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Argentine-Polish geological investigations on Seymour (Marambio) Island, Antarctica, 1988

ABSTRACT: This report describes aims and preliminary results of geological fieldwork carried out by a joint Argentine-Polish party on Seymour (Marambio) and Cockburn islands, Antarctic Peninsula, during austral summer of 1987/88. Seymour Island exposes chiefly shallow-marine, fossiliferous siliciclastic sediments that form an upper, 2000 m thick part in the Mesozoic-Tertiary backarc basin-infill of the Antarctic Peninsula. The fieldwork centered on paleontology and sedimentology of the La Meseta Formation (upper Eocene-lower Oligocene), although some observations of older deposits were carried out also. Clupeoid fishes were discovered in the La Meseta Formation. This is the first record of such fish fossils on the Antarctic continent.

Key words: Antarctica, Seymour (Marambio) Island, Cockburn Island, Cretaceous-Tertiary strata, paleontology, sedimentology.

Introduction

Following an agreement between Instituto Antártico Argentino and the Polish Academy of Sciences a joint Argentine-Polish party carried out geological research on Seymour Island (isla Marambio on Argentine maps) during a period between January 13 and February 25, 1988 (Figs. 1—2). Fieldwork was funded and logistic support provided by the Instituto Antártico Argentino, while travel expenses of Polish participants to Argentina

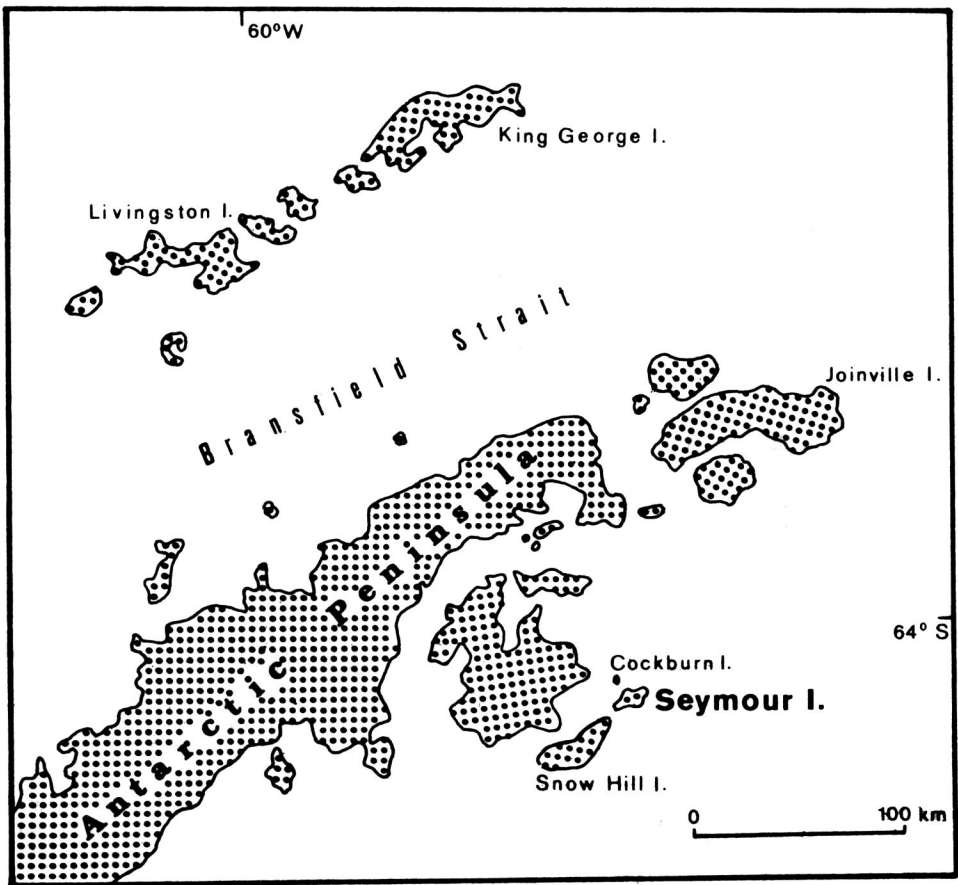


Fig. 1. Locality map for the Antarctic Peninsula region.

and back to Poland were covered by the Polish Academy of Sciences as a part of the budget of 3rd Geodynamic Expedition to West Antarctica (leader Professor A. Guterch; *see* Birkenmajer 1988). The field party, led by Licenciado S. A. Marensi (IAA) and Docent A. Gaździcki (PAS) consisted of six geologists plus two field assistants (Fig. 3) and operated from a permanent camp established in the northeastern part of the island (Figs. 2, 4).

Geological setting

The rock succession exposed on Seymour Island forms the uppermost known part in the Mesozoic-Tertiary backarc basin-infill of the Antarctic Peninsula. The succession, c. 2000 m thick, consists chiefly of marine siliciclastic

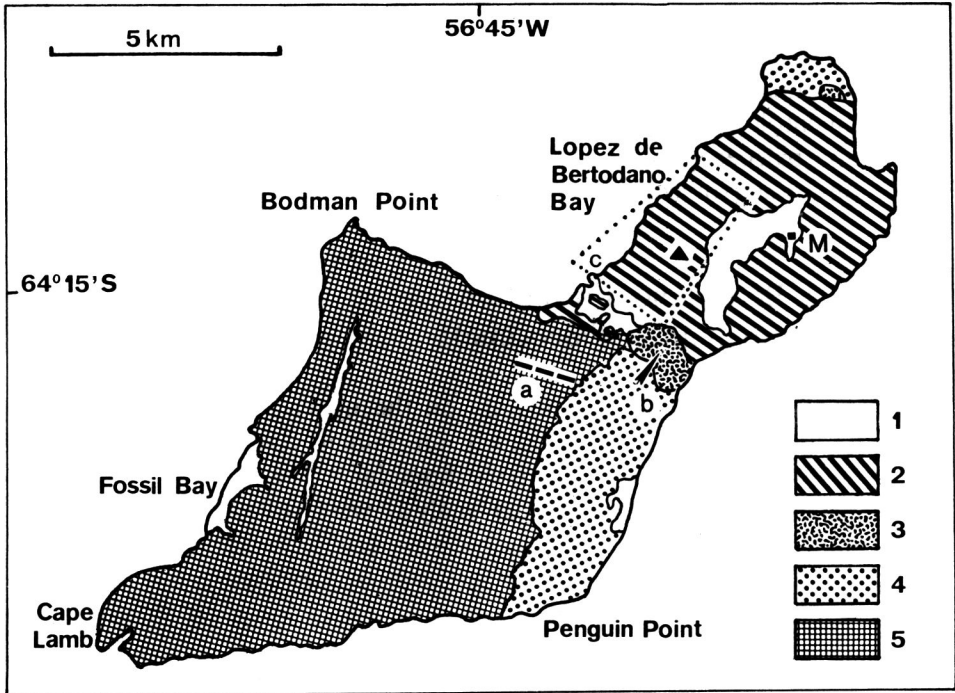


Fig. 2. Geological sketch map of Seymour Island (modified after Maccellari 1986), showing distribution of lithostratigraphic units and positions of studied localities: 1—Quaternary, 2—La Meseta Formation, 3—Cross Valley Formation, 4—Sobral Formation, 5—Lopez de Bertodano Formation; a—section across C/T boundary, b—pyroclastic flow deposits in the Cross Valley Formation, c—area of the La Meseta Formation studied in detail.

M—*Vicecomodoro Marambio* Base; camp site marked by triangle.

sediments which contain abundant, diverse and excellently preserved fossils. The paleontology, stratigraphy and sedimentology of these sediments are relatively well recognized, due to geological work initiated during the Swedish South Polar Expedition in 1901–1903 (Andersson 1906) and continued by a number of Argentine and American expeditions during the 1970s and 1980s (Elliot *et al.* 1975; Rinaldi *et al.* 1978; Zinsmeister 1982, 1984; Elliot and Trautman 1982; Feldmann and Zinsmeister 1984; Woodburne and Zinsmeister 1984; Maccellari 1986; del Valle *et al.* 1987). The succession is divided into the upper Campanian to Paleocene Marambio Group comprised of the Lopez de Bertodano and Sobral formations and the Paleocene–?lower Oligocene Seymour Island Group comprised of the Cross Valley and La Meseta formations (Fig. 2 and Pl. 1, Fig. 1).

Aims and preliminary results

Our work centered on the La Meseta Formation, although some observations of older deposits were carried out also. A brief visit to adjacent

Cockburn Island was made possible due to helicopter service supplied from the Argentine *Vicecomodoro Marambio* Base. The main objectives of the expedition included searching for macrofossils, sampling for microfossils, and sedimentological logging, with particular emphasis given to lateral facies variations, paleoecology of shell banks, and looking for possible signs of glaciations. Field objects and preliminary results are listed below.

Lopez de Bertodano Formation (upper Campanian — Paleocene)

Our fieldwork was focused mainly on the uppermost part of the Lopez de Bertodano Formation and aimed on faunal changes and extinctions events across the Cretaceous/Tertiary boundary (Fig. 2 and Pl. 2). Some 20 samples for micropaleontological analysis were collected throughout this interval.

Cross Valley Formation (Paleocene)

Pyroclastic flow units were identified in the upper part of the Cross Valley Formation (bluff-forming pebbly sandstones of Elliot and Trautman 1982). The units are several meters thick, matrix-supported, very poorly sorted, crudely graded, and show plane stratified tops (Pl. 3). Angular blocks of welded tuff, andesite and basaltic andesite, and charred tree logs are dispersed in an abundant matrix rich in glassy fragments and carbonate cements. The units are interpreted as emplaced subaqueously from hot pyroclastic flows that probably evolved into lahatic debris flows.

La Meseta Formation (upper Eocene — ?lower Oligocene)

The La Meseta Formation — one of the most fossiliferous unit in the rock succession of Seymour Island — has been divided into three informal members and interpreted in terms of deposition on a tide-dominated delta (Elliot and Trautman 1982). Our work was confined mainly to the northeastern part of the island, where best exposures of the formation are situated (inset C in Fig. 2 and Pl. 1, Fig. 2).

In total c. 750 m of sections were measured and long stretches of coastal cliffs logged and correlated. This served as a basis for the construction of an aggregate section of the La Meseta Formation in the area studied



Fig. 3. Argentine-Polish field party on Seymour Island, February 1988; standing from left: A. Gaździcki, S. N. Santillana, S. Marensi, A. V. Vrba, S. J. Porębski, J. C. Ocampo, F. J. Mussel, and M. Doktor.

Photo by M. Doktor

(Fig. 5). The formation consists of a variety of sand and sand-dominated heterolithic lithofacies (Pls. 4–6) which appear to record predominantly marine processes on a tide-influenced, prograding barred nearshore. A range of environments involved includes, among others, shoreface, barrier inlet and spit, lagoon or restricted bay, washover fan or flood-tide delta. Signs of gravity gliding and spreading phenomena, including growth faults, fault-bounded channels with slumped walls (Pl. 6, Fig. 1), angular unconformities, thrust wedges and duplexes, are widespread and attest to a syndepositional tectonic instability.

Among our paleontological findings the most remarkable was the discovery of fish fossils in the basal member of the formation (Unit I of Elliot and Trautman 1982; see Fig. 5 and Pl. 7, Fig. 1), where they are associated with gastropods, bivalves and floral remnants, including *Notophagus*. The fish collection comprises 2 nearly complete specimens belonging to clupeoids (Teleostei) (Pl. 7, Fig. 2), many broken skeletons and scales, and is currently being elaborated by Prof. Anna Jerzmańska (University of Wrocław). This is the first record of clupeoid fishes on the Antarctic continent.

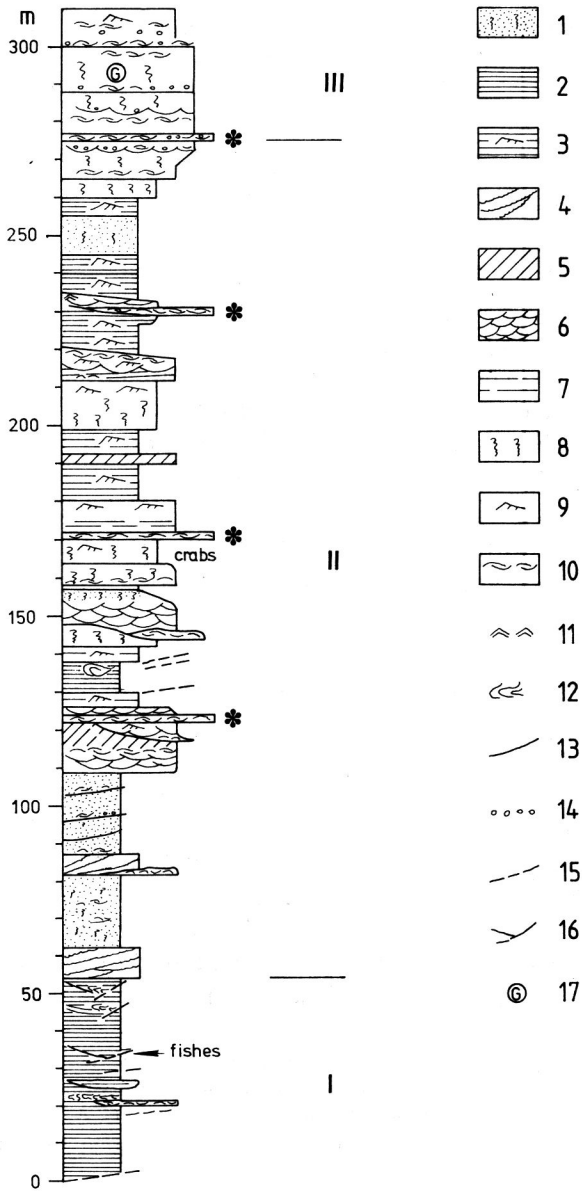


Fig. 4. Camp *Geo-Marambio*
Photo by M. Doktor

Two sites rich in crabs were identified in Unit II (Fig. 5). The crab collection consists of over 500 specimens of *Lyreidus antarcticus* Feldmann and Zinsmeister in different growth stages (Pl. 8, Fig. 3). A number of horizons containing echinoids belonging to schizasterids (Pl. 8, Fig. 2) and cassidulids, were encountered throughout Units II and III. The paleontological elaboration of echinoid fauna by Dr. W. Jesionek-Szymańska (Polish Academy of Sciences, Warszawa) is in progress. Well-preserved *Notophagus* leaves (Pl. 8, Fig. 4) were found at several levels throughout Unit II. The occurrence of excellently preserved crowns of crinoid *Metacrinus* (Pl. 8, Fig. 1) is also worth of mentioning.

Particular attention was given to the composition and structure of *Cucullaea*, *Eurhomalia*, *Turritella*, *Hiatella* and *Panopea* shell banks (Pls. 9–10) which punctuate the dominantly sandy section of the La Meseta Formation. At least four of these were found to be useful markers for

Fig. 5. Composite stratigraphic log of the La Meseta Formation, showing distribution of main lithofacies, laterally persistent shell beds (marked by asterisks) and location of fish and crab fossiliferous sites. The log was constructed from sections measured in the area of inset C in Fig. 2. The base of the log is a fault zone exposed in sea cliff at the mouth of Cross Valley; Roman numerals correspond to informal units distinguished by Elliot



and Trautman (1982). 1 — bioturbated muddy sand and sandy mud, 2—4 — heterolithic facies: 2 — flat, lenticular to wavy laminated heterolithe composed of alternating sorted sand (50—75%) and sandy mud layers, 3 — mainly ripple-laminated and flasery heterolithe composed of sorted sand (75—95%) and mud layers, 4 — epsilon cross-stratification, 5—9 — sorted sand and pebbly sand: 5 — planar cross-stratification, 6 — through cross-stratification, 7 — flat lamination, 8 — bioturbation, 9 — ripple cross-lamination, 10 — shell beds, 11 — wave ripples, 12 — slumping, 13 — low-angle truncation, 14 — pebble and concretionary concentrates, locally with outsized angular clasts, 15 — faulted contact, 16 — fault-bounded channel, 17 — glauconitic sand

mapping and correlation purposes (Fig. 5). Over 200 samples were taken from all members of the formation for microfossil and sedimentologic research.

Weddell Formation (?Quaternary)

Angular pebble detritus scattered among rounded clasts, which appear already within high-energy facies of Units II and III in the La Meseta Formation (Pl. 6, Fig. 2) may represent an ice-rafted debris released from stranded icebergs. The formation is disconformably overlain by a strip of boulder till, referred to as the Weddell Formation (Zinsmeister and de Vries 1983) which on the basis of weak biostratigraphic evidence has been ascribed to the Quaternary (*see also* Malagnino *et al.* 1981). Collection of clast types was gathered from the till in order to compare this petrographic suite with others reported from Tertiary tillites of King George Island (Birkenmajer and Wieser 1985).

Pecten Conglomerate (Pliocene) — Cockburn Island

The type locality of *Chlamys anderssoni* Hennig (*see* Andersson 1906) was visited and many specimens of this pectinid bivalve gathered (Pl. 11). Our observations suggest that these specimens differ from the pectinid fauna collected from the Polonez Cove Formation on King George Island. This supports recent conclusion of Birkenmajer *et al.* (1987) that the previous correlations of these two faunas were based on false ground. A number of samples from *Chlamys*-bearing strata and from lavas above the plateau were collected for micropaleontologic and isotopic dating.

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Resumen

El artículo presenta los resultados de las investigaciones geológicas que llevó a cabo el conjunto argentino-polaco en las islas de Marambio y Cockburn, cerca de la península Antártica, durante un periodo comprendido entre el 13 de Enero y el 25 de Febrero de 1988.

Nuestro trabajo se centró sobre la Formación La Meseta, sin embargo también se realizaron algunas investigaciones sobre depósitos más antiguos. Los objetivos principales de la expedición incluyeron búsqueda de microfósiles, muestreo para micropaleontología y perfilaje sedimentológico dando particular énfasis variaciones laterales de facies, paleoecología de los bancos de conchillas y a la búsqueda de posibles evidencias de glaciación.

Se reconocieron aproximadamente 750 m de sección y se perfilaron y correlacionaron

extensos sectores de los acantilados costaneros. Esto sirvió como la base para la construcción de un perfil compuesto de la Formación La Meseta en el área estudiada. La formación parece registrar procesos predominantemente marinos en una zona litoral progradante y restringida por barras. Las facies distinguidas incluyen, entre otras, las zonas de shoreface, estrechos entre barreras y espigas, lagoon o bahías restringidas, abanicos de lavado o deltas de flujo de mareas. Las evidencias de deslizamientos gravitacionales y de fenómenos de dispersión, los que incluyen fallas de crecimiento, canales limitados por fallas con flancos deslizados y discordancias angulares, están atestiguando una inestabilidad tectónica sindeposicional.

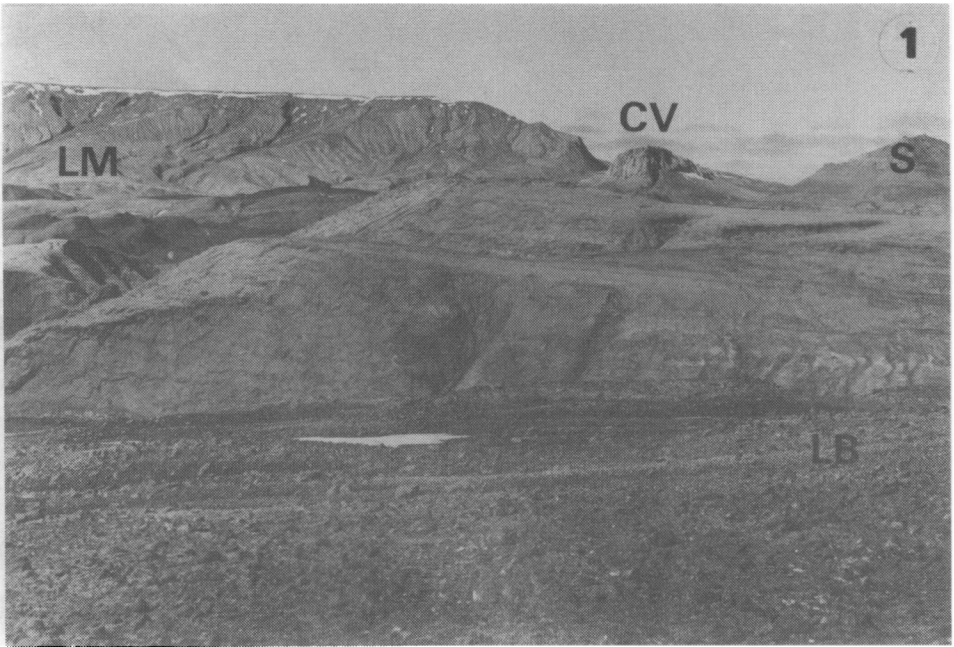
Entre los hallazgos paleontológicos el más importante corresponde al descubrimiento de peces fósiles (Clupeoidei) en el miembro basal de la formación (United I *sensu* Elliot y Trautman 1982) donde éstos están asociados a gastrópodos, bivalvos y fragmentos de hojas, principalmente de *Nothophagus*. Se identificaron también dos localidades ricas en cangrejos fósiles dentro de la Unidad II. La colección de cangrejos consiste en más de 500 ejemplares de *Lyreidus antarcticus* Feldmann et Zinsmeister en diferentes estadios de crecimiento. Se encontraron así mismo a través de las unidades II y III varios horizontes portadores de equinodermos, principalmente schizastéridos y cassiduláridos.

Se prestó particular atención a la composición y estructura de los bancos de *Cucullaea*, *Eurhomalia*, *Turritella*, *Hiatella* y *Panopea*, los cuales aparecen dentro de la fracción arenosa de la Formación La Meseta.

Streszczenie

Praca przedstawia wyniki wspólnych, argentyńsko-polskich badań paleontologiczno-sedymentologicznych, przeprowadzonych na wyspach Seymour i Cockburn (Antarktyka Zachodnia) w okresie od 13 stycznia do 25 lutego 1988 r. (fig. 1—4, pl. 1, 3, 11). Przedmiotem badań były utwory kredy i trzeciorzędu stanowiące fragment wypełnienia basenu załukowego Półwyspu Antarktycznego, a w szczególności osady formacji La Meseta (górnego eocenu-?oligocenu). Formacja ta reprezentuje ilasto-piaszczyste osady morskie wybrzeża barierowego (fig. 5, pl. 4—6). Rozpoznano w niej szereg nieznanych dotąd horyzontów faunistycznych zawierających m.in.: ryby śledziowate z podrzędu Clupeoidei (pl. 7), jeżowce nieregularne z rodziny Schizasteridae (pl. 8, fig. 2), kraby *Lyreidus antarcticus* (pl. 8, fig. 3) oraz liście buka południowego *Nothophagus* (pl. 8, fig. 4). Przeprowadzono analizę paleoekologiczną poziomów muszlowcowych *Cucullaea*, *Eurhomalia*, *Turritella*, *Hiatella* i *Panopea* (pl. 9—10), które mogą służyć jako horyzonty korelacyjne. Zwrócono uwagę na problem granicy kreda/trzeciorzęd i zmienność faun w tym interwale czasowym (pl. 2). Pobrano próby z tzw. zlepieńca pektenowego występującego na Wyspie Cockburn (pl. 11).

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1. View of northwestern slopes of the mesa on Seymour Island, showing outcrops of main Cretaceous-Tertiary formations: LM — La Meseta Formation, CV — Cross Valley Formation, S — Sobral Formation, LB — Lopez de Bertodano Formation.

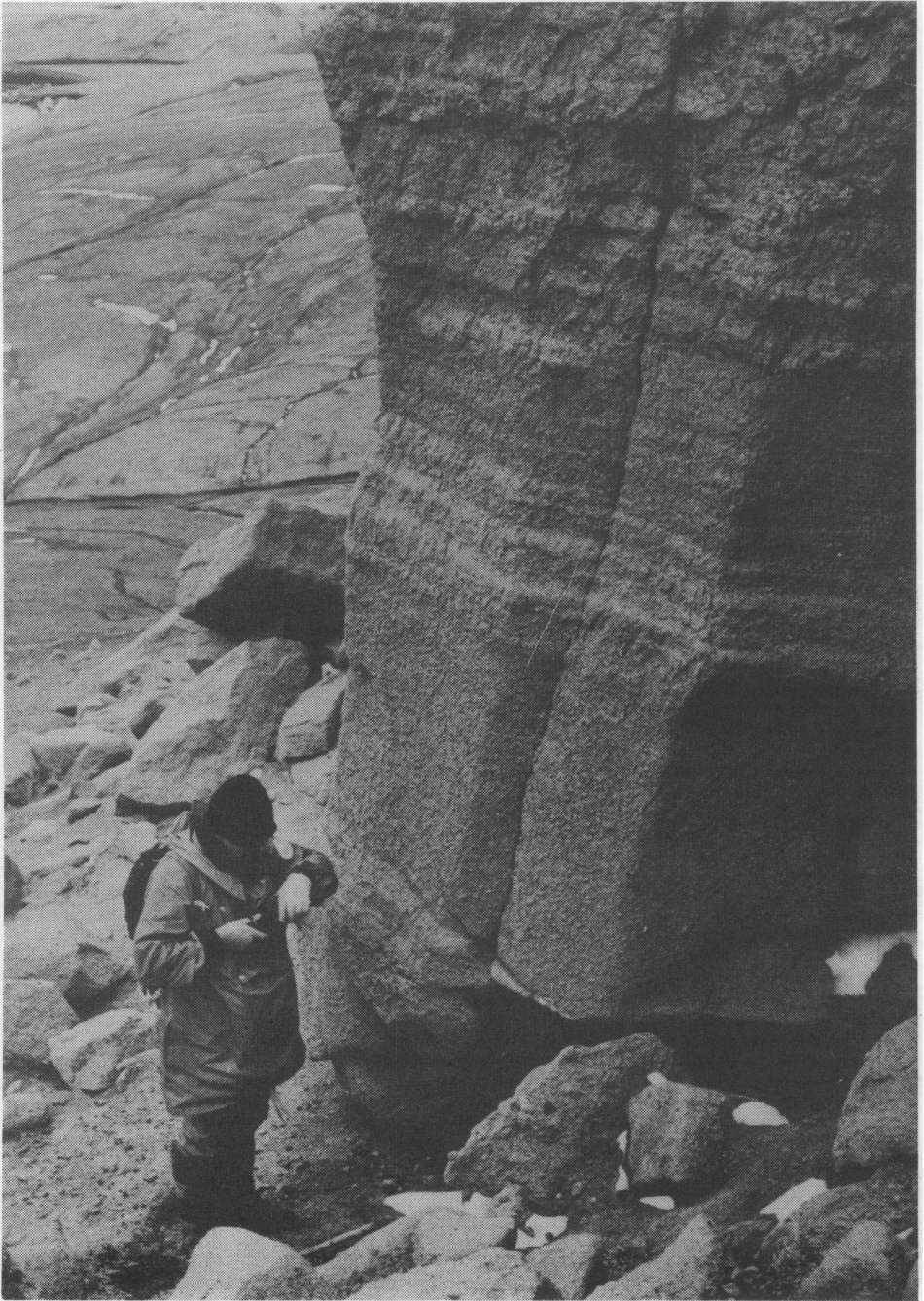
2. Typical outcrop of the La Meseta Formation. The cliff in foreground is c. 35 m high — see log in Fig. 5, 138—172 m. P42-Zerwa.

Photos by A. Gałdzicki

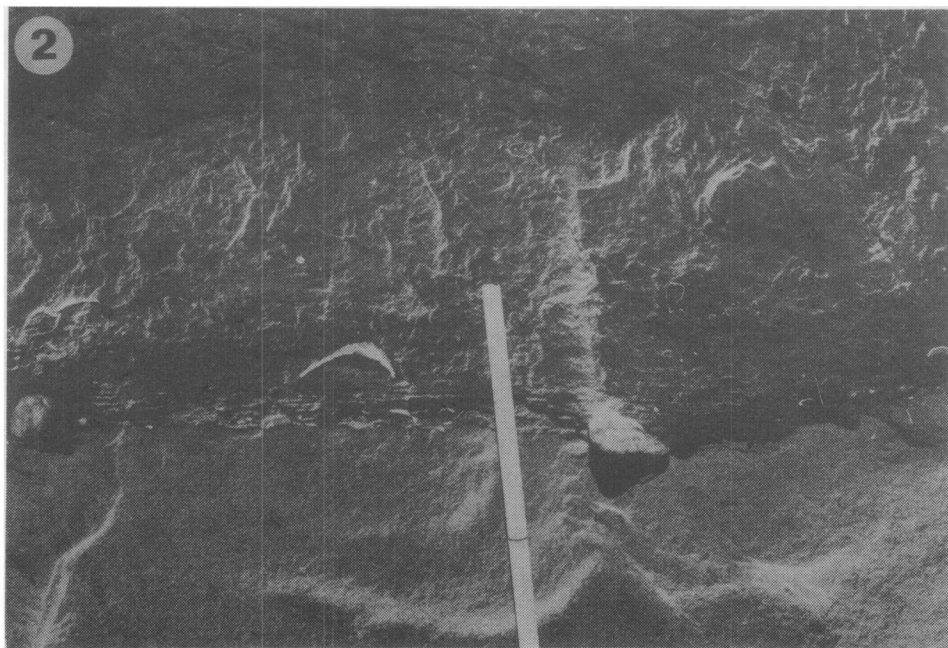
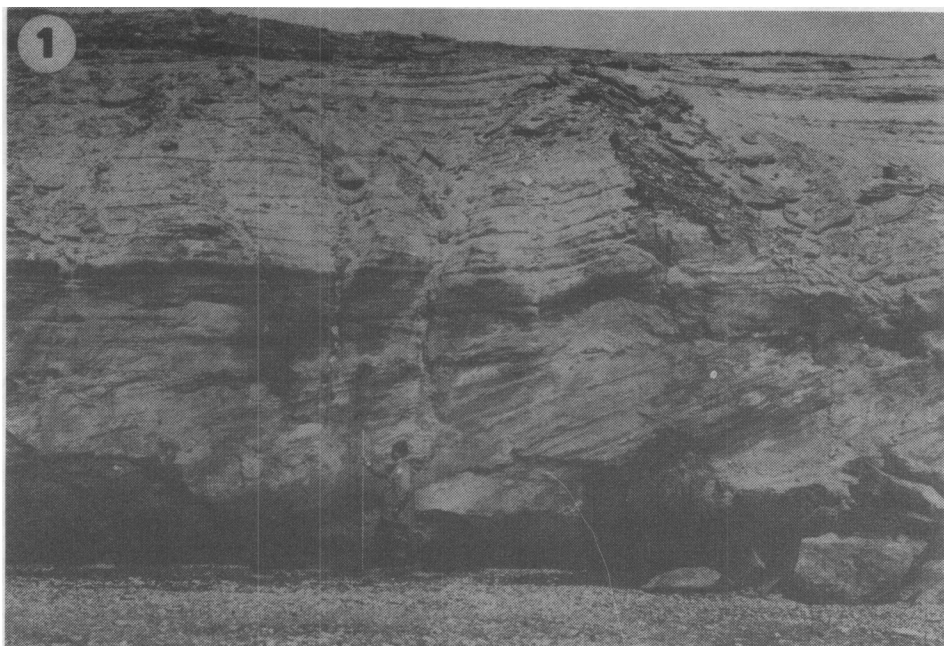


1. Concretion-bearing horizon in the Sobral Formation.
2. Glauconitic sandstone bed (arrowed) in the uppermost part of the Lopez de Bertodano Formation, marking the C/T boundary.

Photos by A. Gaździcki



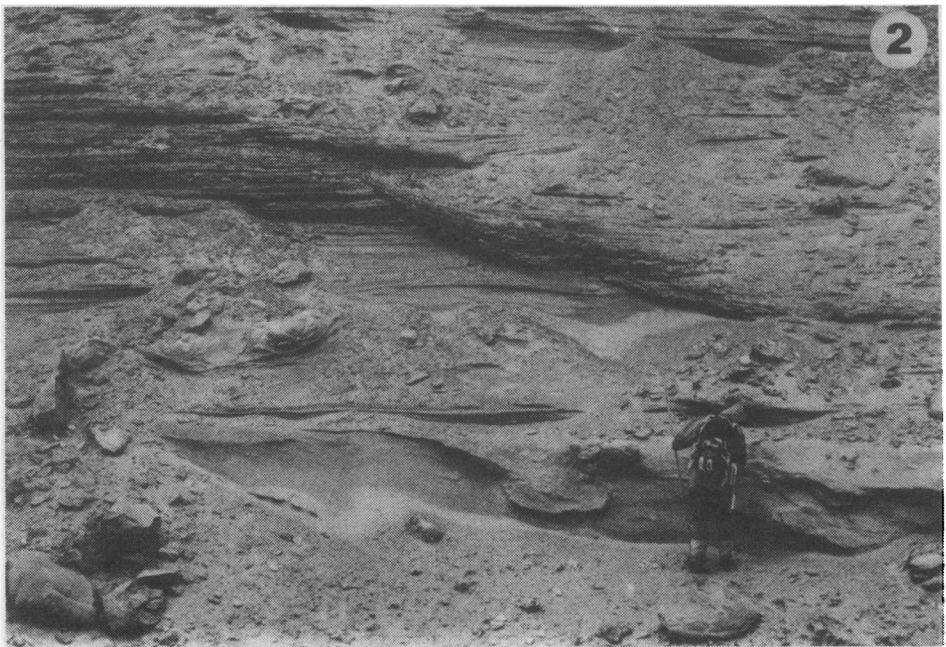
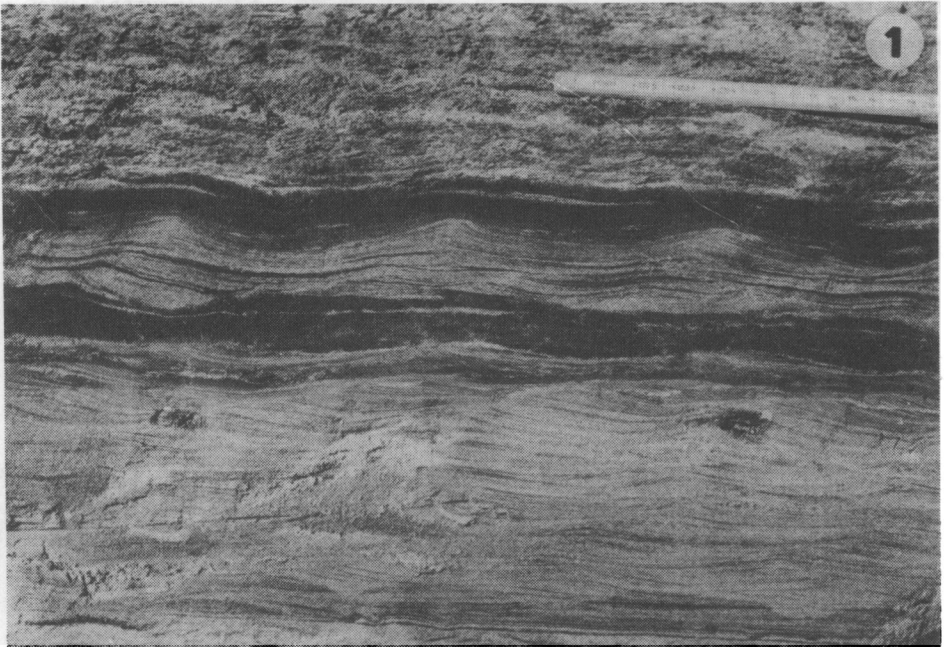
Upper, plane stratified part of thick, graded pyroclastic flow unit in the Cross Valley Formation. MD66-29.
Photo by M. Doktor



Examples of litofacies in the La Meseta Formation (Unit I).

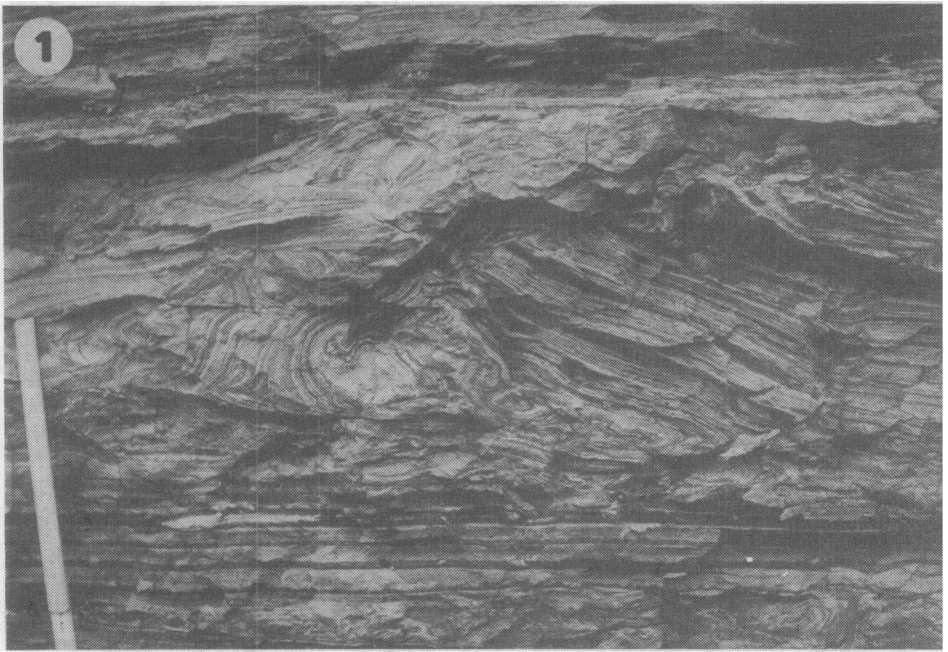
1. Large-scale, composite cross-set made-up of heterolithic facies. The set, min. 4 m thick, is erosively cut by synthetic, low-angle dipping surface. MD9-11.
2. Close-up view of the above erosion surface in the toeset region. The surface, lined by pebbles, concretions and large bivalve shells, is followed upwards by heavily bioturbated muddy sand. MD13-33.

Photos by M. Doktor



Examples of stratification in heterolithic and sand lithofacies of the La Meseta Formation (Unit II). 1. Climbing ripple lamination and wavy bedding; dark flasers and laminae consist of muddy very fine sand enriched in carbonized plant matter. MD41-II. 2. Stacked channel-fills. Lower channel has basal gastropod lag (not seen), overlain by sorted coarse sand showing stratification affected by large hydroplastic deformations and is gradationally capped by reddish-colored, mostly ripple-laminated heterolithe (upper left). The latter represents in part the levee complex of upper channel-infill which, in turn, is followed upwards by thick, bioturbated silty sand unit, rich in crabs and mollusc remains. MD28-14.

Photos by M. Doktor



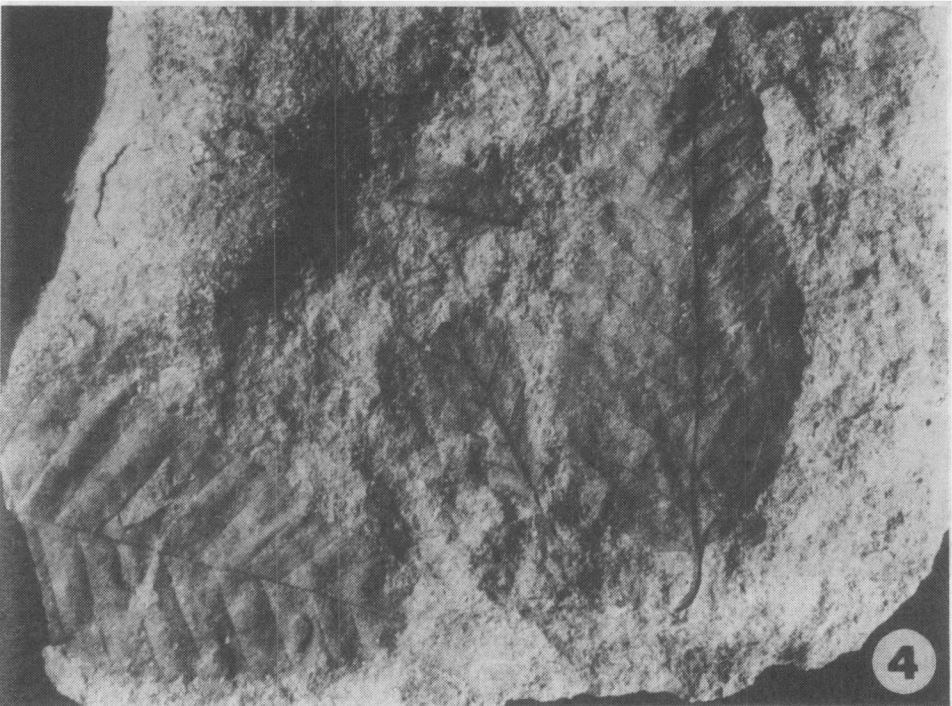
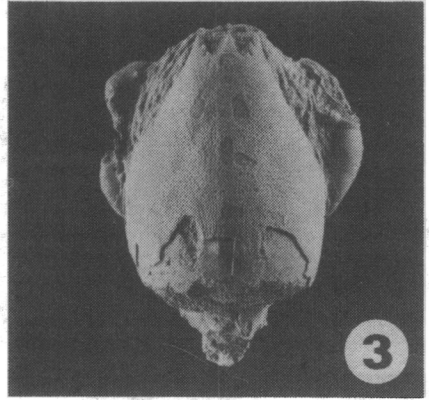
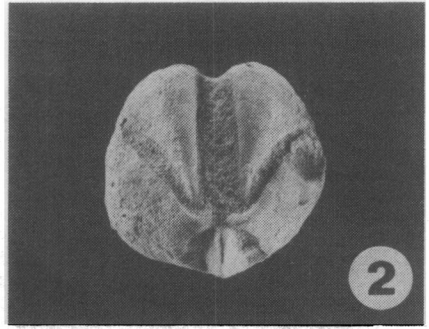
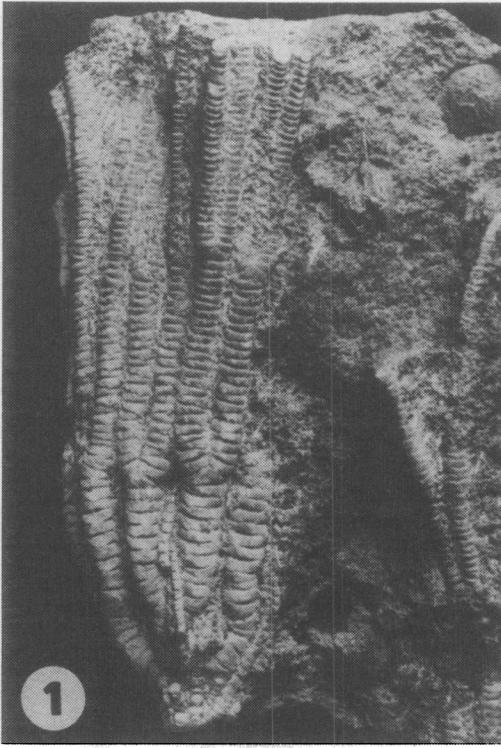
1. Heterolithic lithofacies slumped from the wall of a large fault-bounded channel. Unit I of the La Meseta Formation. MD25-2.
2. Scattered outsized clasts on bedding plane of sorted sandstone bed. Unit III of the La Meseta Formation. MD56-17.

Photos by M. Doktor



1. General view of Unit I of the La Meseta Formation, exposed in sea cliff, showing better cemented and more resistant portions where fish fauna was found (asterisked).
2. Bedding plane of cemented fine sandstone, showing two nearly complete specimens of clupeoid fishes (Teleostei). Scale bar is 5 cm long.

Photos by A. Gaździcki (1) and G. Podbielska (2)



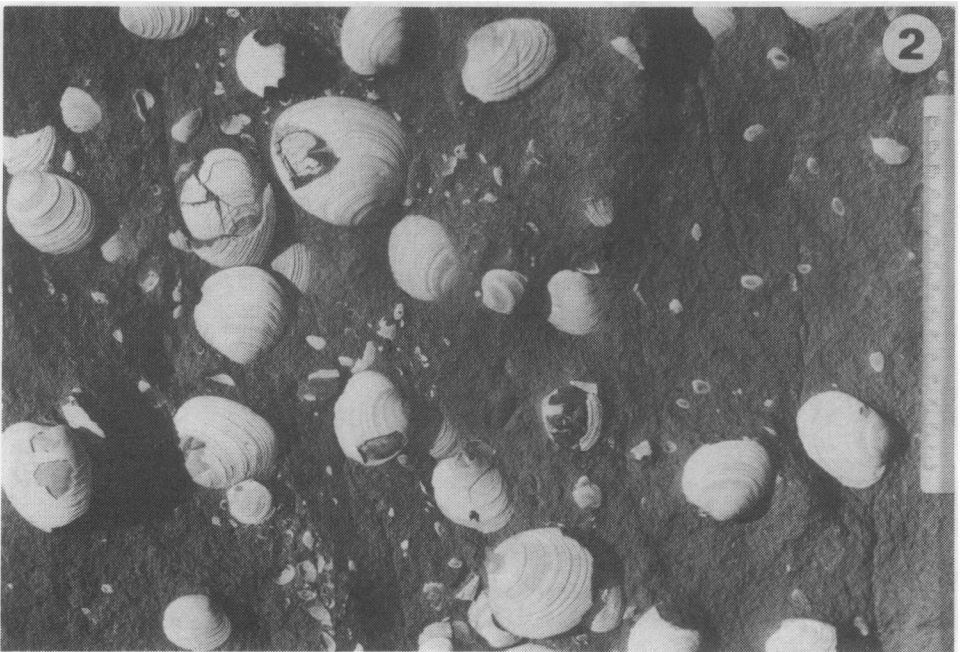
Selected fossils from the La Maseta Formation (all specimens derived from Unit II; natural size)

1. Crown of crinoid *Metaerinus fossilis* Rasmussen, 1980. 2. Schizasterid echinoid, adapical view.

3. Crab *Lyreidus antarcticus* Feldmann and Zinsmeister, 1984; dorsal view of cephalothorax.

4. *Notophagus* leaves impressed into very fine sandstone.

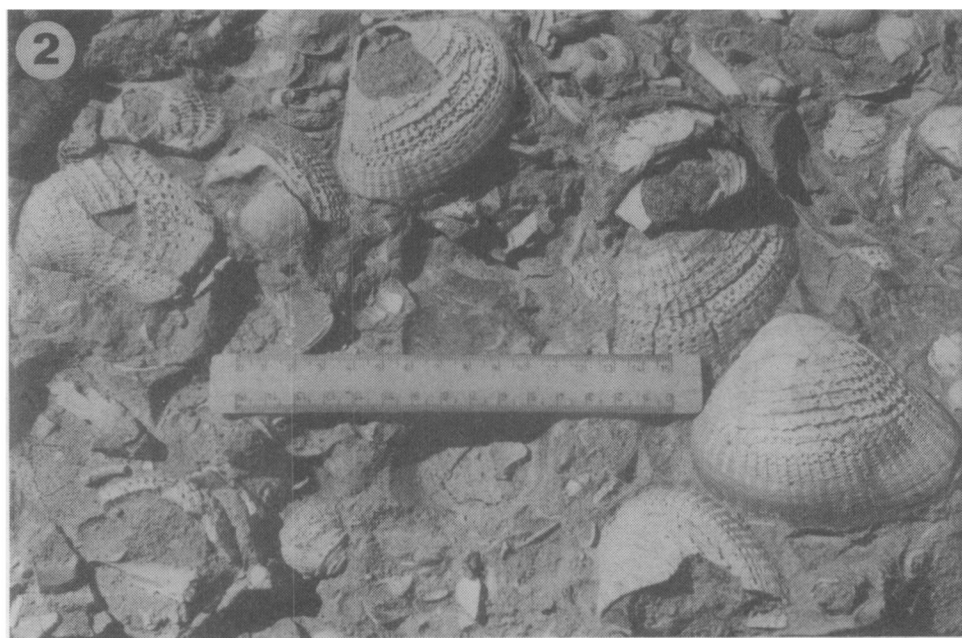
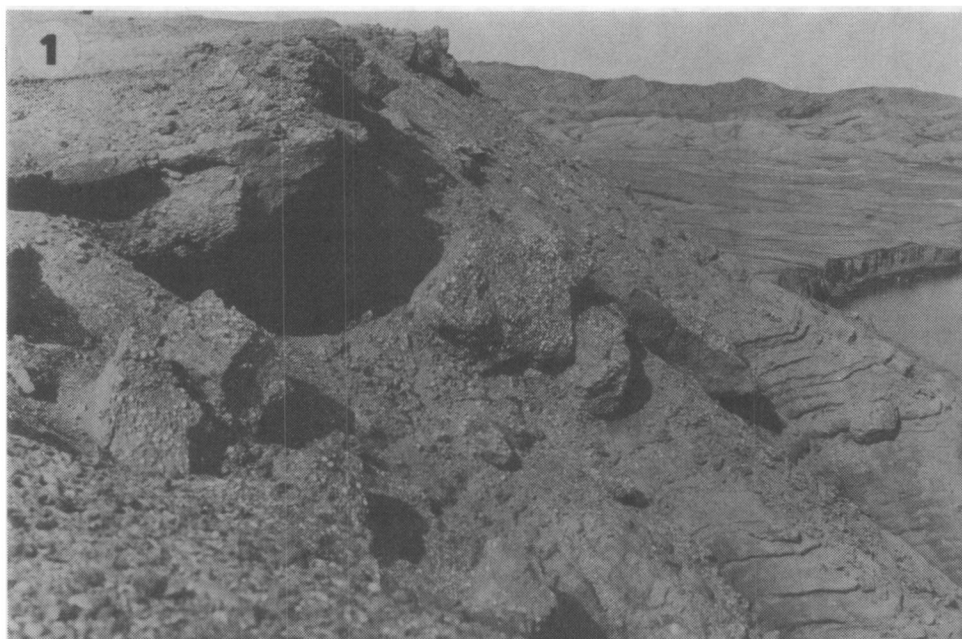
Photos by G. Podbielska



Close-up views of shell beds forming persistent markers in the La Meseta Formation.

1. Gastropod *Turritella*-dominated assemblage, natural size (Unit III).
2. Bivalve *Eurhormalia* assemblage (Unit II).

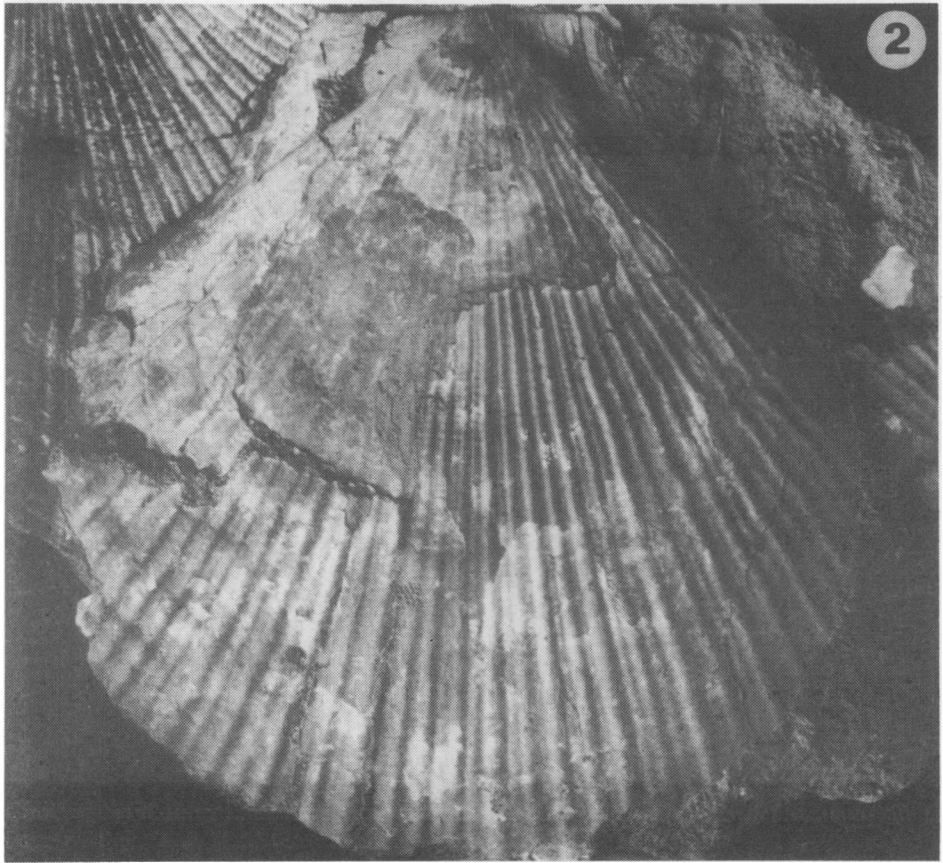
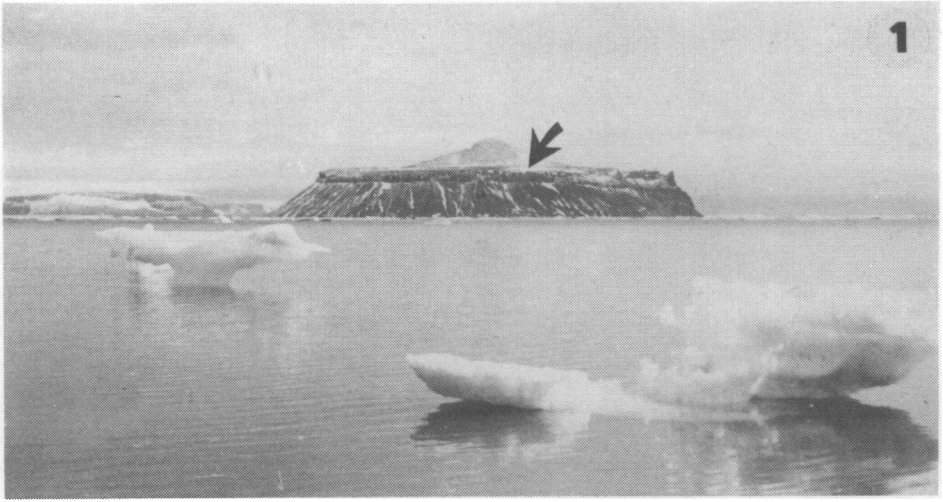
Photos by A. Gaździcki



1. *Cucullaea* shell bank exposed in the highest part of sea cliff in the Lopez de Bertodano Bay; Unit II of the La Meseta Formation.

2. Close-up view of *Cucullaea* bank, shown above.

Photos by A. Gaździcki



1. Southeast coast of Cockburn Island, viewed from the Lopez de Bertodano Bay, Seymour Island. Arrow shows location of *Chlamys*-bearing strata.
2. Bivalve *Chlamys anderssoni* (Hennig, 1911) collected from Cockburn Island. Natural size.
Photos by A. Gaździcki (1) and G. Podbielska (2)