark gray siltstone.

9.0 221.0—Same as below, but with intercalations of more resistant beds. At the top follows a very fine grained dark gray (5Y 5/4) silty sand. Sample 17.

7.5 228.5—Gray sandy silt with concretionary levels. A gray sandstone at the top. Sample 18. Rotularia (A.) sp.

25.5 254.0—Gray (5Y 6/2) sandy silt with intercalations of resistant fine grained silty sandstones. At the top follows a dark gray to tan, very fine grained silty sandstone, somewhat friable. Abundant ellipsoidal concretions (5-10 cm long), gray in fresh, weathering to light brown. Sample 19. Rotularia (A.) tenuilaevia.

7.5 261.5—Gray (5Y 5/1) sandy silt; on top follows 1.5 m of well indurated pale greenish gray, well bedded sandstone. Sample 20. Unident. ammonite; corals.

33.0 294.5—Gray (2.5Y 6/4) silty sandstone relatively well indurated, alternating with more friable beds. Large calcareous concretions preserving the original bedding. Intercalations of brownish gray sandy siltstone with flasser bedding. Sample 21. Rotularia (A.) sp.; Hopioparia stockesi.

33.0 327.5—Brownish gray (2.5Y 6/4) sandy silt with numerous rounded concretions, 8-15 cm in diameter, gray when fresh, weathering to yellowish. At the top follows 1 m of silty sandstone with dark green, rounded intraclasts. Fossils poorly preserved. Sample 22. Unident. ammonite; brachiopods; abundant corals, echinoderm spines; marine reptile bones.
12.0 339.5–Gray (2.5Y 7/0) silt interbedded with friable gray sandstone.  
   Sample 23.

3.0 342.5–Gray (2.5Y 6/4) clayey siltstone, very friable.  Sample 24.

25.0 367.5–Gray (2.5Y 6/2) silt interbedded with thin layers of 10–15cm thick sandstone.  Sample 25.  Rotularia (A.) tenuilaevis;  
   Panope clausa;  Cyclosperis sp.; echinoderm spines.

22.5 390.0–Dark gray (5Y 6/2) clayey silt.  Sample 26.

18.0 408.0–Massive light gray (5Y 6/1) sandy silt with irregular white-weathering concretions (Sample 28a). At the top start well laminated light brown (5Y 5/2) clays and sands without concretions (Sample 28b).  Rotularia (A.) sp.

24.0 432.0–Well laminated gray to light brown (5Y 6/1) clays and sands with more yellowish intercalations. At the top follows a calcareous fine grained sandstone. Sample 29.

17.0 449.0–Friable fine grained sandy siltstone. At the top follows a fine grained well cemented sandy siltstone, 0.6 m thick, weathering to gray greenish colors, but yellowish gray (2.5Y 6/6) when fresh.  Sample 30.  Rotularia (A.) tenuilaevis;  
   Cyclosperis sp.; Thracia sp.; Grossouvrites? sp., echinoderm spines.

19.0 468.0–Poorly exposed, very friable mudstone with numerous rounded (10–30cm) concretions that are red colored on the surface.

35.0 503.0–Very fine grained dark gray to brownish (5Y 6/2) silty sand.  Red weathering concretions. Sample 31.

21.0 524.0–Dark greenish (5Y 5/2), friable, massive silty sandstone.  Serpulids very abundant. Sample 32.  Rotularia (A.) tenuilaevis;  
   Cassidaria mirabilis; echinoderm spines.

13.5 537.5–Tan colored (5Y 5/1), to dark gray in fresh cuts, sandy silt.  
   Very abundant serpulids and echinoderm spines. At the top follows 0.5m of glauconitic silty sand. Sample 33.  Rotularia  
   (A.) tenuilaevis.

10.5 548.0–Tan to gray (5Y 5/1) friable sandy silt. At the top follows a dark reddish gray calcareous sandstone. Sample 34.  
   Linotrigonia (O.) sp.

12.0 560.0–Gray-greenish (5Y 5/2), sandy clayey silt.  Sample 35.

10.5 570.5–Gray-greenish sandy clayey silt.

9.0 579.5–Rock not well exposed, but very friable. Forms a low relief 
   with small rounded hills having slightly more resistant beds
at the top. Intercalations of fine grained calcareous sandstones (2.5Y 5/4), and scattered red-colored concretions. Sample 36. Serpulids abundant. Rotularia (A.) sp.

33.0 612.5—Mostly covered, but when exposed, composed of a friable siltstone, with scattered rounded and irregular concretions. Serpulids very abundant. Sample 37. Rotularia (A.) tenuilaevis; Linotrignia (O.) pygoscellum; Nucula (L.) suboblonga; Pycnodonte cf. vesiculosa; Perissoptera sp., unident. ammonite.

22.0 634.5—Very friable sandy siltstone, mostly covered. Concretions present. At the top follows a dark gray (5Y 5/2) friable silty sandstone, followed by a 15–20cm thick indurated, calcareous fine grained sandstone. Sample 38. Rotularia (A.) sp.

18.0 652.5—Dark gray friable sandy siltstone, poorly exposed, with intercalations of more indurated fine grained sandstone. Sample 39. Callianassa meridionalis; Rotularia (A.) sp.; Nucula (L.) suboblonga; Linotrignia (O.) pygoscellum; Gastropoda sp.

7.5 660.0—Dark gray (5Y 5/2) massive sandy silt (Sample 40a) followed by a flasser bedded, bioturbated gray sandy silt with intercalations of more yellowish layers. Sample 40b.

26.5 686.5—Gray (5Y 5/2), sandy silt with concretions. Very abundant fauna found at the top. Sample 41. Rotularia (R.) shackletoni; Diplomoceras lambi; Kitchinotes darwinii; Kossmaticeras (Natalites)? weddelliensis; Nucula suboblonga; Linotrignia pygoscellum; Gonioyma hyriiformis; Pycnodonte seymourianus; Eunaticina arctowskiana; Cryptothytes philippiana; Cassidaria mirabilis; Perissoptera sp.; Amberleya spinigera.

16.5 703.0—Gray friable sandy siltstone. Very abundant macrofauna. Sample 42. Rotularia (A.) zinsmeisteri; Maorites seymourianus; Nucula suboblonga; Eryphyla drygalskiana; Panope clausa; Gonioyma hyriiformis; Laevitrignia (E.) eclipstia; Cryptothytes philippiana; Eunaticina arctowskiana; marine reptile bones.

18.0 721.0—Gray (5Y 5/3), very fine grained friable silty sandstone. At the top follows a 20 cm thick sandstone. Sample 43. Maorites seymourianus; Nucula (L.) suboblonga; Indogrammatodon cf. lormandi; Linotrignia (O.) pygoscellum.

24.0 745.0—Sandy silt with numerous reddish concretions. At the top follows a gray (2.5Y 5/4), well bedded fine grained sandstone (40 cm thick). Sample 44. Maorites sp.; Gonioyma hiiryformis; Amberleya spinigera; Cryptothytes philippiana.
15.0 760.0—Gray silt with concretions. Ammonites very abundant. At the
top follows a clacareous, very fine grained gray sandstone.

4.5 764.5—Base not exposed. At the top: 50 cm of well cemented, gray
(5Y 5/3), fine grained sandstone. Serpulids very abundant.
Sample 45. Rotularia (A.) zinsmeisteri.

15.0 779.5—Friable siltstone, mostly covered. At the top follows a
thin, indurated gray sandstone. Sample 46. Maorites
seymourianus; Panope clausa; Limotrigonia (O.) pygoscelium;
Thrácia sp.; Cassidaria mirabilis; Pleurotomaria larseniana;
Eunaticina arctowskiana; Parasmilia anderssoni (coral);
echinoderm spines; fossil wood.

21.0 800.5—Gray (5Y 6/2), friable siltstone with one 30cm. thick
intercalation of sandstone (at 15m). Sample 47. Maorites
densicostatus; Kitchinites darwini; echinoderm spines.

21.0 821.5—Friable siltstone. 10 m above the base: Sample 47+.
(Rotularia (A.) zinsmeisteri; Nordenskjöldia nordenskjoldi;
Laevitrigonia (E.) ecplecta; Pycnodonte seymourianus). At the
top follows a concretionary bed. Sample 48. Echinoderm
spines; gastropoda sp indet.

—Section continues at approximately the same level along
strike. Sample 49. Kitchinites darwini; Maorites
seymourianus; Nordenskjoldia nordenskjoldi; shark vertebrae.

33.0 854.5—Gray (5Y 6/4) friable sandy siltstone with one intercalation
of (approx. 40 cm thick) fine grained sandstone. Sample 50.
Rotularia (A.) sp.; unident. gastropods and ammonites.

15.0 869.5—Friable, gray (5Y 5/2) sandy clayey siltstone with scattered
concretions. Sample 51. Grossouwrites gemmatus.

12.0 881.5—Friable, gray (5Y 6/3) clayey sandy siltstone followed at the
top by 30 cm of very fine grained, cemented sandstone. Sample
52. Rotularia (R.) shackletoni; gastropods.

7.5 889.0—Gray greenish (5Y 6/2), sandy silt with some indurated
horizons that are not laterally continuous. Sample 53a,b.

6.0 895.0—Massive, medium grained moderately cemented gray (5Y 6/2)

3.0 898.0—Hard, bioturbated, gray, massive sandstone. Corals.

18.0 916.0—Massive, gray (5Y 6/4) silty sand with scattered concretions.
Corals and fossil wood. Sample 55.

10.5 926.5—Moderately bedded tan-brownish sandy silt followed by a gray
silt (5Y 6/2) with intercalations of massive gray sandstones
(~2 m thick)(rock similar to Sample 54). Sample 56. Grossouvrites gemmatus; Panope clausa; Nucula (L.) suboblonga; Amberleya spinigerata.

21.0 947.5—Gray (5Y 5/2), massive sandy silt. A more indurated level (20cm) at 7.5m; at the top is a 40 cm thick glauconitic siltstone. Sample 57.

12.0 959.5—Moderately bedded gray (5Y 5/3) sandy silt. At the top follows a glauconitic bed, 50 cm thick. Sample 59.

13.5 994.0—Yellowish gray (2.5Y 6/4), silt with concretionary levels. At the top: 60 cm of indurated gray calcareous sandstone with concretions. Sample 60. Rotularia (A.) zinsmeisteri; Perissopetera sp.; echinoderm spines (abundant); bone fragments.

10.0 1004.0—Yellowish (5Y 6/1) silt. At the top: 8cm of gray fine grained sandstone. Samples 61 and 61bis. Rotularia (A.) sp.; Maorites densicostatus; M. suturalis; Grossouvrites gemmatus; Pachydiscus (P.) riccardi.

27.0 1031.0—Yellowish to tan (2.5Y 6/6) sandy silt with scattered concretions. Sample 62. Hoploparia stockesi; unident. ammonite.

10.5 1041.5—Tan (5Y 5/2) sandy silt. On top is a 50 cm thick medium grained, very fossiliferous glauconitic sandstone with concretionary levels. Sample 63. Maorites tenuicostatus; Pseudophyllites loryi; Cucullaea sp.; Perissopetera sp.; unident. gastropod.

7.5 1049.0—Dark green (5Y 5/2) sandy silt. Concretionary levels approximately 2-3m wide and 1 m thick. Sample 64. Unident. ammonites.

19.5 1068.5—Dark greenish to yellowish (2.5Y 6/4) sandy silt with very large (up to 50cm.) rounded concretions; on top follows a 20 cm thick yellowish gray, calcareous sandstone. Sample 65. Diplomoceras lambi; unident. bivalve.

19.5 1088.0—Dark gray (5Y 5/1) sandy silt with numerous concretions. Three (0.4 to 1.5m thick) glauconitic intercalations. Sample 66. Maorites tenuicostatus; Pycnodontes cf. vesiculosa; Cyclorismina incognita.

12.0 1100.0—Gray-greenish (5Y 6/1) silty sand. Sample 67.

25.5 1125.5—Gray (5Y 5/2), fine grained friable, massively bedded sandy silt, with yellowish and grayish bands. Very abundant serpulids. Sample 68. Rotularia (A.) sp.; Pachydiscus ultimus (very abundant); Pycnodontes cf. vesiculosa (Very
abundant); echinoderm spines.

15.0 1140.5—Gray (5Y 5/1) sandy silt with very large, strongly bioturbated concretions, Sample 69a. Greenish (5Y 5/3) silty sand with pale greenish concretions Sample 69b. Pachydiscus ultimus (v. abundant); Lahilla larseni.

27.0 1167.5—Greenish silty sand with numerous concretions (pale brown outside, gray inside). Sample 70. Rotularia (A.) sp.; Cucullaea elliotti; echinoderm spines.

4.5 1172.0—Green massive silty sand with concretions (up to 20 cm. in diameter). Cucullaea elliotti.

18.0 1190.0—Greenish (5Y 6/2) silty sand with large concretions. Sample 71. Lahilla larseni; Pleurotomaria larseniana; Nucula (L.) suboblonga; Cerithium sp.; Cinulia? sp.

Sobral Formation

13.5 13.5—Well bedded brownish green (5Y 6/2) silty sand with numerous concretions. At the top follows a level with rounded intraclasts (up to 4 cm in diameter). Sample 72. Nucula (L.) suboblonga; Acesta (A.) webbi; Pinna sp.; Perissoptera nordenskjoldi; fossil wood.

25.5 39.0—Greenish gray silty sand with abundant large concretions (0.6 to 1 m in diameter). At 15m a 0.5m glauconitic bed and another at 22.5m (1m thick). Samples 73a,b,c,d (see locations in fold-out figure at the back). 73a: laminated silt (5Y 4/3); 73b: massive light greenish gray (5Y 6/2) silty sand; 73c: dark brown and yellowish (5Y 6/2), well bedded sandy silt with intercalations of clay; 73d: gray (5Y 6/1) sandstone. Pleurotomaria larseniana (73a).

13.5 52.5—Greenish gray (5Y 4/3) silty sand followed by a grayish green glauconitic sandy silt (50cm. thick). Sample 74.

11.0 63.5—Dark greenish gray (5Y 4/2) massive silty sand. At 6 m is another glauconitic bed. Local levels with much harder rocks. Sample 75. Lahilla larseni; Austrophaera patagonica; Perissoptera nordenskjoldi; Pinna anderssoni.

14.5 78.0—Greenish silt. At 5m starts a level with intraclasts. At 8m starts a greenish glauconitic sandstone with clay intraclasts. Sample 76.

10.5 88.5—Greenish (5Y 6/1) glauconitic silty sand changing to gray color upwards. A hard layer at the top. Sample 77.

12.0 100.5—Green sandy siltstone with concretionary horizons. At 12m a
thin (15-20cm) creamy white (5Y 7/3) mudstone (ash layer?). Sample 78. Gastropod.

13.0 113.5-Greenish silt. At 3m is a dark gray laminated silt and at 4m a 50cm thick white yellowish bed. At 11 starts a gray, hard sandstone (approx. 2m thick). Sample 79. Scattered fragments of coal.

16.5 130.0-Starts a different lithology, with a more friable rock, and very few concretions. Levels of well cemented, gray (5Y 6/1), calcareous sandstone. Very abundant fossil wood. Sample 80. Bivalve.

16.5 146.5-Greenish (5Y 5/1) silt. At 3m is a 5cm, thick yellowish-red layer. On top, follows approximately 6 m of gray, medium grained massive to poorly bedded sandstone. Sample 81.

22.5 169.0-Gray (5Y 6/1) silt intercalated with massive, hard sandstone. At 15m was found a thin (15cm) red bed. Sample 82.

Cross Valley Formation
(The contact is possibly faulted)

-Crossbedded, medium grained glauconitic sandstone. Sample 83.

25.5 25.5-Gray (5Y 6/1), friable fine grained sandstone with yellowish horizons. Sample 84.

37.5 63.0-Fine grained greenish (5Y 6/1) sandstone, very friable but with more cemented horizons. Tangential and planar crossbedding at 19.5m. Large wood fragments. A well cemented bed at the top of the section. Sample 85.

Total thickness of Section A: 1422m.

SECTION B

Cross Valley Formation

A= individual thickness; B= cumulative thickness of the formation (meters).

<table>
<thead>
<tr>
<th>A</th>
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<td>1.5</td>
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</table>

Section starts at a glauconitic crossbedded sandstone (C-52).

1.5 1.5 -Green, medium to coarse grained, trough crossbedded sandstone. Channels 2-7m wide. On top follows an orange-yellowish layer.

3.0 4.5 -Green (5GY 6/1), friable sandstone. Stratification not
observed. On top follows a coarser grained 50cm thick hard sandstone. Sample 198.

18.0 22.5-Greenish to dark brown (5GY 7/1), friable sandstone with spherical concretions with a yellowish-orange patina. On top follows a coarser grained sandstone. Large fragments of fossil wood, sometimes carbonized. Sample 199.

4.5 27.0-Friable green (5GY 6/1) sandstone with some concretions. At the top is a 0.5m thick, hard layer. Fossil wood. Sample 200.

3.0 30.0-Friable green (5GY 6/1) sandstone. On top is a thickly bedded green sandstone, followed by an orange-yellowish layer. Sample 201.

12.0 42.0-Greenish (5GY 5/1), friable sandstone with abundant fossil wood, with perforations. Sample 202.

6.0 48.0-Trough cross-bedded sandstone. Individual sets are 1m thick. Large channels are observed. On top follows a one meter thick yellowish orange (5Y 8/6) sandstone. Sample 203.

9.2 57.2-One m. of dark gray, poorly sorted coarse sandstone, followed by a fine grained brown sandstone. At the top: a thick massive, gray (5GY 6/1) sandstone. Sample 204.

4.0 61.2-Friable, greenish, medium grained sandstone that becomes trough cross-bedded towards the top. Fossil wood. Sample 206.

Total thickness of Section B: 61.2m.

SECTION C

Lopez de Bertodano Formation

A= individual thickness; B= cumulative thickness of the formation (meters).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray, cemented, 30cm thick fine grained, strongly bioturbated, calcareous sandstone. Follows a light gray laminated sandy silt with well preserved small fossils. Sample 315. Linotrigonia (O.) pygoscellum; Vanikoro? sp.; Taitoma charcotianus; Brachiopoda sp. indet.; echinoderm spines; Gastropoda sp. indet.</td>
<td>7.5 7.5-Friable gray sandy siltstone. Sample 316.</td>
</tr>
</tbody>
</table>
9.0 16.5—Friable gray sandy siltstone. On top, a more brownish bed, 1m thick. Sample 317. Rotularia (R.) shackletoni; Maarites densicostatus; Amberleya spinigera; calcareous tubes.

11.0 27.5—Gray, well laminated sandy silt. Sample 318.

1.0 28.5—Same as below; very abundant concretions. Sample 319. Maarites sp. (juveniles); Laevitrigonia (E.) ecplecta; Perissoptera nordenskjoldi; echinoderm spines.

1.5 30.0—Well bedded dark gray sandy silt. Sample 320.

9.0 39.0—Well bedded gray sandy silt. On top is a more cemented gray, well bedded, calcareous, fine sandstone. Samples 321a,b. Rotularia (A.) cf. zinsmeisteri; Maarites densicostatus (juveniles); Amberleya spinigera (very common); Cassidaria mirabilis.

12.0 51.0—Well bedded gray sandy silt. Serpulids very abundant. Sample 322. Rotularia sp.; Cucullaea antarctica; Pulvinites antarcticus; Diplomoceras lambi; Cassidaria mirabilis; abundant echinoderm spines.

10.5 61.5—Well bedded gray sandy silt becoming more greenish at the top. Sample 323. Rotularia sp.; bone fragments of a marine reptile bone.

10.5 72.0—Gray-greenish sandy silt. Concretions present on the surface. Sample 324. Rotularia sp. very abundant.

3.0 75.0—Gray-greenish sandy silt with large concretions (up to 0.5m). Sample 325. Pachydiscus riccardi; Grossouwrites gemmatus; Maarites densicostatus; Kitchinites sp.

1.5 76.5—Greenish-gray sandy silt. Sample 326. Rotularia sp.; Pachydiscus riccardi (specimens large and very abundant); Grossouwrites gemmatus (spec. 30 cm in diameter); Kitchinites sp.; Amberleya spinigera.

10.5 87.0—Gray-greenish sandy silt, apparently massive. Fossils "in situ". Sample 327. Rotularia sp. (v. abundant); Pachydiscus riccardi; echinoderm spines.

9.0 96.0—Gray-greenish sandy silt. Sample 328a. Rotularia (A.) sp. (abundant); Taioa charcotianus; Amberleya spinigera. At the top it is observed a darker layer (Sample 328b).

7.5 103.5—Gray sandy silt with concretions. Sample 329. Rotularia (A.) sp. (v. abundant); Pachydiscus riccardi (abundant); Anagaudryceras cf. mikobokense; Maarites densicostatus; M. tenulicostatus (juveniles very abundant); Taioa charcotianus; Amberleya spinigera; bored fossil wood; shark vertebrae.
9.0 112.5—Greenish gray sandy silt with a more glauconitic bed at 3m. At the top: gray, massive sandy silt. Sample 330. Maorites densicostatus; Anagaudryceras cf. mikobokense; Cucullaea antarctica; Laevitrigonia (E.) ecplecta (in situ); Amberleya spinigera; marine reptile bones.

7.5 120.0—Gray greenish sandy silt with very large concretions. Sample 331. Grossouwrites gemmatus; Maorites densicostatus (juveniles); Perissoptera nordenskjoeldi; Cucullaea antarctica; small bivalves; marine reptile bones; shark vertebrae; large burrows.

13.5 133.5—Gray-greenish sandy silt with large concretions and abundant burrows. Sample 332. Rotularia sp.; Grossouwrites gemmatus; Maorites densicostatus; Pinna sp.; Cyclorhisma incognita; Cucullaea antarctica; Amberleya spinigera; echinoderm spines.

9.0 142.5—Lithology same as below. Sample 333. Rotularia shackletoni; very large Anagaudryceras cf. mikobokense (68 cm in diam.); Grossouwrites gemmatus; Pinna anderssoni.

9.0 151.5—Massive dark gray sandy silt. Sample 334. Pinna sp.; gastropoda sp. indet.; echinoderm spines.

4.5 156.0—Massive dark greenish gray sandy silt. Sample 335. Scattered fossils: Amberleya spinigera; Lahilla larseni.

10.5 166.5—Same lithology. Sample 336. Rotularia (A.) sp.; Maorites densicostatus.

6.0 172.5—Massive dark greenish-gray sandy silt with large irregular calcareous concretions that are strongly bioturbated. Sample 337. Rotularia (A.) sp.; Pachydiscus riccardi; Grossouwrites gemmatus; Diplomoceras lambi; Maorites cf. suturalis; Pycnodonte cf. vesiculosa; Limatula antarctica; Acesta snowhillensis; Lahilla larseni; Laevitrigonia (E.) ecplecta; Amberleya spinigera; corals; burrows very abundant.

3.0 175.5—Greenish sandy silt, probably more glauconitic, and with smaller concretions than below. Sample 338. Pachydiscus riccardi; Diplomoceras lambi; Grossouwrites gemmatus.

6.0 181.5—Lithology same as below, with scattered concretions. Abundant vertical and oblique burrows. At the top is a 10 cm thick calcareous, very fine grained sandstone. Serpulids. Sample 339.

6.0 187.5—Massive gray sandy silt with small irregular concretions; large burrows. Sample 340. Rotularia (A.) sp. (abundant); Pachydiscus riccardi; Grossouwrites gemmatus; Diplomoceras lambi; Maorites densicostatus; Pseudophyllites loryl; Pycnodonte cf. vesiculosa; Limatula antarctica; Lahilla
larseni; Laevicarinatia (E.) eclecta; Pinna anderssoni;
Fulvinites antarcticus; Amberleya spinigera; Cryptorhitys
philippiana; Cassidaria mirabilis; echinoderm spines.

9.0 196.5—Massive brownish-gray sandy silt with reddish concretions (up
to 30 cm) with burrows. Sample 341. Rotularia (A.) sp.;
Maorites densicostatus; Grossouvreites gemmatus; Pachydiscus
sp.; Labilla larseni.

10.5 207.0—Massive brownish-gray sandy silt with large, strongly
bioturbated concretions. Sample 342. Rotularia (A.) sp.
(abundant); Pachydiscus sp.; Maorites densicostatus;
Pycnodonte cf. vesiculosa; Cucullaea antarctica; Limatula
antarctica; Labilla larseni; Pinna anderssoni; Taloma
charcotianus; Amberleya spinigera; Cryptorhitys philippiana;
Eunaticina arctowskiana; echinoderm spines.

4.5 211.5—Gray massive sandy silt. Samples 344, 344bis, 345, 346, 347.
Rotularia (A.) sp.; Pachydiscus ultimus; Grossouvreites
gemmatus; Diplomoceras lambi; Maorites densicostatus;
Eutrephoceras simile; Pycnodonte cf. vesiculosa; Goniomya
hyriformis; corals, small unident. gastropods; echinoderm
spines. This is the last ammonite bearing horizon.

1.5 213.0—0.5m of glauconite, followed by a greenish sandy silt.
Sample 348. Labilla larseni; bored fossil wood.

3.0 216.0—Greyish-green sandy silt. Irregular concretionary horizons.
Sample 349 (at the base); Sample 343 (at the top). Rotularia
(A.) sp.; Labilla larseni; Panope sp.; bored fossil wood;
echinoderm spines.

9.0 225.0—Light gray massive sandy silt, more sand rich than below.
Irregular small concretions. Several more glauconitic levels.
Sample 350. Rotularia (A.) sp.; Nucula (L.) suboblonga;
Cucullaea ellioti; Labilla larseni; Perissoptera
nordenskjoldi; echinoderm spines.

14.0 239.0—Grayish-green sandy silt. At 11 m is a 0.5m thick
yellow-brownish weathering silt. At the top follows a
glauconitic bed with irregular concretions. Sample 351.
Labilla larseni; Perissoptera nordenskjoldi; Cucullaea
ellioti; bored fossil wood.

15.0 254.0—Poorly exposed; grayish silty sand with rounded calcareous
concretions (up to 30 cm.). Sample 352. Nucula (L.)
suboblonga; Labilla larseni; Austrocominella patagonica;
Perissoptera nordenskjoldi.

32.0 286.0—Gray to brownish silty sand with abundant large rounded
concretions. Sample 353. Nucula (L.) suboblonga; Labilla
larseni; Cucullaea ellioti.
**SECTION D**

**Lopez de Bertodano Formation**

A= individual thickness; B= cumulative thickness of the formation (meters).

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<td>16.5</td>
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<td>19.5</td>
<td>201.0</td>
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</table>
37.5 238.5—Mostly covered. At the top is a thickly bedded gray (5Y 5/3) sandstone with some concretions. **Sample 96.**

10.5 249.0—Intercalations of thin and well cemented gray (5Y 5/1) sandstone with more friable siltstone. At the top is a conspicuous calcareous concretionary horizon. **Sample 97.**

15.0 264.0—Gray (5Y 5/3) siltstone. At 12m starts a calcareous well bedded sandstone with corals and serpulids. **Sample 98.**

264.0—Section continues along strike.

**Sample 99.** Rotularia (A.) sp.; Diplomoceras lambi; Linotrigonia (O.) sp.; Erithyla drygalskiana; Cassidaria mirabilis; Taipa charcotianus; corals; echinoderm spines.

37.5 301.5—Mostly covered. Gray (5Y 6/1) silty clay with some concretions. **Sample 100.** Maorites sp.

21.0 322.5—Gray mudstone with levels bearing large irregular concretions. **Sample 101.** Diplomoceras lambi; Panope clausa.

48.5 371.0—Mostly covered. Dark gray to grayish green (2.5Y 5/4) clayey silt with abundant calcareous concretions. No fossils. **Sample 102.**

60.0 431.0—Mostly covered. Gray (5Y 5/2) clayey silt with concretions. From 12 to 30m serpulids are very abundant. **Sample 103.** Rotularia (A.) sp.; Goniomya hyriiformis.

27.0 458.0—Gray clayey silt with concretions. **Sample 104.** Maorites seymourianus; Pycnodonte cf. seymourianus; Cucullaea sp.

21.0 479.0—Gray (5Y 5/2) silt with concretions. At the top there is a 10cm thick sandstone. **Sample 105.** Rotularia shackletoni; Maorites sp.; Nucula suboblonga; Panope clausa; Cucullaea antarctica; Cryptorhitys philippiana; Eunaticina arctowskiana; Amberleya spinigera.

15.0 494.0—Brownish (5Y 5/2) silt with concretions. Two intercalations of calcareous sandstones, one at 4m and the other at the top. **Sample 106.** Rotularia (R.) shackletoni; Pycnodonte seymourianus; Amberleya spinigera.

20.0 514.0—Brownish gray (5Y 5/2) silt. At the top is a thin, well cemented fine grained sandstone. **Sample 107.** Rotularia (A.) tenulaevis; Grossouwrites gemmatus; Maorites seymourianus; Kitchinrites darwinii; Cassidaria mirabilis; Amberleya spinigera.

Continues section along strike.

Gray to brownish (5Y 6/4) sandy silt with concretions and more calcareous horizons. **Sample 142.** Rotularia (A.)
zinsmeisteri; R. (R.) shackletoni; Kitchinites darwinii; Pycnodonte cf. vesiculosa; Linotrignonia (O.) pygoscellum.

16.5 530.5—Light gray (5Y 6/2) sandy silt with calcareous levels. Macrofauna very abundant. Sample 143. Rotularia (A.) zinsmeisteri; Maorites seymourianus; Kossmaticeras (Natalites)? weddelliensis; Kitchinites darwinii; Eutrepheceras simile; Nucula suboblonga; Nordenskjoldia nordenskjoeldi; Laevitrigonia (E.) eeclecta; Pinna sp.; Amberleya spinigera; Pleurotomaria larseniana; echinoderm spines; fossil wood.

18.0 548.5—Brownish gray (5Y 5/4) sandy silt with more sandy, calcareous levels towards the top. Sample 144. Rotularia (A.) sp.; Rotularia (R.) shackletoni; Kitchinites sp.; Linotrignonia (O.) pygoscellum; Eutrepheceras simile; shark vertebrae.

22.5 571.0—Brownish gray (5Y 6/2) sandy silt. Sample 145. Rotularia (A.) zinsmeisteri; Rotularia (R.) shackletoni; Kitchinites sp.; Eutrepheceras simile; Nordenskjoldia nordenskjoeldi; Amberleya spinigera; echinoderm spines; corals.

22.5 593.5—Dark greenish brown (5Y 6/2) sandy silt. Sample 146. Rotularia (A.) sp.; Cassidaria mirabilis; Perissoptera sp.; Cryptorhysis philippiana; Gastropoda sp.; Paramuria anderssoni (coral).

22.5 616.0—Pale brown (5Y 6/2) sandy silt with abundant concretionary levels. Sample 147. Rotularia (R.) shackletoni; Ditrupa sp.; Linotrignonia (O.) pygoscellum; Perissoptera nordenskjoeldi; echinoderm spines.

34.5 650.5—Gray (5GY 6/1) sandy silt. Sample 148. Maorites sp.; Pseudophyllites loryi; Perissoptera nordenskjoeldi; Cassidaria mirabilis; Taloma charcotianus; gastropoda sp. indet.; corals.

19.5 670.0—Gray (5Y 6/2) silt with small rounded concretions. At the top is 30 cm of massive, very calcareous sandy siltstone, forming a continuous level. Sample 149. Grossouvreites gemmatus; Amberleya spinigera; Perissoptera nordenskjoeldi; Cassidaria mirabilis.

24.0 694.0—Yellowish gray (5GY 6/1) sandy silt with levels with irregular concretions, some bioturbated. Sample 150. Maorites sp. (abundant juveniles); Maorites suturalis; Kitchinites laurae; Linotrignonia (O.) pygoscellum; Laevitrigonia (E.) eeclecta; Cassidaria mirabilis; Amberleya spinigera; Hoploparia stockesi.

27.0 721.0—Sandy silt with irregular concretions. Numerous broken fragments of Cucullaea antarctica. Sample 151. Maorites densicostatus; Pachydiscus ricardi (abundant); Diplomoceras lambi; Laevitrigonia (E.) eeclecta; Cucullaea antarctica;
Cassidaria mirabilis; Taioma charcotianus; Cryptorhytis philippiana; Amberleya spinigera.

12.0 733.0—Yellowish brown (2.5Y 6/4) sandy silt with irregular concretions. Serpulids are abundant. At the top is a well cemented glauconitic bed. **Sample 152. Pachydiscus riccardi** (abundant).

19.5 752.5—Yellowish silt. The upper 12 m are composed of a green (5GY 5/1) glauconitic silty sandstone, more consolidated at the top. Macrofauna is very abundant. **Sample 153. Rotularia (A.) sp.; Maorites suturalis; Pachydiscus riccardi; Grossouvrrites gemmatus; Kitchinites laurate; Anagaudryceras cf. mikobokense; Eutrephoceras simile; Laevitrignia (E.) eplectea; Cucullaea antarctica; Cassidaria mirabilis; Cryptorhytis philippiana; unident. gastropod; shark vertebrae; marine reptile bones.**

10.5 763.0—Greenish gray (5Y 6/2) sandy silt with occasional concretions. **Sample 154. Maorites tenuicostatus.**

7.5 770.5—Gray to yellowish (5G 6/1) sandy silt. At the top follows 20cm of fine grained well cemented greenish calcareous sandstone. **Sample 155.**

8.5 779.0—Gray (5Y 6/2) silty sand. **Sample 156. Rotularia (A.) sp.; Maorites suturalis; Grossouvrrites gemmatus; Lahilla larseni; Laevitrignia eplectea; Cryptorhytis philippiana; Perissoptera sp.; unident. brachiopod; echinoderm spines.**

13.5 792.5—Gray greenish (5GY 5/1) silty sand. On top: 1m of more cemented greenish silty sandstone. **Sample 157. Maorites densicostatus; Grossouvrrites gemmatus; Anagaudryceras cf. mikobokense; Lahilla larseni; Laevitrignia (E.) eplectea; Perissoptera nordenskjoldi.**

24.0 816.5—Gray (5GY 5/1), massive sandy silt, with scattered concretions. At the top is a more glauconitic bed with reddish concretions. **Sample 158. Abundant juvenile specimens of Maorites tenuicostatus.**

6.0 822.5—Gray sandy silt with scattered concretions. **Maorites densicostatus.**

10.5 833.0—Tan gray (5Y 6/2) silty sand with irregular concretions. **Sample 159. Perissoptera sp.**

22.5 855.5—Light gray to tan-greenish (5Y 6/2) silty sand with abundant irregular concretions. **Sample 160. Rotularia (A.) sp.; Maorites densicostatus; Grossouvrrites gemmatus; Pachydiscus sp.; Diplomoceras lambi; Laevitrignia (E.) eplectea; Lahilla larseni; Cycloismina incognita; Cryptorhytis philippiana;**
Cassidaria mirabilis; Taioma charcotianus.

This new section starts at approximately the same level than Station 157.

792.5-Gray massive sandy silt; no concretions. Stake placed in the ground. Sample 395.

9.0 801.5-Gray massive sandy silt. Abundant small small worm tubes (Ditrupa sp.), and small bivalves and corals. Sample 396. Amberleya spinigera.

9.2 810.7-Gray massive sandy silt. Sample 397. Rotularia (A.) sp.; Grossouvrines gemmatus; Maorites cf. suturalis; Pachydiscus riccardi; Pycnodonte cf. vesiculosa; Taioma charcotianus; unident. bivalves; small bivalves; echinoderm spines; bored fossil wood.

9.0 819.7-Starts with a dark brown-greenish silt with numerous irregular (10-20cm) concretions. Follows a greyish-brownish sandy silt with numerous concretions (several are elongated, and up to 30cm long). Sample 398. Grossouvrines gemmatus (abundant); Pachydiscus ultimus; Maorites densicostatus; Laevitrigonia (E.) eclecta; Cucullanæ antarctica; Phelopteria sp.; Limatula antarctica; Perissoptera nordenskjoldi; Amberleya spinigera.

28.5 848.2-Grayish sandy silt, sandier than below, with brownish-yellowish spots. Abundant, irregular, bioturbated concretions. Sample 399. Rotularia (A.) sp.; Grossouvrines gemmatus (abundant); Pachydiscus ultimus (abundant); Maorites cf. suturalis; Eutrephoceras sile; Pycnodonte cf. vesiculosa (very abundant); Lahilla larseni; Cucullanæ sp.; Limatula antarctica; Amberleya spinigera; Taioma charcotianus; Cryptorhynchis philippiana; unident. gastropods; echinoderm spines; marine reptile bones.

9.0 857.2-Gray, but more greenish towards the top, sandy silt with very few concretions. Sample 400. Rotularia (A.) sp.; Vertebratae kayi; Pachydiscus ultimus; Pycnodonte cf. vesiculosa; Entoliæ sp.; echinoderm spines.

39.0 896.2-Grayish greenish sandy silt. The lower 10.5m do not have concretions. On top, concretions are small but more abundant. The highest bed is a 30cm thick glauconite. Samples 401, 402; 403. Rotularia (A.) sp.; Lahilla larseni; Pycnodonte cf. vesiculosa; Panope clausa; Goniatomya hystrix; bored fossil wood, and coalified wood.

23.0 919.2-The lower 10m are composed of a light green sandy silt with small concretions. Follows a massive light gray sandy silt with rounded small concretions. Sample 404. Lahilla larseni (abundant); Perissoptera nordenskjoldi; Nucula
suboblonga; Cyclorisma incognita; bored fossil wood.

11.0 930.2-Gray but somewhat more greenish than below, micaceous, sandy silt. At the top there is a more cemented fine grained sandstone, 30-40 cm thick, with rounded concretions. Sample 405. Lahilla larseni; Nucula suboblonga; Cyclorisma incognita; Cucullaea ellioti; Perissoptera nordskjoldi.

26.0 956.2-Brownish gray silty sand with very abundant large spherical concretions. A the top, the concretions become smaller and weather to a red color. Sample 406. Lahilla larseni (v. abundant); Nucula suboblonga; Perissoptera nordskjoldi; bored fossil wood.

21.0 977.2-Brownish gray silty sand with scattered small irregular concretions. Sample 407. Lahilla larseni; Nucula suboblonga; Perissoptera nordskjoldi. At the top is the contact with the Sobral Formation (a stake was placed at this point).

Total measured thickness of section D: 977.2m

SECTION E

Lopez de Bertodano Formation

A= individual thickness; B= cumulative thickness of the formation (meters).

<table>
<thead>
<tr>
<th>A</th>
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<tbody>
<tr>
<td>Gray (5Y 5/2) silty sand with concretions. At the top follows a 20 cm. thick bed of coarser grained, well cemented sandstone. Sample 114. Grossouvrrites gemmatus; Pycnodonte cf. vesiculosa; gastropods.</td>
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<tr>
<td>3.0</td>
<td>3.0</td>
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</tbody>
</table>

3.0 3.0-Green (5GY 5/1), glauconitic sandy silt. Sample 115.

12.0 15.0-Gray (5Y 5/2), flaser bedded sandy silt, with brown-yellowish streaks. At the top follows 40 cm of a dark brown layer. Sample 116. Pachydiscus ultimus; Maorites densicostatus; Grossouvrrites gemmatus; Laevitrigonia (E.) ecpecta; Pinna sp.; Pycnodonte cf. vesiculosa; Pycnodonte cf. seymourianus.

13.0 28.0-Gray (5Y 5/2) sandy silt with more brownish levels with gray mottling; level with elongated concretions. Sample 117. Rotularia (A.) sp.; Maorites densicostatus; Eutrephoceras simile.

30.0 58.0-Gray-greenish (5GY 6/1) silty sand with irregular concretions. Sample 118. Lahilla larseni; Cucullaea ellioti.
10.5 68.5—Gray (5Y 5/2) silty sand with irregular concretions. Sample 119. Lahilla larlesi (v. abundant); Cucullaea elliotii; Cyclorhismina incognita; Perissoptera nordenskoldi.

30.0 98.5—Light green but weathering to greenish brown (5Y 5/2) sandy silt with intercalations of more consolidated sandstone layers. Sample 120.

3.0 101.5—Same lithology as below.

Sobral Formation

6.0 6.0—"Brown-chocolate layer". Well laminated to flasser bedded, dark brown (5Y 4/2), clayey silt. Small channels and very small scale trough cross-bedding. Sample 121. Shark tooth.

6.0 12.0—Continues the same unit, but channels are more frequent. Large burrows. Sample 122.

10.5 22.5—Gray (5Y 6/1) sandy silt; at 4.5m were found gray, ellipsoidal, calcareous concretions (Sample 122+4.5). At 10.5m another level of concretions, but smaller, and irregular, forming an almost continuous level.

10.5 33.0—Brownish gray sandy silt, apparently massive.

4.5 37.5—Brown, flasser bedded mudstone ("to the "Brown-chocolate layer"), with more sandy (yellowish) layers. At the top: a gray (5Y 6/1), calcareous concretionary level, 15-30cm thick. Sample 123. Unident. bivalves.

15.0 52.5—Dark brown (5Y 5/2) intercalated with yellow, well bedded clayey silt ("to the "Brown-chocolate layer"). At the top follows a harder, calcareous sandstone. Sample 124.

10.5 63.0—Light brownish-yellowish (5Y 5/3) massive silty sand. Sample 125.

2.0 65.0—Medium grained glauconitic (5G 5/1) sand with a calcareous, harder level at the top. This is a local guide unit. Sample 126.

12.0 77.0—Light brown (N5) sandy silt with calcareous concretionary levels. Two 5 cm thick white units. On top is a greenish silty sand followed by 20 cm of calcareous, well cemented silty sandstone. Abundant fossil wood (some large trunks). Sample 127.

7.5 84.5—White-yellowish clay (0.4m thick), followed by 1.5m, brown, flasser bedded silt. From 3 m to the top is a light green (5GY 7/1) medium sand which is more cemented at the top.
Sample 128.

13.5 98.0—Light greenish (5GY 7/1), fine to medium grained sand. On top: 1.6m of the same rock but well lithified (calcareous cement). Vertical burrows (Skolithos sp.). Sample 129.

22.5 120.5—Light green (weathering to light green-gray with yellowish mottling) fine to medium grained silty sand with irregular yellowish concretions. On top follows a massive greenish-brown calcareous sandstone. Fossil wood and oblique burrows. Sample 130.

12.0 132.5—Gray (5Y 6/1) to brownish green to yellowish, fine grained sand. At the top: a more massive, hard, medium grained sandstone which is followed by a thin reddish-yellowish weathering horizon. Sample 131.

13.5 146.0—Greenish-yellowish (5Y 6/3) silty sand with numerous burrows. On top follows a moderately cemented, coarse sandstone with numerous reddish concretions. Sample 132. Cucullaea ellipti.

7.5 153.5—Friable silty sand. At the top follows a well bedded, cemented sandstone. Sample 133.

22.5 176.0—Light green (5GY 6/1) with yellowish-red tints silty sand. On top is a 0.5m thick, hard, calcareous, micaceous sandstone with burrows and poorly preserved bivalves. Sample 134.

Cross Valley Formation

4.5 4.5—Cross-bedded glauconitic sand. Sample 135.

9.0 13.5—Greenish (5GY 7/1), friable sandstone. At the top follows 1.5m of a well indurated tabular cross-bedded sandstone. Sample 136.

22.0 35.5—Greenish (5Y 6/4) sand, locally cross-bedded. Sample 137.

12.0 47.5—Greenish (5Y 6/2) sand with rounded concretions (concretions 1-1.5m in diam.), which preserve the original bedding. Sample 138.

15.0 62.5—Greenish (5GY 6/1) sand with concretionary levels. A reddish patina is observed on the rock surface. Sample 139.

13.5 76.0—Fine grained yellowish (5GY 7/1) sand. At the top is a glauconitic, coarse grained pebbly sandstone, changing laterally from very friable to well indurated. Oblique burrows (toothlets?). Sample 140

3.0 79.0—Fine grained conglomerate with pebbles, mostly volcanic, not
exceeding 1 cm. Sample 141.

Total measured thickness of Section E: 356.5 m.

SECTION F

Lopez de Bertodano Formation

A = individual thickness; B = cumulative thickness of the formation (meters).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.5</td>
<td>19.5-Grayish brown (5Y 6/4) sandy silt with intercalations of calcareous, harder levels at the top. Sample 161.</td>
</tr>
<tr>
<td>26.0</td>
<td>45.5-Gray (5Y 6/2) sandy silt with more calcareous levels. Sample 162. Echinoderm spines.</td>
</tr>
<tr>
<td>19.5</td>
<td>65.0-Brownish gray (5Y 6/2) sandy silt. Sample 163. Rotularia (A.) tenuilaevis; unident. ammonite; echinoderm spines.</td>
</tr>
<tr>
<td>24.0</td>
<td>89.0-Gray (5Y 6/2) sandy silt with more resistant calcareous intercalations. Sample 164. Rotularia (A.) tenuilaevis; Brachiopoda sp. Indet.</td>
</tr>
<tr>
<td>22.5</td>
<td>111.5-Gray sandy silt with more sandy calcareous levels with corals. Sample 165. Rotularia (A.) sp.; corals; unident. bivalves.</td>
</tr>
<tr>
<td>34.5</td>
<td>146.0-Gray (5Y 5/3) sandy silt. Sample 166. Rotularia (A.) tenuilaevis; Linotrigonla (O.) pygoscelium; echinoderm spines.</td>
</tr>
<tr>
<td>24.0</td>
<td>170.0-Brownish gray (5Y 5/3) sandy silt. At 15 m start abundant, small red concretions. Frequent concretionary levels are observed near the top. Sample 167. Rotularia (A.) tenuilaevis; Cucullaea antarctica; Bivalvia sp. Indet.; echinoderm spines.</td>
</tr>
<tr>
<td>33.0</td>
<td>203.0-Brownish gray (5Y 5/4) sandy silt with rounded small (up to 15 cm) concretions. Sample 168. Rotularia (A.) sp.; echinoderm spines.</td>
</tr>
<tr>
<td>18.0</td>
<td>221.0-Dark gray (5Y 4/3) sandy silt. At the top the rock is darker and has small, rounded, gray concretions. Sample 169. Rotularia (A.) sp.; echinoderm spines.</td>
</tr>
<tr>
<td>30.0</td>
<td>251.0-Dark gray (5Y 5/2) sandy silt with small concretions. Sample 170. Rotularia (A.) sp.</td>
</tr>
</tbody>
</table>
19.5 270.5-Brownish gray (5Y 5/3) sandy silt with scattered concretions. At the top is a 15cm thick calcareous sandstone that weathers to reddish colors. Sample 171. Bivalvia sp. indet.

9.0 279.5-Dark brown to grayish (5Y 5/2) sandy silt. At 9m is a well lithified greenish, calcareous sandstone (10cm thick). Large irregular and reddish weathering concretions start at the top. Sample 172. Rotularia (A.) tenuilaeviis; Rotularia (R.) shackletoni; Maorites seymourianus; Nucula suboblonga.

37.5 317.0-Brown grayish (5Y 6/3) sandy silt with frequent concretions. Sample 173. Rotularia (R.) shackletoni; Grossouwrites gemmatus; Kitchinutes darwini; Pycnodonte seymourianus (very abundant); Pinna sp.

30.0 347.0-Brownish gray (5Y 5/4) sandy silt. Concretions are smaller than below. Sample 174. Rotularia (R.) shackletoni; Kitchinutes darwini; Kossmaticeras (Natalites)? weddelliensis.

19.5 366.5-Brownish gray (5Y 5/3) sandy silt. Sample 175. Rotularia (A.) zinsmeisteri; Maorites seymourianus; Kitchinutes darwini; Panope clausa; Nucula suboblonga; Amberleya spinigera; shark vertebrae; bored fossil wood.

30.0 396.5-Gray (5Y 6/2) massive sandy silt with small concretions. Sample 176. Taima charcotianus.

24.0 420.5-Gray sandy silt with scattered concretions. At the top is a more resistant, 20-30cm thick silty sandstone. Sample 177. Grossouwrites gemmatus; Maorites seymourianus; Panope clausa; Taima charcotianus; Amberleya spinigera.

38.0 458.5-Gray to yellowish (5Y 6/3) sandy silt with small concretions. Sample 178. Grossouwrites gemmatus; Amberleya spinigera; Perissoptera nordenskoldi.

Continues section slightly displaced along strike. Gray sandy silt with occasional rounded concretions. On top is a 30 cm thick calcareous layer. Sample 179. Hoploparia stockesi; Maorites cf. seymourianus; Diplomoceras lambi; Cucullaea antarctica; Laevitrigonia (E.) eclecta; Eunicetina arctowskiana; Amberleya spinigera; Cryptorhytis philippiana; Gastropoda sp nov.; corals; echinoderm spines.

18.0 476.5-Gray (5Y 6/3) sandy silt with a calcareous sandstone (0.5m thick) at the top. Sample 180. Rotularia (R.) shackletoni; Limatula antarctica; Taima charcotianus; Eunicetina arctowskiana; echinoderm spines.

24.0 500.5-Gray (5Y 6/3) sandy silt with very few concretions. At the top is a 40 cm thick, calcareous, fine grained sandstone. Sample 181. Ditrupa sp.; Rotularia (R.) shackletoni;
Laevitrigonia (E.) eclecta; Lahilla larseni; Taloma charcoticanus; Eunaticina arctowskiana; Cryptorhitis philippiana; Amberleya spinigera; echinoderm spines; corals.

19.5 520.0—Gray sandy silt with a 30 cm thick calcareous sandstone. Sample 182. Laevitrigonia (E.) eclecta; Panope clausa; Cassidaria mirabilis; Eunaticina arctowskiana.

2.0 522.0—Thickly bedded (beds approx. 0.5m thick) gray (5Y 6/2), bioturbated silty sand. Sample 183.

16.0 538.0—Massive, gray (5Y 5/3) sandy silt. At the top was found a 15cm thick, bioturbated, calcareous sandstone. Sample 184.

30.0 568.0—Gray (5Y 6/3), massive, sandy silt. From 18m follows a brownish-yellowish silt. A thin calcareous concretionary level is found at the top. Sample 185. Rotularia (A.) sp.; Panope clausa; Bivalvia sp. Indet.; Perissoptera nordenskjoldi.

22.5 590.5—Brownish-yellowish (5Y 5/4) sandy silt followed by a gray, calcareous sandstone at the top of the unit. Sample 186. Rotularia (A.) sp; Laevitrigonia (E.) eclecta; Cucullaea antarctica; echinoderm spines; shark vertebrae.

18.0 608.5—Brownish-yellowish sandy silt with occasional reddish, rounded concretions. Sample 187. Rotularia (A.) sp.; Grossouvreites gemmatus; Cucullaea antarctica; unident. gastropods.

10.5 619.0—Brownish-yellowish sandy silt. At the top is a 20cm thick, gray (5GY 6/1) calcareous sandstone. Sample 188. Pachydiscus riccardi; Cryptorhitis philippiana; Gastropoda sp. Indet.; shark vertebrae.

7.5 626.5—Gray (5GY 6/1) sandy silt. Sample 189. Pachydiscus riccardi; Maorites densicostatus; Maorites tenuicostatus; Grossouvreites gemmatus; Laevitrigonia (E.) eclecta; Lahilla larseni.

3.0 629.5—Yellowish brown (2.5Y 6/4) sandy silt with large reddish concretions, and very abundant macrofauna. Sample 190. Sample 189. Pachydiscus riccardi; Maorites tenuicostatus; Kitchinates laurae; Eutrephoceras simile; Taloma charcoticanus; Amberleya spinigera; shark vertebrae; bored fossil wood.

24.0 653.5—Greenish sandy silt with a yellowish brown (2.5Y 6/4) sandstone at the top. Sample 191. Maorites densicostatus; Grossouvreites gemmatus; Laevitrigonia (E.) eclecta; Cassidaria mirabilis; Cryptorhitis philippiana.

27.0 680.5—Yellowish brown (2.5Y 6/6) sandy silt with reddish
concretions, intercalated with greenish horizons. Sample 193. Lahilla Larseni.

22.5 703.0-Brownish yellow to greenish gray (5GY 6/1) sandy silt with concretions. Sample 194 (taken at 15m); Sample 195 (taken at 22.5m). Maorites tenuicostatus (V. abundant juveniles); Grossouwrites gemmatus; Limatula antarctica; Panope clausa; Pycnodonte cf. vesiculosa.

Section F is continued at a level equivalent to Station 189.

626.5-Gray sandy silt with numerous concretions with burrows. Sample 356. Rotularia (A.) sp. (abundant); Pachydiscus riccardi (very abundant); Maorites densicostatus (very abundant); Grossouwrites gemmatus; Kitchinutes cf. laurae; Panope clausa; Cucullaea antarctica; Cyclorhismina incognita; abundant small bivalves; Amberleya spinigera; Cryptorhytis philippiana; Perissoptera nordenskjoldi; Traoma charcotianus; Cassidaria mirabilis; unident. gastropods; unident. brachiopods; bored fossil wood.

7.5 634.0-Dark gray massive sandy silt with small calcareous, irregular concretions; macrofossils abundant, and many are found "in situ". Sample 357. Rotularia (A.) sp. (abundant); Pachydiscus riccardi (very abundant); Maorites densicostatus; Maorites tenuicostatus; Grossouwrites gemmatus; Pseudophyllites loryi; Eutrephoceras simile; Laevitrigonia (E.) ecplecta; Amberleya spinigera; Cassidaria mirabilis; Hoploparia stockesi.

4.5 638.5-Dark gray to yellowish gray sandy silt with small, rounded concretions. Sample 358. Lahilla Larseni.

29.5 668.0-Gray massive sandy silt, more sand-rich than below. At the top is 30cm of consolidated calcareous sandstone forming a concretionary horizon. Sample 359. Rotularia (A.) sp.; Rotularia (R.) shackletoni; Maorites densicostatus; Grossouwrites gemmatus; Línotrígona (O.) pygoscélleum; Perissoptera nordenskjoldi.

12.0 680.0-Gray sandy silt. On top follows a more cemented horizon. Sample 360. Rotularia (A.) sp.; Pachydiscus riccardi; Maorites densicostatus (adults, and abundant juveniles); Grossouwrites gemmatus (abundant); Diplomoceras lambi; Pseudophyllites loryi; Panope clausa; Cucullaea antarctica; Pinna sp.; Lahilla Larseni (abundant); Limatula antarctica; Amberleya spinigera; echinoderm spines; Hoploparia stockesi.

12.5 692.5-Gray sandy silt. Sample 361. Maorites densicostatus; Grossouwrites gemmatus; Vertebrítes sp.; Panope clausa; Cucullaea antarctica; Lahilla Larseni; Laevitrigonia (E.) ecplecta; Pinna anderssoni (abundant); Eunaticina arctowskiana; Amberleya spinigera; Cryptorhytis philippiana;
Perissoptera nordskjoldi; abundant echinoderm spines.

17.0 709.5—Abundant rounded, reddish concretions in a massive gray, sandy silt. Very well preserved delicate fossils. Sample 362. Rotularia (A.) sp.; Rotularia (R.) shackletoni; Maorites densicostatus (abundant); Lahilla larsenii (very abundant); Amberleya spinigera (very abundant); Cryptorhitys philippiana; echinoderm spines; corals; fossil wood.

4.5 714.0—Gray sandy silt. Level with abundant straight worm tubes (Ditrupa sp.). Sample 363.

4.5 718.5—Greenish-gray, glauconitic, sandy silt (1m thick). Brownish concretions are abundant beneath the glauconite. Sample 364. Maorites densicostatus (abundant); Grossouvrrites gemmatus; Diplomoceras lambii; Lahilla larsenii; Pycnodonte cf. vesiculosa; Amberleya spinigera (very abundant).

21.0 739.5—Gray sandy silt with rounded reddish concretions, and a glauconitic level. Sample 366a (below the glauconite); Sample 366b (glauconite). Rotularia (A.) sp.; Rotularia (R.) shackletoni; Maorites densicostatus; Maorites sp.; Grossouvrrites gemmatus; Lahilla larsenii (abundant); Laevitrigonia (E.) ecplecta; Amberleya spinigera; Hoplopuria stockesi (abundant).

8.0 747.5—Gray sandy silt with rounded, bioturbated concretions; a level with Ditrupa is found at the top of the unit, followed by a 0.3m thick glauconite. Sample 367. Rotularia (A.) sp.; Pycnodonte cf. vesiculosa; Amberleya spinigera.

6.0 753.5—Gray massive sandy silt with reddish, rounded concretions. At the top is a greenish bed, approx. 3cm thick. Sample 368. Rotularia (A.) sp.; Rotularia (R.) shackletoni; Pachydiscus ultimo; Maorites densicostatus (adults and abundant juveniles); Grossouvrrites gemmatus; Diplomoceras lambii; Anagaudryceras sp.; Pycnodonte cf. vesiculosa (very abundant); Acosta snowhillensis; Lahilla larsenii; Laevitrigonia (E.) ecplecta; Amberleya spinigera; Cryptorhitys philippiana; Perissoptera nordskjoldi; crinoid fragments; echinoderm spines; fossil wood.

7.5 761.0—Gray with brownish spots, bioturbated, massive, sandy silt. Sample 369. Rotularia (A.) sp.; Pycnodonte cf. vesiculosa; unident. bivalve; Perissoptera nordskjoldi; echinoderm spines; fossil wood.

4.8 765.8—Same lithology as below but with some irregular, small concretions. At the top follows a glauconitic bed. Sample 370a (gray silt); Sample 370b (glauconite).

10.5 776.3—Greenish, glauconitic sandy silt. Sample 371. Rotularia
(A.) sp. (abundant); Pachydiscus ultimus; Grossouvrites gemmatus; Pycnodonte cf. vesiculosa; echi nodoerm spines.

12.0 788.3—Brownish gray sandy silt with reddish concretions. Some of the concretions are strongly bioturbated. Rotularia (A.) sp. (very abundant); Pachydiscus ultimus (very abundant); Grossouvrites gemmatus; Lahilla larseni; Amberleya spinigera; Perissoptera nordenskjoldi; Taïoma charcotianus; echi nodoerm spines; fossil wood.

18.0 806.3—Friable massive, gray sandy silt with small to large round to irregular concretions. Sample 373. Rotularia (A.) sp.; Cucullaea ellioti; Lahilla larseni (very common); Perissoptera nordenskjoldi.

21.0 827.3—Grayish brown sandy silt with medium to large irregular to round concretions. Sample 374. Lahilla larseni (abundant); Cucullaea ellioti; Perissoptera nordenskjoldi.

18.0 845.3—Brownish gray massive concretionary sandy silt. Lahilla larseni; fossil wood.

6.0 851.3—Brownish gray sandy silt with concretions. Lahilla larseni; fossil wood.

3.0 854.3—Massive gray sandy silt; no concretions observed. Sample 375. Lahilla larseni; Perissoptera nordenskjoldi.

25.0 879.3—Grayish brown sandy silt with occasional large concretions. Lahilla larseni; fossil wood.

4.0 883.3—Gray massive silty sand with very few concretions. Sample 376. Lahilla larseni; fossil wood.

14.0 897.3—Brownish gray, massive silty sand. At the top starts the "brown chocolate layer" of the Sobral Formation.

Total measured thickness of Section F: 897.3 m.

DESCRIPTION OF OTHER LOCALITIES

Locality A
Rotularia (A.) tenuilaevis (very abundant); Pycnodonte seymourianus; Gastropoda sp. indet.; marine reptile bone.

Locality B
Rotularia (A.) tenuilaevis; R (R.) shackletoni; Maorites seymourianus; Eutrephoceras simile; Nucula suboblonga; Cucullaea antarctica; Pinna anderssoni; Laevitrigonia (E.) ecplecta; Pycnodonte seymourianus; Pycnodonte cf. vesiculosa; Goniomya hyriiformis; Cassidaria mirabilis;
Perissoptera cf. nordenskjoldi; Gastropoda sp. indet.; corals (Cyclosferis sp.).

Locality C
Maorites sp.; Amberleya spinigera; Eunaticina arctowskiana; Cryptorhitis philippiana; Cassidaria mirabilis;

Locality D
Diplomoceras lambi.

Locality D'
Eunaticina arctowskiana; large and well preserved corals.

Locality E
R (R.) shackletoni; Maorites seymourianus; Kitchinites darwini; Nucula suboblonga; Panope clausa; Indogrammatodon cf. lormandi; Cucullaea antarctica; Laevitrigonia (E.) eclecta; Linotrigonia (O.) pygoscellum; Soleyma roseiana; Thyasira townsendi; Eunaticina arctowskiana; Cassidaria mirabilis; Perissoptera sp.; Gastropoda sp. indet.

Locality F
Rotularia (A.) zinsmeisteri; R (R.) shackletoni; Maorites seymourianus; Kitchinites darwini; Grossouvrites gemmatus; Eutrephoceras simile; Nucula suboblonga; Panope clausa; Indogrammatodon cf. lormandi; Nordenskjoldia nordenskjoldi; Cucullaea antarctica; Pinna anderssoni; Laevitrigonia (E.) eclecta; Pycnodonte seymourianus; Amberleya spinigera; Eunaticina arctowskiana; Cryptorhitis philippiana; Cassidaria mirabilis; Perissoptera sp.; corals; echinoderm spines; shark vertebrae.

Locality H
Maorites seymourianus; Kitchinites darwini; Pseudophyllites loryi; Nordenskjoldia nordenskjoldi; Gonolymna hyriiformis; Amberleya spinigera; Eunaticina arctowskiana; Cryptorhitis philippiana; Pleurotomaria larseniana.

Locality H'
Pachydiscus ootacodensis; Maorites seymourianus; Grossouvrites gemmatus; Cucullaea antarctica; Pycnodonte sp.; Lahilla larseni; Cryptorhitis philippiana; Eunaticina arctowskiana.

Locality J
Grossouvrites gemmatus; Maorites densicostatus; Cucullaea antarctica; Laevitrigonia (E.) eclecta.

Locality A-83
Diplomoceras lambi; Pinna anderssoni; Lahilla larseni; Perissoptera nordenskjoldi. Pockets of the La Meseta Formation cutting into the Lopez de Bertodano Formation.

Locality B-83
Rotularia (A.) sp.; Rotularia (R.) shackletoni; Pachydiscus sp.; Grossouvrites gemmatus; Cucullaea antarctica; Thyasira townsendi (very
abundant); Lucina? scotti; Solemya rossiana; Panope clausa.

Locality C-83
Rotularia (A.) sp.; Maorites densicostatus (adults, and abundant juveniles); Grossouvrîtes gemmatus; Anagaudryceras cf. mikobokense; Lahilla larsenii; Entolium sp.; Laevitrîgîna (E.) ecplecta; Cucullaea antarctica; unident. small bivalves; Amberleya spinigera; shark vertebrae.

Locality D-83
Gray sandy silt followed by a bioturbated gray sandstone (0.4m thick). Concretions with serpulids "in situ" (most are in a vertical position). Rotularia (A.) sp.; Pachydiscus ricardi (abundant); Maorites densicostatus; Kitchînitès laurae; Cucullaea antarctica; Laevitrîgîna (E.) ecplecta; Amberleya spinigera; Taloma charcotianus; Cryptorhytis philippiana; Cassidaria mirabilis.

Locality E-83
Gray silty sand with numerous small dark gray concretions. Rotularia (A.) sp.; Maorites densicostatus; Kitchînitès laurae; Cucullaea antarctica; Amberleya spinigera.

Locality F-83
Mostly covered. Dominant lithology composed of a brownish gray sandy silt with scattered concretions. Fossils poorly preserved and uncommon. Rotularia (R.) shackletoni; Maorites sp.; Amberleya spinigera.

Locality G-83
Thick sequence of gray sandy silt with more indurated well-bedded sandstones. Level with numerous small reddish concretions; bioturbation is common in some concretionary levels. Rotularia tenuilaevis; Maorites tuberculatus; Panope clausa; Pinna andersonii; Taloma charcotianus; Cryptorhytis philippiana; Eunaticina arctowskiana; corals; fossil wood; marine reptile bones.

Locality G'-83
Maorites tuberculatus.

Locality H-83
Typical lithology of the Rotularia facies: gray clayey silt with intercalations of well-bedded calcareous sandstones.

Locality I-83
Large calcareous concretions preserving the original bedding.

Locality J-84
Rotularia (A.) cf. tenuicostatus; Diplomoceras laubi.

Locality K-84
Rotularia (A.) cf. tenuilaevis; R (R.) shackletoni; Maorites seymourianus; Kitchînitès darwinii; Eutrephoceras simile; Nucula suboblonga (abundant); Cucullaea antarctica; Pycnodonte seymourianus.
(very abundant); *Amberleya spinigera*; *Eunaticina arctowskiana*; *Cryptothyris philippiana*; *Cassidaria mirabilis*; *Taloma charcotianus*; *Pleurotomaria larseniana*; corals; echinoderm spines.

**Locality L-84**

**Locality M-84**
*Rotularia* (A.) cf. *tenuilaevi*; R (R.) *shackletoni*; *Maorites seymourianus*; *Kitchinites darwini*; *Grossouvrrites gemmatus*; *Kosmaticeras (Natalites)*? *weddellensis*; *Cucullaea antarctica*; *Pinna anderssoni*; *Laevitrigonia* (E.) *ecplecta*; *Pycnodonte seymourianus* (abundant); *Goniomya hyriiformis*; *Pleurotomaria larseniana*; *Cryptothyris philippiana*; *Cassidaria mirabilis*; calcareous tubes.

**Locality N-84**
Very abundant macrofauna; intraclasts and levels with reworked fauna, forming a coquina. *Rotularia* (A.) sp.; *Maorites densicostatus* (very abundant, generally juvenile specimens); *Grossouvrrites gemmatus* (juvenile specimens); *Diplomoceras lambi* (juveniles); *Vertebrites kayei*; *Lucina*? *scotti* (very abundant); *Solemya rossiana* (very abundant); *Thyasira townsendi* (very abundant); *Lahilla larseni* (abundant); *Acesta* sp.; *Cyclorismina incognita*; *Panope clausa*; *Limatula antarctica*; *Goniomya hyriiformis*; *Pycnodonte* cf. *vesiculosa*; *Amberleya spinigera*; *Cryptothyris philippiana*; *Perissoptera* sp.; corals; echinoderm spines.

**Locality O-83**
*Pachydiscus riccardi* (very abundant); *Grossouvrrites gemmatus* (abundant); *Maorites densicostatus*; *Entolium* sp.; *Taloma charcotianus*; *Cryptothyris philippiana*; *Cassidaria mirabilis*; shark vertebrae.

**Station St.5**
This is the last ammonite horizon. Several small ammonites are present. *Rotularia* (A.) sp.; *Rotularia* (R.) *shackletoni*; *Diplomoceras lambi*; *Kitchinites cf. laurae*; *Zelandites* sp.; *Maorites densicostatus*; *Eutrepheceras simile* (abundant); *Acesta snowhillensis*; *Gerithium*? sp.; bored fossil wood, and relatively abundant bone fragments, including some large vertebrae.

**Station St.6**
*Grossouvrrites gemmatus* (very abundant); *Anagaudryceras* sp.; *Maorites densicostatus*; *Diplomoceras lambi* (abundant); *Pachydiscus riccardi*; *Amberleya spinigera* (very common); *Taloma charcotianus*; *Cryptothyris philippiana*.

**Station St.7**
Strongly bioturbated, large (up to 1 m) concretions. *Rotularia* (A.) sp.; *Pachydiscus ultimus* (abundant); *Pycnodonte* cf. *vesiculosa*.

**Station 377**
Gray sandy silt with numerous rounded concretions. Rotularia (A.) sp.; Pachydiscus riccardi; Maorites densicostatus (juveniles); Grossouvrrites gemmatus; Cyclorismina incognita; Taíoma charcotianus; Cryptorhytis philippiana; Perissoptera nordenskjoldi; unidentified small bivalves; bored fossil wood.

Station 378
Rotularia (A.) sp. (very common); Kitchinites laurae; Pachydiscus riccardi (common); Maorites densicostatus; Eriphyla drygalskiana; bored fossil wood.

Stations 379-380-381
Gray massive sandy silt to silty sand with small grayish concretions; sandstone layers show bioturbation and burrows. Fossils scattered, but well preserved. Rotularia (A.) sp.; Maorites cf. seymourianus; Gonioforma hyriformis; Linotrigonia (O.) pygoscelium; Cucullaea antarctica; Amberleya spinigera; Perissoptera nordenskjoldi; Eunaticina arctowski; echinoderm spines; corals; scaphopods; fossil wood.

Station 382
Brownish sandy silt with intercalations of more indurated horizons; numerous rounded concretions. Maorites cf. seymourianus; Kitchinites darwini; Pinna anderssoni; Linotrigonia (O.) pygoscelium; Laevitrigonia (E.) eclecta; Cucullaea antarctica; Panope clausa; Eriphyla drygalskiana; Cerithium? sp.; Taíoma charcotianus; Amberleya spinigera.

Station 383
Dark gray massive sandy silt with scattered concretions. Rotularia (A.) zinsmeisteri; Rotularia (R.) shackletoni; Maorites seymourianus; Kitchinites darwini; Nordenskjoldia nordenskjoldi; Perissoptera sp., echinoderm spines.

Station 384
Rotularia (A.) zinsmeisteri; Rotularia (R.) shackletoni; Kitchinites darwini (abundant); Maorites seymourianus (abundant); Grossouvrrites gemmatus; Nucula suboblonga; Nordenskjoldia nordenskjoldi (abundant); Pinna anderssoni; Pleurotomaria larseniana; Cryptorhytis philippiana; Amberleya spinigera.

Station 386
Gray massive sandy silt. Rotularia (A.) fallax; Grossouvrrites? sp.

Station 387
Dark gray massive clayey sandy silt. Rotularia (A.) fallax.

Station 390
Gray, laminated sand with some bioturbation. Rotularia (A.) tenullaevis (common); Rotularia (R.) shackletoni; Linotrigonia (O.) sp.; corals; echinoderm spines.

Station 391
Rotularia (A.) tenullaevis (very abundant); Grossouvrrites? sp.
Station 392
Gray-brownish sandy silt; concretions unfrequent and small. *Rotularia (A.*) tenuilaevis; *Rotularia (R.*) shackletoni.*

Station 393
Mostly covered. *Rotularia (A.*) tenuilaevis* (very abundant); poorly preserved ammonites.

Station 394
*Rotularia (A.*) zinsmeisteri; Rotularia (R.*) shackletoni; Diplomoceras lambi;* *Mazorites seymourianus; Kitchinities darwini* (very abundant); *Grossouvrrites gemmatus; Eutrephoceras similis; Pycnodonte seymourianus; Nordenskjoldia nordenskjoldi; Amberleya spinigera; Cryptorhytis philippiana.*

Station 418
Brownish gray clayey sandy silt, followed by a well bedded gray fine grained sandstone with abundant burrows. *Rotularia (A.*) tenuilaevis* (very abundant); *Perissoptera?* sp.; echinoderm spines; corals.

Station 420
Brownish gray sandy silt followed by a more cemented, bioturbated sandstone. *Rotularia (A.*) tenuilaevis; Pinna?* sp.; *Pycnodonte sp.*

Station 421
Gray sandy silt with frequent concretions. *Rotularia (A.*) tenuilaevis* (abundant); *Rotularia (R.*) shackletoni; Bivalvia sp. indet. Gastropoda sp. indet.*

Station 422
Brownish, massive sandy silt with small (up to 15 cm), irregular concretions. *Rotularia (A.*) cf. tenuilaevis; Rotularia (R.*) shackletoni; Mazorites sp.; Pycnodonte seymourianus; Acesta cf. snowhillensis; Goniomya hyrilliformis; Eunaticina arctowskiana; Cryptorhytis philippiana.*

Station 423
*Rotularia (A.*) cf. zinsmeisteri; Rotularia (R.*) shackletoni; Mazorites seymourianus (abundant); Kitchinities darwini (abundant); Kosmaticeras (Natalites)? weddelliensis; Grossouvrrites gemmatus; Gaudrycerid sp. indet.; Nordenskjoldia nordenskjoldi* (very abundant); *Pycnodonte seymourianus* (very abundant); *Nucula suboblonga; Laevitrigonia (E.*) eclepta; Goniomya hyrilliformis; Pinna anderssoni; Pleurotomaria larseniana; Amberleya spinigera* (abundant); fossil wood.

Station 424
Gray massive sandy silt with scattered concretions. *Rotularia (A.*) tenuilaevis; Cyclorisma?* sp.; *Cryptorhytis philippiana; echinoderm spines.*

Station 425
Gray massive sandy silt. *Rotularia (A.*) tenuilaevis; echinoderm spines.*
Station 426
Gray massive sandy silt with small irregular concretions, and a concretionary level. Rotularia (A.) tenuilaevis; Maorites seymourianus; Nucula suboblonga (abundant); Linotrigonia (O.) pygoscelium; Cryptorhytis philippiana; calcareous tubes.

Station 427
Gray massive sandy silt, followed by a thin calcareous sandstone. Rotularia (A.) cf. tenuilaevis; Grossouvrites gemmatus; Kitchinlites darwini; Maorites seymourianus; Eutrephoceras simile; Pinna anderssonii; Acesta cf. snowhillensis; Coniomya hyriformis; Pycnodonte sp.; Amberleya? sp.

Station 428
Gray massive sandy silt with somewhat rounded, reddish concretions. Rotularia (A.) cf. tenuilaevis; Rotularia (R.) shackletoni (abundant); Grossouvrites gemmatus; Kitchinlites darwini; Maorites seymourianus; Nucula suboblonga; Pinna anderssonii; Coniomya hyriformis; Pycnodonte seymourianus (abundant); Laevitrigonia (E.) eclectta; Linotrigonia (O.) pygoscelium; Amberleya spinigera; echinoderm spines.

Station 429
Gray sandy silt with small, grayish concretions. Rotularia (R.) shackletoni; Kitchinlites darwini; Panope clausa; Nucula suboblonga; Laevitrigonia (E.) eclectta; Lucina? sp.; Amberleya spinigera; Cryptorhytis philippiana; Cerithium? sp.; echinoderm spines; corals.

Station 430
Gray massive sandy silt with rounded irregular concretions.

Station 431
Massive gray silty sand with brownish concretionary levels. Corals; echinoderm spines; Ditrupa? sp.; burrows.

Station 432
Brownish-gray sandy silt with rounded reddish concretions. Rotularia (A.) tenuilaevis; Rotularia (R.) shackletoni; Maorites seymourianus; Kitchinlites darwini; Perissoptera nordenskjoldi.

Station 433
Gray clayey silt with scattered reddish concretions containing poorly preserved fragments of Maorites tuberculatus.

Station 434
Gray, indurated calcareous sandstone capped by a laterally discontinuous, thin (5-6cm) stromatolite. Corals.
APPENDIX B

GLAUCONITE DATING

Four glauconite samples were processed for K-Ar dating. The samples were washed and then wet sieved in distilled water. Grains coarser than 3.25 φ were separated, washed in distilled water, and ultrasonically cleaned. The sample was treated with 0.1 N. HCl for approximately one day in order to remove carbonates and then wet-sieved again, retaining the fraction larger than 3.25 φ. The obtained residue was processed through a Frantz isodynamic Separator, and the greener grains were hand-picked. Two grams of glauconite were picked for each of the four samples.

Glaucnites were then analyzed in the Potassium-Argon Laboratory at the Ohio State University, by Dr. K. O. Foland. The results are presented in Table 3. Additionally, Dr. L. Krisek processed one sample (411) by X-ray diffractometry from which he obtained spikes characteristic of well evolved glauconite.

Table 3--Potassium and argon analytical results and K-Ar ages of glauconites from Seymour Island.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Stratigraphic level</th>
<th>K (wt.%)</th>
<th>K2O</th>
<th>40Ar rad (x 10^10 mol/g)</th>
<th>40Ar rad Ar tot</th>
<th>Calculated age (Millions of years)</th>
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<tr>
<td>83</td>
<td>Cross Valley Fm.</td>
<td>4.427</td>
<td>4.141</td>
<td>0.492</td>
<td></td>
<td>53.5 ± 1.7</td>
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<tr>
<td></td>
<td></td>
<td>4.445</td>
<td>4.236</td>
<td>0.573</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>4.423</td>
<td></td>
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<td>4.487</td>
<td>5.36</td>
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<td>Av: 4.446</td>
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<td>4.188</td>
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<tr>
<td>76</td>
<td>Sobral Fm. (Unit 1)</td>
<td>4.700</td>
<td>4.665</td>
<td>0.720</td>
<td></td>
<td>53.9 ± 0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.715</td>
<td>4.674</td>
<td>0.745</td>
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<tr>
<td></td>
<td></td>
<td>Av: 4.708</td>
<td>5.67</td>
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<tr>
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<td></td>
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<td>4.470</td>
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<td>411</td>
<td>Lopez de Bertodano Fm. (uppermost Unit 9)</td>
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<td>4.674</td>
<td>0.228</td>
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<td>58.9 ± 1.0</td>
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<td>4.657</td>
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<td></td>
<td></td>
<td>Av: 4.492</td>
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<td>4.666</td>
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<td>153</td>
<td>Lopez de Bertodano Fm. (base of Unit 9)</td>
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<td>Av: 3.887</td>
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<td>4.394</td>
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*Analytical uncertainties at the 95% confidence level.

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APPENDIX C

GRAIN SIZE ANALYSIS

The numerical results of grain size analysis of samples from the Lopez de Bertodano, Sobral, and Cross Valley formations, are presented in tables 4, 5, and 6, respectively. The methodology employed is outlined in Chapter VI (p. 166).
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Table 4: Results of grain size analysis of samples from the Lopez de Bertodano Formation.
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<th>54</th>
<th>56a</th>
<th>60</th>
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<th>86</th>
<th>101</th>
<th>147</th>
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<th>115</th>
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<tr>
<td>SAND %</td>
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<td>14</td>
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<td>45</td>
<td>36</td>
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<td>SILT %</td>
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</tr>
<tr>
<td>CLAY %</td>
<td>12</td>
<td>21</td>
<td>15</td>
<td>11</td>
<td>17</td>
<td>21</td>
<td>12</td>
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<tr>
<td>MUD %</td>
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<td>67</td>
<td>40</td>
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<tr>
<td>0.500 Ø</td>
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</tr>
<tr>
<td>1.500 Ø</td>
</tr>
<tr>
<td>--</td>
</tr>
<tr>
<td>2.675 Ø</td>
</tr>
<tr>
<td>0.70 0.27 0.50 1.40 0.44 0.96 1.24 0.05 -- 1.93 -- 0.33 -- 11.12 1.28 0.21</td>
</tr>
<tr>
<td>2.875 Ø</td>
</tr>
<tr>
<td>1.23 0.34 0.67 2.34 0.62 1.27 4.21 0.16 1.06 5.91 6.08 1.01 1.02 10.83 3.07 0.40</td>
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<tr>
<td>3.125 Ø</td>
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<tr>
<td>2.50 1.60 1.08 7.32 2.39 3.20 16.52 0.46 1.67 16.86 11.17 7.27 8.03 7.38 9.56 1.80</td>
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<tr>
<td>3.375 Ø</td>
</tr>
<tr>
<td>8.14 8.93 7.76 23.77 13.84 12.00 17.78 2.92 5.08 22.86 23.26 18.12 15.36 8.36 21.70 8.80</td>
</tr>
<tr>
<td>3.625 Ø</td>
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<tr>
<td>3.875 Ø</td>
</tr>
<tr>
<td>6.39 9.34 7.68 7.42 7.70 6.58 7.15 5.24 9.93 3.84 5.42 4.85 3.64 1.93 5.97 6.76</td>
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<tr>
<td>4.500 Ø</td>
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<td>4.96 -- 4.70 5.25 4.95 5.33 5.73 -- -- -- -- -- -- -- -- -- -- -- --</td>
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<td>Mean Ø</td>
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(Continued)
Table 5 -- Grain size analysis, Sobral Formation.

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<th>73B</th>
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<td>SAND %</td>
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<td>38</td>
<td>48</td>
<td>16</td>
<td>62</td>
<td>86</td>
<td>20</td>
<td>81</td>
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<tr>
<td>MUD %</td>
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<td>62</td>
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<td>84</td>
<td>38</td>
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Indiv. % (Center of Class)

<table>
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<tr>
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<tbody>
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<td>0.500 Ø</td>
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<tr>
<td>1.000 Ø</td>
</tr>
<tr>
<td>2.000 Ø</td>
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<td>2.375 Ø</td>
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<td>3.375 Ø</td>
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<tr>
<td>3.625 Ø</td>
</tr>
<tr>
<td>3.875 Ø</td>
</tr>
</tbody>
</table>

SAND FRACTION

| Mean Ø | 3.52 | 3.55 | 3.29 | 3.40 | 2.71 | 2.76 | 3.48 | 2.75 |
| St. dev. Ø | 0.27 | 0.26 | 0.35 | 0.29 | 0.61 | 0.38 | 0.35 | 0.37 |

Table 6 -- Grain size analysis, Cross Valley Formation.

<table>
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<td>MUD %</td>
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Indiv. % (Center of Class)

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<td>-0.625 Ø</td>
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<td>-0.125 Ø</td>
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<td>0.075 Ø</td>
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<td>0.375 Ø</td>
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<td>0.875 Ø</td>
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<td>1.125 Ø</td>
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<tr>
<td>3.625 Ø</td>
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<tr>
<td>3.875 Ø</td>
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</table>

SAND FRACTION

| Mean Ø | 2.77 | 2.71 | 1.61 |
| St. dev. Ø | 0.36 | 0.42 | 1.20 |
PLATES
Plate 1

Thin sections of Rotularia spp. from Seymour Island.
(All specimens approximately 2.5 X)

Figure 1—Rotularia (Australrotularia) fallax, specimen OSU 36780, locality 16, Seymour Island.

Figure 2—R. (Australrotularia) tenuilaevis, specimen OSU 36781, locality A.

Figure 3—R. (Australrotularia) tenuilaevis, specimen OSU 36782, locality 30.

Figure 4—R. (Australrotularia) zinsmeisteri, specimen OSU 36783, locality 45.

Figure 5—R. (Australrotularia) zinsmeisteri specimen OSU 36784, sectioned in different planes; note the high degree of bioturbation of the sediment, locality 47.

Figure 6—Horizontal view of R. (Australrotularia) fallax, specimen OSU 36785, locality 16.

Figure 7—Horizontal view of R. (Australrotularia) tenuilaevis, specimen OSU 36786, locality 29.

Figure 8—R. (Australrotularia) sp., specimen OSU 36787, locality 61.

Figure 9—Rotularia (Australrotularia) sp., specimen OSU 36788, locality 68.

Figure 10—R. (Australrotularia) sp., specimen OSU 36789, locality 61.

Figure 11—R. (Australrotularia) zinsmeisteri, specimen OSU 36790, random section showing high degree of bioturbation in the sediment. Locality 145.
PLATE 2

Rotularia (Australrotularia) fallax (Wilckens)
(All figures 1.5 X)

Figure 1a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36651.

Figure 2a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36652.

Figure 3a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36653.

Figure 4a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36654.

Figure 5a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36655.

Figure 6a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36656.

Figure 7a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36657.

Figure 8a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36658.

Figure 9a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36659.

Figure 10a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36660.
Rotularia (Australrotularia) tenuilaevia
Macellari
(All specimens 1.5 X)

Figure 1a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36661.

Figure 2a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36662.

Figure 3a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36663.

Figure 4a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36664.

Figure 5a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36665.

Figure 6a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36666.

Figure 7a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36667.

Figure 8a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36668.
PLATE 4

Rotularia (Australrotularia) zinsmeisteri Macellari
(All specimens 1.5 X)

Figure 1a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36669.

Figure 2a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36670.

Figure 3a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36671.

Figure 4a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36672.

Figure 5a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36673.

Figure 6a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36674.

Figure 7a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36675.

Figure 8a,b,c—Dorsal, apertural and umbilical views, specimen OSU 36676.
PLATE 5

Figure 1a,b,c—Rotularia (Australrotularia) sp., (1.5 X). Dorsal, apertural and umbilical views, specimen OSU 36677.

Figure 2a,b,c—Rotularia (Australrotularia) sp., (1.5 X). Dorsal, apertural and umbilical views, specimen OSU 36678.

Figure 3a,b,c—Rotularia (Australrotularia) sp., (1.5 X). Dorsal, apertural and umbilical views, specimen OSU 36679.

Figure 4a,b—R. (Rotularia) shackletoni (Wilckens) (natural size), dorsal and umbilical views, specimen OSU 36680.

Figure 5—R. (Australrotularia) zinsmeisteri Macellari (1.5 X). Lateral view of a specimen showing a well developed central ridge with three carinas of approximately equal degree of development. Specimen OSU 36669, Station 45, Lopez de Bertodano Formation, Seymour Island.

Figure 6—R. (Australrotularia) zinsmeisteri Macellari, (1.5 X) lateral view, specimen OSU 36676. Station 45, Lopez de Bertodano Formation.

Figure 7—R. (Australrotularia) zinsmeisteri Macellari, (1.5 X), lateral view, specimen OSU 36671. Station 45.

Figure 8—R. (Australrotularia) tenuilaevis Macellari, lateral view (1.5 X), specimen showing a relatively angular margin with three faintly developed carinae. Specimen OSU 36662, station 163, Lopez de Bertodano Formation, Seymour Island.

Figure 9—R. (Australrotularia) tenuilaevis Macellari, lateral view (1.5 X), specimen OSU 36666, station 167, Lopez de Bertodano Formation, Seymour Island.

Figure 10—R. (Australrotularia) tenuilaevis Macellari, lateral view (1.5 X), specimen OSU 36668, station 167.

Figure 11—R. (Australrotularia) sp., lateral view (1.5 X), specimen OSU 36679, Station BZ-459, Lopez de Bertodano Formation, Seymour Island.

Figure 12—Eutrepheceras simile Spath, lateral view, spec. St.5-1 (0.78 X). Station St.5, Lopez de Bertodano Formation, Seymour Island.

Figures 13a,b—Eutrepheceras simile Spath, Spec. St.5-2 (1.5 X). Station St.5, Lopez de Bertodano Formation, Seymour Island. 13a—Ventral view; 13b—Apertural view.
Figures 1,2—Anagaudryceras cf. mikobokense Collignon. Spec. 153-1 (0.68 X). Pachydiscus riccardí Zone, Lopez de Bertodano Formation, Seymour Island. 1-Lateral view; 2-Apertural view.

Figures 3-4—Anagaudryceras cf. mikobokense Collignon. Spec. 153-2 (1 X). Lopez de Bertodano Formation, Seymour Island. 3-Apertural view; 4-Lateral view.

Figures 5,6—Vertebrites kayei (Forbes). Spec. SI-1 (1 X). Lopez de Bertodano Formation, Seymour Island. 5-Lateral view; 6-Apertural view.
Figures 1, 2—Pseudophyllites loryi (Kilian and Reboul), Spec. 458-6 (1.5 X). Station BZ-458, Pachydiscus riccardi Zone, Lopez de Bertodano Formation, Seymour Island. 1-Lateral view; 2-Apertural view.

Figure 3—Pseudophyllites loryi (Kilian and Reboul), lateral view, Spec. 458-7 (1.5 X). Station BZ-458, Pachydiscus riccardi Zone, Lopez de Bertodano Formation, Seymour Island.

Figures 4, 5—Pseudophyllites loryi (Kilian and Reboul), Spec. 458-4 (2 X). Station BZ-458, Pachydiscus riccardi Zone, Lopez de Bertodano Formation, Seymour Island. 4-Ventral view; 5-Lateral view.

Figure 6—Pseudophyllites loryi (Kilian and Reboul), lateral view, Spec. 458-5 (1.5 X). Station BZ-458, Pachydiscus riccardi Zone, Lopez de Bertodano Formation, Seymour Island.

Figures 7, 8—Zelandites sp. cf. Z. varuna japonica Matsumoto, Spec. 411-1 (1.5 X). Station 411, Pachydiscus ultimus Zone, Lopez de Bertodano Formation, Seymour Island. 7-Lateral view; 8-Apertural view.

Figure 9—Kitchinites (Kitchinites) darwini (Steinmann), lateral view, Spec. 143-1 (0.79 X). Station 143, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.

Figures 10, 11—Kitchinites (Kitchinites) darwini (Steinmann), Spec. SI-1 (0.87 X). Lopez de Bertodano Formation, Seymour Island. 10-Lateral view; 11-Ventral view.
Figure 1—Kitchinites (Kitchinites) darwinii (Steinmann). Spec. H-1 (0.82 X). Lateral view. Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.

Figure 2—Kitchinites (Kitchinites) darwinii (Steinmann). Spec. F-1 (0.82 X). Lateral view. Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.

Figure 3—Kitchinites (Kitchinites) darwinii (Steinmann). Spec. 143-1 (0.82 X). Ventral view. Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.

Figure 4—Diplomoceras lambi Spath. Spec. 41-1 (1 X). Lopez de Bertodano Formation, Seymour Island.
Figures 1, 2—*Kitchinites* (Kitchinites) laurae, n. sp., Spec. 190-1 (0.8X). *Pachydiscus riccardi* Zone, Lopez de Bertodano Formation, Seymour Island. 1—Ventral view; 2—Lateral view.

Figures 3, 4—*Kitchinites* (Kitchinites) laurae, n. sp., Spec. 150-1 (1X) (holotype). *Pachydiscus riccardi* Zone, Lopez de Bertodano Formation, Seymour Island. 3—Lateral view; 4—Apertural view. Arrow indicates the initiation of the living chamber.
Plate 10


Figure 3—*Maorites tenuicostatus* Marshall. Spec. 458-2 (1.45 X). Lateral view. Lopez de Bertodano Formation, Seymour Island.

Figures 4, 5—*Maorites densicostatus* (Kilian and Reboul). Spec. 117-1 (1.45 X). *Pachydiscus ultimus* Zone. Lopez de Bertodano Formation, Seymour Island. 4-Lateral view; 5-Apertural view.

Figure 6—*Maorites densicostatus* (Kilian and Reboul). Spec. SI-F-1 (1.45 X). Lateral view. Lopez de Bertodano Formation, Seymour Island.

Figures 7, 8, 9—*Maorites densicostatus* (Kilian and Reboul). Spec. 158-1 (1X). *Pachydiscus riccardi* Zone, Lopez de Bertodano Formation, Seymour Island. 7-Apertural view; 8-Ventral view; 9-Lateral view.
PLATE 11

Figure 1—Maorites tenuicostatus Marshall. Spec. 63+3-1 (1 X). Lateral view. Station 63, Pachydiscus ricardi Zone, Lopez de Bertodano Formation, Seymour Island. (Arrow indicates the initiation of the body chamber).

Figure 2—Maorites seymourianus (Kilian and Reboul). Spec. 143-1 (1X). Lateral view "microcouch". Station 143. Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.
Figures 1, 2—Maorites seymourianus (Kilian and Reboul). Specimen H-4 (0.6X), "microconch". Station H, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island. 1—Lateral view; 2—Ventral view.
PLATE 13
(All specimens 1 X)

Figures 1, 2—Maorites seymourianus (Kilian and Reboul), Specimen H-3, macroconch?. Station H-, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island. 1—Lateral view; 2—Apertural view.

Figure 3—Maorites seymourianus (Kilian and Reboul), Specimen H-5, lateral view. Station H-, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.

Figure 4—Maorites densicostatus (Kilian and Reboul), Specimen 61+1-1, lateral view of a plaster cast. Pachydiscus riccardi Zone, Lopez de Bertodano Formation, Seymour Island.
Figures 1, 3—Macrîtes seymourianus (Kilian and Reboul), Specimen H^~2, macroconch? (1X). Station H^~, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island. 1-Lateral view; 2-Ventral view; 3-Apertural view.

Figure 3—Maorites suturalis Marshall, Spec. 156-1 (1 X), lateral view (arrow indicates the initiation of the living chamber). Station 156, Pachydiscus riccardi Zone, Lopez de Bertodano Formation, Seymour Island.

Figure 4—Maorites suturalis Marshall, juvenile specimen (spec. 458-1) (1.5X), lateral view. Station 458, Lopez de Bertodano Formation, Seymour Island.
PLATE 16

(All figures 1X)

Figure 1—Kossmaticeras (Natalites)? weddelliensis n. sp., Specimen 143-1, lateral view (arrow indicates the initiation of the living chamber). Station 143, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.

Figures 2-4—Kossmaticeras (Natalites)? weddelliensis n. sp., Specimen H`-1 (holotype). Station H`, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island. 2-Ventral view; 3-Apertural view; 4-Lateral view.

Figure 5—Kossmaticeras (Natalites)? weddelliensis n. sp., Specimen 174-1, lateral view. Station 174, Pachydiscus ootacodensis Zone, Lopez de Bertodano Formation, Seymour Island.
Figures 1, 2—Grossouvrîtes gemmatus (Huppe), Spec. 83-SI-1 (0.71 X). Lopez de Bertodano Formation, Seymour Island. 1—Lateral view; 2—Apertural view.

Figure 3—Grossouvrîtes gemmatus (Huppe), lateral view, Spec. BH-1 (1 X). Lopez de Bertodano Formation, Seymour Island.


Figure 6—Maorîtes tuberculatus Howarth, lateral view, Spec. G-83-1 (1 X). Station G-83, Lopez de Bertodano Formation, Seymour Island.

Figure 7—Gunnarîtes kalîka (Stoliczka), lateral view of a cast (1.4 X), Spec. l-l. Station 1, lowermost Lopez de Bertodano Formation in Seymour Island.
Figures 1,2—Pachydiscus (Pachydiscus) ultimus n. sp., Specimen S.I-1 (holotype). Lopez de Bertodano Formation, Seymour Island.  
1-Apertural view; 2-Lateral view.

Figure 3,4—Pachydiscus (Pachydiscus) ultimus n. sp., Specimen 68-1. Station 68, Lopez de Bertodano Formation, Seymour Island.  
3-Lateral view; 4-Ventral view.
Figures 1, 2—*Pachydiscus* (Pachydiscus) *ultimus* n. sp., Specimen 116-1 (0.65X). Station 116, Lopez de Bertodano Formation, Seymour Island. 1—Lateral view; 2—Apertural view.

Figures 3, 4—*Pachydiscus* (Pachydiscus) *riccardi* n. sp., Specimen 61+-1 (IX). Station 61+, Lopez de Bertodano Formation, Seymour Island. 3—Apertural view; 4—Lateral view.
PLATE 20

(All figures 0.73X)

Figures 1, 3--Pachydiscus (Pachydiscus) riccardi n. sp., Specimen 151-1 (holotype). Station 151, Lopez de Bertodano Formation, Seymour Island. 1-Lateral view; 2-Ventral view; 3-Apertural view.
PLATE 21
(All figures 1X)

Figures 1-2—Pachydiscus ootacodensis (Stoliczka), Specimen BZ-38-3.
Lopez de Bertodano Formation, Seymour Island. 1-Apertural view; 2-Lateral view.

Figures 3-4—Pachydiscus ootacodensis (Stoliczka), Specimen 37-20.
Station BZ-37, Lopez de Bertodano Formation, Seymour Island. 3-Ventral view; 4-Lateral view.
PLATE 22
(unless indicated, all figures 1 X)

Figure 1—Nucula (Leionucula) suboblonga (Wilckens), left valve. Specimen SI-1, Lopez de Bertodano Formation, Seymour Island.

Figure 2—Nucula (Leionucula) suboblonga (Wilckens), internal mould, left valve. Specimen F-1, Lopez de Bertodano Formation, Seymour Island.

Figure 3—Nucula (Leionucula) suboblonga (Wilckens), right valve. Specimen 42-2. Station 42, Lopez de Bertodano Formation, Seymour Island.

Figure 4—Nucula (Leionucula) suboblonga (Wilckens), left valve, internal view. Specimen 42-3. Station 42, Lopez de Bertodano Formation, Seymour Island.

Figure 5—Nucula (Leionucula) suboblonga (Wilckens), dorsal view. Specimen 42-1. Station 42, Lopez de Bertodano Formation, Seymour Island.

Figures 6,7—Malletia (Malletia) gracilis Wilckens, Specimen 9-1-1, Sobral Formation, Seymour Island. 6-Dorsal view; 7-Left valve.

Figure 8—Solemya (Solemya) rossiana (Wilckens), left valve. Specimen E-3. Station E, Lopez de Bertodano Formation, Seymour Island.

Figures 9,10—Solemya (Solemya) rossiana (Wilckens). Specimen E-1. Station E, Lopez de Bertodano Formation, Seymour Island. 9-Dorsal view; 10-Right valve.

Figure 11—Solemya (Solemya) rossiana (Wilckens), left valve. Specimen 459-1. Station 459, Lopez de Bertodano Formation, Seymour Island.

Figure 12—Pinna (Pinna) anderssoni Wilckens, left valve (0.65 X), Specimen F-1. Station F, Lopez de Bertodano Formation, Seymour Island.

Figures 13, 14—Indogrammatodon cf. lormandi Freneix, right valve, Specimen 43-1. Station 43, Lopez de Bertodano Formation, Seymour Island. 13-External view; 14-Internal view.
PLATE 23

(All figures 1 X)

Figures 1,3—Indogrammatodon cf. lormandi Freneix, right valve, Specimen F-1. Locality F, Lopez de Bertodano Formation, Seymour Island. 1-External view; 2-Internal view; 3-Dorsal view.

Figures 4,5—Indogrammatodon cf. lormandi Freneix, Specimen E-1. Station E, Lopez de Bertodano Formation, Seymour Island. 4-Right valve; 5-Left valve.

Figures 6,7—Nordenskjoldia nordenskjoldi Wilckens, right valve, Specimen 143-2. Station 143, Lopez de Bertodano Formation, Seymour Island. 6-Internal view; 7-External view.

Figures 8,9—Nordenskjoldia nordenskjoldi Wilckens, left valve, Specimen 37-10-1. Station BZ-37, Lopez de Bertodano Formation, Seymour Island. 8-Internal view; 9-External view.

Figure 10—Nordenskjoldia nordenskjoldi Wilckens, dorsal view, Specimen 143-1. Station 143, Lopez de Bertodano Formation, Seymour Island.

Figure 11—Nordenskjoldia nordenskjoldi Wilckens, right valve, Specimen 49-1. Station 49, Lopez de Bertodano Formation, Seymour Island.

Figure 12—Nordenskjoldia nordenskjoldi Wilckens, right valve, Specimen SI-1. Lopez de Bertodano Formation, Seymour Island.
PLATE 24

(All figures 1 X)

Figures 1, 2—Cucullaea antarctica Wilckens, left valve, Spec. 153-1. Station 153, Lopez de Bertodano Formation, Seymour Island. 1-Internal view; 2-External view.

Figures 3, 4—Cucullaea antarctica Wilckens, right valve, Spec. 153-2. Station 153, Lopez de Bertodano Formation, Seymour Island. 3-Internal view; 4-External view.

Figure 5—Cucullaea antarctica Wilckens, left valve, Spec. J-1. Station J, Lopez de Bertodano Formation, Seymour Island.

Figure 6—Cucullaea antarctica Wilckens, dorsal view, Spec. 186-2. Station 186, Lopez de Bertodano Formation, Seymour Island.

Figure 7—Cucullaea antarctica Wilckens, dorsal view, Spec. 37-10-1. Station BZ-37, Lopez de Bertodano Formation, Seymour Island.

Figures 8, 9—Cucullaea antarctica Wilckens, left valve, Spec. 42-1. Station 42, Lopez de Bertodano Formation, Seymour Island. 8-Internal view; 9-External view.

Figure 10—Cucullaea antarctica Wilckens, right valve, Spec. 186-2. Station 186, Lopez de Bertodano Formation, Seymour Island.
PLATE 25

(All figures 1 X)


Figures 3, 4—Cucullaea elliotti n. sp., left valve, Spec. 485-1. Station 485, uppermost Lopez de Bertodano Formation, Seymour Island. 3—External view; 4—Internal view.

Figures 5, 10—Cucullaea elliotti n. sp., left valve, Spec. 9-3. Station IPS-9, uppermost Lopez de Bertodano Formation, Seymour Island. 5—External view; 10—Internal view.

Figures 6, 9—Cucullaea elliotti n. sp., right valve, Spec. 9-18. Station IPS-9, uppermost Lopez de Bertodano Formation, Seymour Island. 6—Internal view; 9—External view.

Figures 7, 8—Cucullaea elliotti n. sp., right valve, Spec. 9-13 (Holotype). Station IPS-9, uppermost Lopez de Bertodano Formation, Seymour Island. 7—External view; 8—Internal view.

Figures 11, 12—Cucullaea elliotti n. sp., left valve, Spec. 9-4. Station IPS-9, uppermost Lopez de Bertodano Formation, Seymour Island. 11—External view; 12—Internal view.
Figures 1, 2—*Pulvinites antarctica* Zinsmeister, right valve, Spec. 340-1 (1 X). Station 340, Lopez de Bertodano Formation, Seymour Island.
1-Internal view (muscle scar observed is a mould of the left valve); 2-External view, showing foramen near to the umbo.

Figure 3—*Pulvinites antarctica* Zinsmeister, left valve, Spec. 340-1 (1 X). Station 340, Lopez de Bertodano Formation, Seymour Island.

Figure 4—*Pulvinites antarctica* Zinsmeister, right valve, Spec. 340-1 (3 X). Station 340, Lopez de Bertodano Formation, Seymour Island, showing detail of the hinge.

Figure 5—*Phelopteria* sp., left valve, Spec. 398-1 (1.35 X). Station 398, Lopez de Bertodano Formation, Seymour Island.

Figure 6—*Phelopteria* sp., right valve, Spec. 398-2 (1.35 X), showing a circular scar produced by the growth of the shell around a spine of the gastropod *Amberleya spinigera*. Station 398, Lopez de Bertodano Formation, Seymour Island.

Figure 7—*Phelopteria* sp., internal mould of a right valve, Spec. 398-3 (1 X). Station 398, Lopez de Bertodano Formation, Seymour Island.

Figure 8—*Limopsis (Limopsis) antarctica* Wilckens, left valve, Spec. St.5-1 (1.9 X). Lopez de Bertodano Formation, Seymour Island.

Figure 9—*Entolium* sp., Spec. 377-3 (1 X). Station 377, Lopez de Bertodano Formation, Seymour Island.

Figure 10—*Entolium* sp., Spec. 377-1 (1 X). Station 377, Lopez de Bertodano Formation, Seymour Island.

Figure 11—*Entolium* sp., Spec. 377-2 (1 X). Station 377, Lopez de Bertodano Formation, Seymour Island.
PLATE 27
(Unless indicated, figures 1 X)

Figure 1—Limatula (Limatula) antarctica (Wilckens), right valve, Spec. 458-1 (1.5X). Station BZ-458, Lopez de Bertodano Formation, Seymour Island.

Figure 2—Limatula (Limatula) antarctica (Wilckens), right valve, Spec. 180-1 (2 X). Station 180, Lopez de Bertodano Formation, Seymour Island.

Figure 3—Limatula (Limatula) antarctica (Wilckens), right valve, Spec. 458-2 (1.5X). Station BZ-458, Lopez de Bertodano Formation, Seymour Island.

Figures 4, 5—Acesta (Acesta) webbi n. sp., Spec. 72-1 (Holotype). Station 72, Sobral Formation, Seymour Island. 4—Anterodorsal view; 5—Right valve.

Figure 6—Acesta (Acesta) webbi n. sp., left valve, Spec. 72-2. Station 72, Sobral Formation, Seymour Island.

Figure 7—Acesta (Acesta) snowhillensis (Wilckens), left valve, Spec. SI-1 (0.75 X). Lopez de Bertodano Formation, Seymour Island.

Figures 8, 9—Lucina? scotti (Wilckens), Spec. 459-1 (1.5 X). Station BZ-459, Lopez de Bertodano Formation, Seymour Island. 8—Left valve; 9—Dorsal view.

Figure 10—?Laevitrigonia (Eselaevitrigonia) eclepta (Wilckens), dorsal view, Spec. BZ 39-1. Station BZ-39, Lopez de Bertodano Formation, Seymour Island.
Figures 1, 2—?Laevitrigonia (Eselaevitrigonia) ecpecta (Wilckens), left valve, Spec. 116-1. Station 116, Lopez de Bertodano Formation, Seymour Island. 1-External view; 2-Internal view.

Figures 3, 4—?Laevitrigonia (Eselaevitrigonia) ecpecta (Wilckens), left valve, Spec. 37-19-5. Station BZ-37, Lopez de Bertodano Formation, Seymour Island. 3-External view; 4-Internal view.

Figures 5, 6—?Laevitrigonia (Eselaevitrigonia) ecpecta (Wilckens), right valve, Spec. 37-19-3. Station BZ-37, Lopez de Bertodano Formation, Seymour Island. 5-External view; 6-Internal view.

Figure 7—?Laevitrigonia (Eselaevitrigonia) ecpecta (Wilckens), left valve, Spec. 37-19-8. Station BZ-37, Lopez de Bertodano Formation, Seymour Island.

Figures 8, 9—Linotrigonia (Oistotrigonia) pygoscellum (Wilckens), left valve, Spec. 46-1 (1.5 X). Station 46, Lopez de Bertodano Formation, Seymour Island. 8-External view; 9-Internal view.

Figure 10—Linotrigonia (Oistotrigonia) pygoscellum (Wilckens), left valve, Spec. 166-1. Station 166, Lopez de Bertodano Formation, Seymour Island.

Figure 11—Linotrigonia (Oistotrigonia) pygoscellum (Wilckens), right valve, Spec. 46-2. Station 46, Lopez de Bertodano Formation, Seymour Island.

Figures 12, 13—Linotrigonia (Oistotrigonia) pygoscellum (Wilckens), left valve, Spec. SI-3 (1.5 X). Lopez de Bertodano Formation, Seymour Island. 12-External view; 13-Internal view.

Figures 14, 15—Linotrigonia (Oistotrigonia) pygoscellum (Wilckens), left valve, Spec. 39-1 (1.5 X). Station 39, Lopez de Bertodano Formation, Seymour Island. 14-External view; 15-Internal view.
PLATE 29

(All figures 1X)

Figure 1—Lahilla (Lahilla) larseni (Sharman and Newton), right valve, Spec. BZ-28. Lopez de Bertodano Formation, Seymour Island.

Figure 2—Lahilla (Lahilla) larseni (Sharman and Newton), hinge of right valve, Spec. BZ-3. Lopez de Bertodano Formation, Seymour Island.

Figure 3—Lahilla (Lahilla) larseni (Sharman and Newton), hinge of right valve, Spec. BZ-4. Lopez de Bertodano Formation, Seymour Island.

Figure 4—Lahilla (Lahilla) larseni (Sharman and Newton), dorsal view, Spec. BZ-2. Lopez de Bertodano Formation, Seymour Island.

Figure 5—Lahilla (Lahilla) larseni (Sharman and Newton), right valve, Spec. BZ-40-1. Lopez de Bertodano Formation, Seymour Island.

Figure 6—Lahilla (Lahilla) larseni (Sharman and Newton), hinge of left valve, Spec. BZ-4. Lopez de Bertodano Formation, Seymour Island.
PLATE 30

(Unless indicated, all figures 1 X)

Figures 1, 2—Eryphyla drygalskiana Wilckens, left valve, Spec. 37-17-5.
Station EZ-37, Lopez de Bertodano Formation, Seymour Island.
1—Internal view; 2—External view.

Figures 3, 4—Eryphyla drygalskiana Wilckens, right valve, Spec. 37-17-1.
Station EZ-37, Lopez de Bertodano Formation, Seymour Island.
3—External view; 4—Internal view.

Figure 5—Cyclorisma incognita n. sp., left valve, Spec. IPS-9-1.
Station IPS-9, Lopez de Bertodano Formation, Seymour Island.

Figure 6—Cyclorisma incognita n. sp., internal mould of left valve,
Spec. 66-1. Station 66, Lopez de Bertodano Formation, Seymour Island.

Figure 7—Cyclorisma incognita n. sp., left valve, Spec. IPS-9-5.
Station IPS-9, Lopez de Bertodano Formation, Seymour Island.

Figures 8, 9—Cyclorisma incognita n. sp., Spec. 119-1. Station 119,
uppermost Lopez de Bertodano Formation, Seymour Island. 8—Dorsal view; 9—Right valve.

Figure 10—Cyclorisma incognita n. sp., hinge of right valve, Spec.
160-2 (1.5 X). Station 160, Lopez de Bertodano Formation, Seymour Island.

Figure 11—Cyclorisma incognita n. sp., right valve, Spec. 160-1.
Station 160, Lopez de Bertodano Formation, Seymour Island.

Figure 12—Cyclorisma incognita n. sp., dorsal view, Spec. IPS-9-8.
Station IPS-9, Lopez de Bertodano Formation, Seymour Island.

Figures 13, 14—Cyclorisma incognita n. sp., Spec. IPS-9-4. Station
IPS-9, Lopez de Bertodano Formation, Seymour Island. 13—Dorsal view; 14—Right valve.

Figure 15—Thracia (Thracia) n. sp., left valve, Spec. 46-1. Station
46, Lopez de Bertodano Formation, Seymour Island.

Figure 16—Thracia (Thracia) n. sp., left valve, Spec. 30-1. Station
30, Lopez de Bertodano Formation, Seymour Island.

Figures 17, 18—Thracia (Thracia) n. sp., Spec. JR-1-1. Station JR-1,
Lopez de Bertodano Formation, The Naze, James Ross Island.
17—Dorsal view; 18—Left valve.
Plate 31

(All figures 1 X)

Figures 1, 2—Thyasira (Conchocele) townsendi (White), Spec. 459-1. Station BZ-459, Lopez de Bertodano Formation, Seymour Island. 1-Left valve; 2-Posterodorsal margin.

Figures 3, 4—Panope (Panope) clausa (Wilckens), Spec. 56-1. Station 56, Lopez de Bertodano Formation, Seymour Island. 3-Right valve; 4-Dorsal view.

Figure 5—Panope (Panope) clausa (Wilckens), Spec. 181-1, showing dentition. Station 181, Lopez de Bertodano Formation, Seymour Island.

Figures 6, 7—Goniomya (Goniomya) hyriiformis (Wilckens), Spec. 42-1. Station 42, Lopez de Bertodano Formation, Seymour Island. 6-Right valve; 7-Dorsal view.

Figure 8—Goniomya (Goniomya) hyriiformis (Wilckens), left valve, Spec. H-1. Station H, Lopez de Bertodano Formation, Seymour Island.

Figures 9, 10—Pycnodonte (Phygraea) cf. seymourianus (Wilckens), left valve, Spec. 116-1. Station 116, Lopez de Bertodano Formation, Seymour Island. 9-External view; 10-Internal view.
PLATE 32

(All figures 1 X)

Figure 1—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), left valve, Spec. 68-1. Station 68, Lopez de Bertodano Formation, Seymour Island.

Figure 2—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), left valve, Spec. B-1. Station B, Lopez de Bertodano Formation, Seymour Island.

Figure 3—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), left valve, Spec. 116-1. Station 116, Lopez de Bertodano Formation, Seymour Island.

Figure 4—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), right valve, Spec. V-9-1, Lopez de Bertodano Formation, Vega Island.

Figure 5—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), right valve, Spec. B-1. Station B, Lopez de Bertodano Formation, Seymour Island.

Figure 6—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), right valve, Spec. 116-1. Station 116, Lopez de Bertodano Formation, Seymour Island.

Figure 7—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), left valve, Spec. V-9-1, Lopez de Bertodano Formation, Vega Island.

Figure 8—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), left valve, Spec. BZ-1, Lopez de Bertodano Formation, Seymour Island.

Figure 9—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), internal view of right valve, Spec. 142-1. Station 142, Lopez de Bertodano Formation, Seymour Island.

Figure 10—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), right valve, Spec. BZ-1, Lopez de Bertodano Formation, Seymour Island.

Figures 11, 12—Pycnodonte (Phygraea) cf. vesiculosa (Somerby), left valve, Spec. 195-1. Station 195, Lopez de Bertodano Formation, Seymour Island. 11-External view; 12-Internal view.
PLATE 33

(All figures 1 X)

Figures 1,2—Pycnodonte seymourianus (Wilckens), left valve, Spec. 37-16-1. Station BZ-37-16, Lopez de Bertodano Formation, Seymour Island. 1—External view; 2—Internal view.

Figures 3,4—Pycnodonte seymourianus (Wilckens), left valve, Spec. A-1. Station A, Lopez de Bertodano Formation, Seymour Island. 3—External view; 4—Internal view.

Figures 5,6—Pycnodonte seymourianus (Wilckens), Spec. 47+-1. Station 47+, Lopez de Bertodano Formation, Seymour Island. 5—Left valve, external view; 6—Right valve external view.
PLATE 34

(All specimens 1 X)

Figures 1, 2—Pleurotomaria (Perotrochus) larseniana (Wilckens), Spec. 46-1. Station 46, Lopez de Bertodano Formation, Seymour Island. 1-Spiral view; 2-Apertural view.

Figures 3, 4—Pleurotomaria (Perotrochus) larseniana (Wilckens), Spec. 46-2. Station 46, Lopez de Bertodano Formation, Seymour Island. 3-Spiral view; 4-Apertural view.

Figures 5, 6—Perissoptera nordenskjoldi Wilckens, Spec. 9-1-1. Station IPS-9, uppermost Lopez de Bertodano Formation, Seymour Island. 5-Back; 6-Aperture.

Figures 7, 8—Perissoptera nordenskjoldi Wilckens, Spec. 9-1-2. Station IPS-9, uppermost Lopez de Bertodano Formation, Seymour Island. 7-Back; 8-Aperture.

Figures 9, 10—Amberleya (Amberleya) spinigera Wilckens, Spec. 41-1. Station 41, Lopez de Bertodano Formation, Seymour Island. 9-Apertural view; 10-Back view.

Figures 11, 12—Eunaticina (Eunaticina) arctowskiana Wilckens, Spec. 42-1. Station 42, Lopez de Bertodano Formation, Seymour Island. 11-Apertural view; 12-Back view.
PLATE 35

(All Figures 1 X)

Figures 1,2—Cassidaria mirabilis Wilckens var. papillosa Wilckens, Spec. 151-1. Station 151, Lopez de Bertodano Formation, Seymour Island. 1-Back view; 2-Aperture view.

Figure 3—Cassidaria mirabilis Wilckens, var. papillosa Wilckens, back view, Spec. C-1. Station C, Lopez de Bertodano Formation, Seymour Island.

Figures 4,5—Austrosphaera patagonica (Feruglio), Spec. 9-1, Station IPS-9, uppermost Lopez de Bertodano Formation, Seymour Island. 4-Back view; 5-Aperture view.

Figure 6—Taioma charcotianus (Wilckens), back view, Spec. 377-1. Station 377, Lopez de Bertodano Formation, Seymour Island.

Figures 7,8—Taioma charcotianus (Wilckens), Spec. 397-1. Station 397, Lopez de Bertodano Formation, Seymour Island. 7-Back view; 8-Aperture view.


Figure 11—Eunaticina (Eunaticina) arctowskiana Wilckens, back view, Spec. 41-1. Station 41, Lopez de Bertodano Formation, Seymour Island.
PLATE 36

(All figures 1 X)

Figure 1—Cryptorhytis philippiana Wilckens, back view, Spec. F-1.
Station F, Lopez de Bertodano Formation, Seymour Island.

Figures 2, 3—Cryptorhytis philippiana Wilckens, Spec. H^-2. Station
H^-, Lopez de Bertodano Formation, Seymour Island. 2-Back view;
3-Apertural view.

Figure 4—Cryptorhytis philippiana Wilckens, back view, Spec. H^-1.
Station H^-, Lopez de Bertodano Formation, Seymour Island.

Figures 5, 6—Cryptorhytis philippiana Wilckens, Spec. 188-1. Station
188, Lopez de Bertodano Formation, Seymour Island. 5-Back view;
6-Apertural view.

Figure 7—Cryptorhytis philippiana Wilckens, back view, Spec. BZ-38-2-1.
Station BZ-38, Lopez de Bertodano Formation, Seymour Island.

Figures 8, 9—Cryptorhytis philippiana Wilckens, Spec. 458-1. Station
BZ-458, Lopez de Bertodano Formation, Seymour Island. 8-Back view;
9-Apertural view.
LOPEZ DE BERTODANO FM.

SECTION A

SECTION C

SECTION D

SECTION E

SECTION F

(See description of sections in Appendix A.)