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Recycled Upper Cretaceous calcareous nannoplankton from the *Pecten* Conglomerate of Cockburn Island, Antarctica

ABSTRACT: Upper Cretaceous calcareous nannoplankton recycled into the Pliocene *Pecten* Conglomerate of Cockburn Island (Antarctic Peninsula) provide a paleontological record of Upper Cretaceous sedimentary sequences in the James Ross Basin. The calcareous nannofossil assemblage comprises nearly 40 taxa and is dominated by Campanian-Maestrichtian species. The investigated assemblage shares some features with the southern high-latitude contemporaneous calcareous nannofossil assemblages from outcrops on adjacent Seymour (Marambio) Island and many with deep-sea drilling sites in the circum-Antarctic region.

K e y w o r d s: Antarctica, James Ross Basin, Upper Cretaceous, calcareous nannoplankton.

Introduction

The type locality of the *Pecten* Conglomerate on Cockburn Island in the northeastern Antarctic Peninsula region (Figs 1—2) contains either a micro- and macrofossil assemblages and is the most paleontologically diverse Pliocene sequence known in Antarctica (Buckman 1910, Hennig 1910, Holland 1910, Wilckens 1924, Gaździcki and Webb *in preparation*).

Micropaleontological analysis of the rocks from the *Pecten* Conglomerate of Cockburn Island reveal, among other taxonomic groups the presence of reworked Upper Cretaceous calcareous nannoplankton, which cover the tests of reworked Upper Cretaceous planktic foraminifers. This provides a means for cross-checking the ages of recycled planktic assemblages.

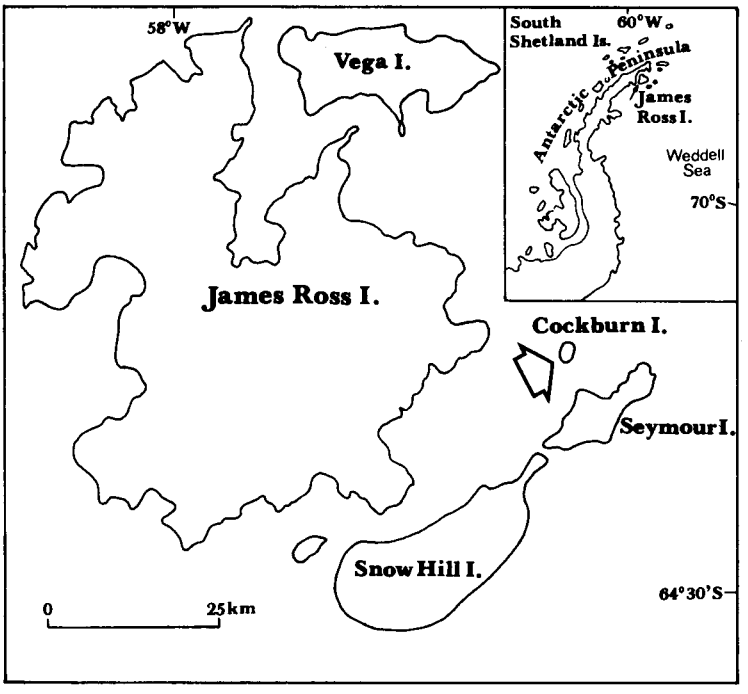


Fig. 1. Location map of James Ross Island and surrounding islands (James Ross Basin *sensu* Elliot 1988). Cockburn Island arrowed.

The samples were collected by one of us (AG) during the work of the Argentine-Polish field party in the austral summer od 1987—1988 *see* Doktor *et al.* (1988). Calcareous nannoflora was examined with scanning electron microscope only. No nannofossil preparation techniques were employed, thus the observed assemblage showed its burial composition.

The study material is housed in the Institute of Paleobiology, Polish Academy of Sciences, Warszawa.

Geological setting

Cockburn Island lies in the northwestern part of the Weddell Sea, near the tip of the Antartcic Peninsula, less than 10 km from Seymour (Marambio) Island (Fig. 1). The island is built by the Upper Cretaceous (Campanian) and the Tertiary (Eocene-Pliocene) sedimentary successions and the Pliocene basalt flows (Fig. 2) *see also* Andersson (1906), Andersson *In:* Buckman (1910), Zinsmeister and Webb (1982), Webb and Andreasen (1986), Askin *et al.* (1991), Gaździcki (1993), Gaździcki and Webb (*in preparation*).

The studied *Pecten* Conglomerate strata are preserved on an erosional, horizontal bench in the Pliocene basalts located approximately 250 m above sea

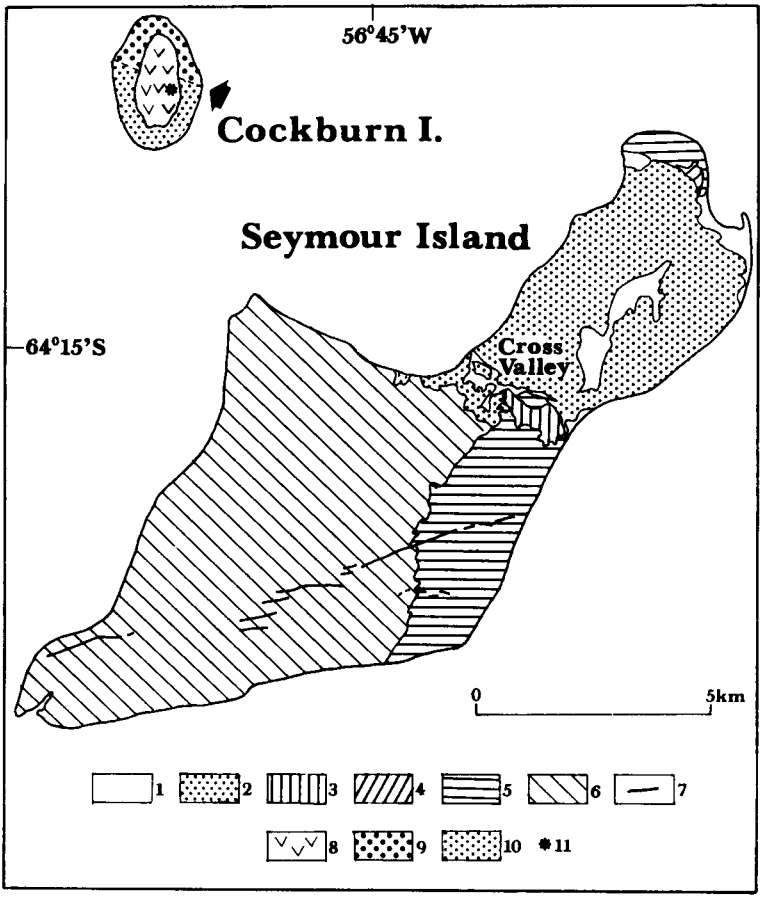


Fig. 2. Geological map of Cockburn and Seymour islands (*after* Askin *et al.* 1991). **Seymour Island:** 1 — Quaternary, 2 — La Meseta Formation, 3 — Cross Valley Formation, 4 — "Wiman Formation", 5 — Sobral Formation, 6 — López de Bertodano Formation, 7 — dike. **Cockburn Island:** 8 — James Ross Island Volcanic Group, 9 — Tertiary strata, 10 — Cretaceous strata, 11 — *Pecten* Conglomerate collecting site (asterisked).

level (Fig. 3). They consist of poorly sorted conglomeratic sandstones and gravelly sandstones which often contain well-preserved bivalve shells of *Chlamys anderssoni* (Hennig, 1910). The clasts in conglomerate are mostly basaltic in composition and represent the rocks of the Upper Miocene-Pliocene James Ross Island Volcanic Group (*cf.* Webb and Andreasen 1986).

The K/Ar radiometric data obtained from the basalts which underlie the *Pecten* Conglomerate (Webb and Andreasen 1986, R. A. Keller *personal commun.*, 1992), as well as the studies of diatoms and benthonic foraminifers, which, were found *in situ* in the conglomerate point to a late Pliocene age (Harwood 1986, Gaździcki and Webb *in preparation*). The biota of the *Pecten* Conglomerate indicate relatively warm interglacial conditions with higher sea level during the deposition of this sequence (*cf.* Andersson 1906, Soot-Ryen 1952, Adie 1964, Gaździcki and Webb *in preparation*).

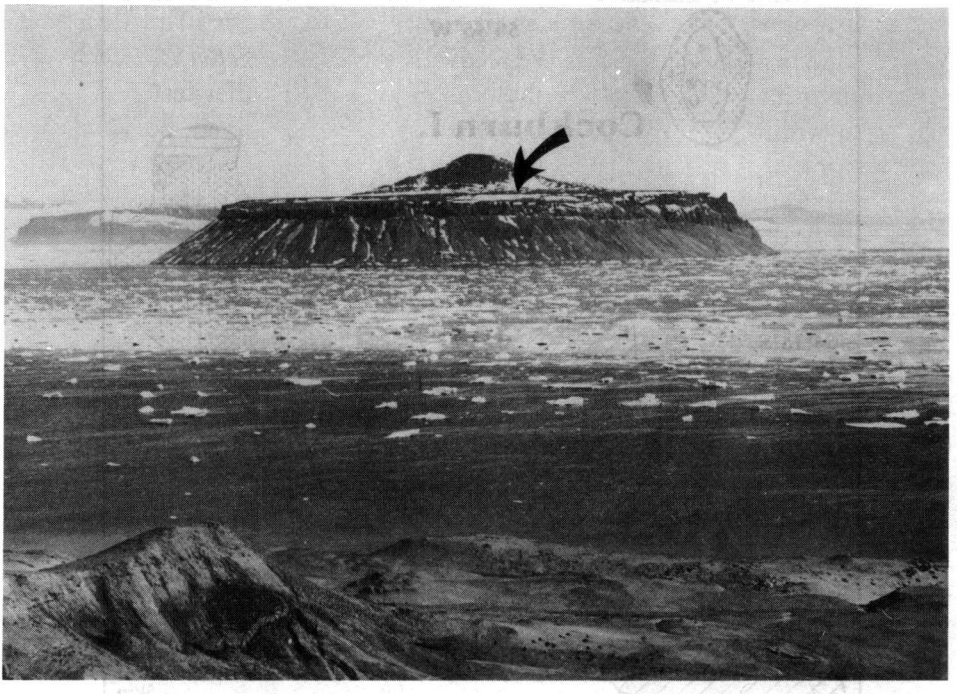


Fig. 3. Cockburn Island, viewed from the López de Bertodano Bay, Seymour Island. Arrow shows the *Pecten* Conglomerate collecting site. *Photo by A. Gaździcki, January 1988.*

Reworked Cretaceous micro- and nannofossils

Micropaleontological analysis of the rocks of the *Pecten* Conglomerate from Cockburn Island shows the presence of recycled Upper Cretaceous planktic foraminifera along with the calcareous nannoplankton, which indicate reworking of the Upper Cretaceous sediments from the James Ross Basin.

Planktic foraminifera. The recycled planktic foraminifer assemblage consists of over 30 specimens containing often broken and poorly to moderately preserved tests of heterohelicids, mostly *Heterohelix globulosa* (Ehrenberg, 1839), *Globigerinelloides,* represented by the species *G. multispinus* (Lalicker, 1948), a few hedbergellids and rare specimens of the genera *Rugoglobigerina* Brönnimann, 1952 and ?*Archaeoglobigerina* Pessagno, 1967. This assemblage is dominated by the species of *Heterohelix* and *Globigerinelloides* and is similar to the foraminiferal Late Cretaceous Austral Province faunas described from the López de Bertodano Formation of the James Ross Island region (Huber 1988) and southern high-latitude DSDP and ODP sites (Krasheninnikov and Basov 1983, Huber 1990, 1991a). Recognized taxa range from the late Campanian to Maestrichtian in the high southern latitudes (*cf.* Huber 1988, 1990, 1991a, b; 1992).

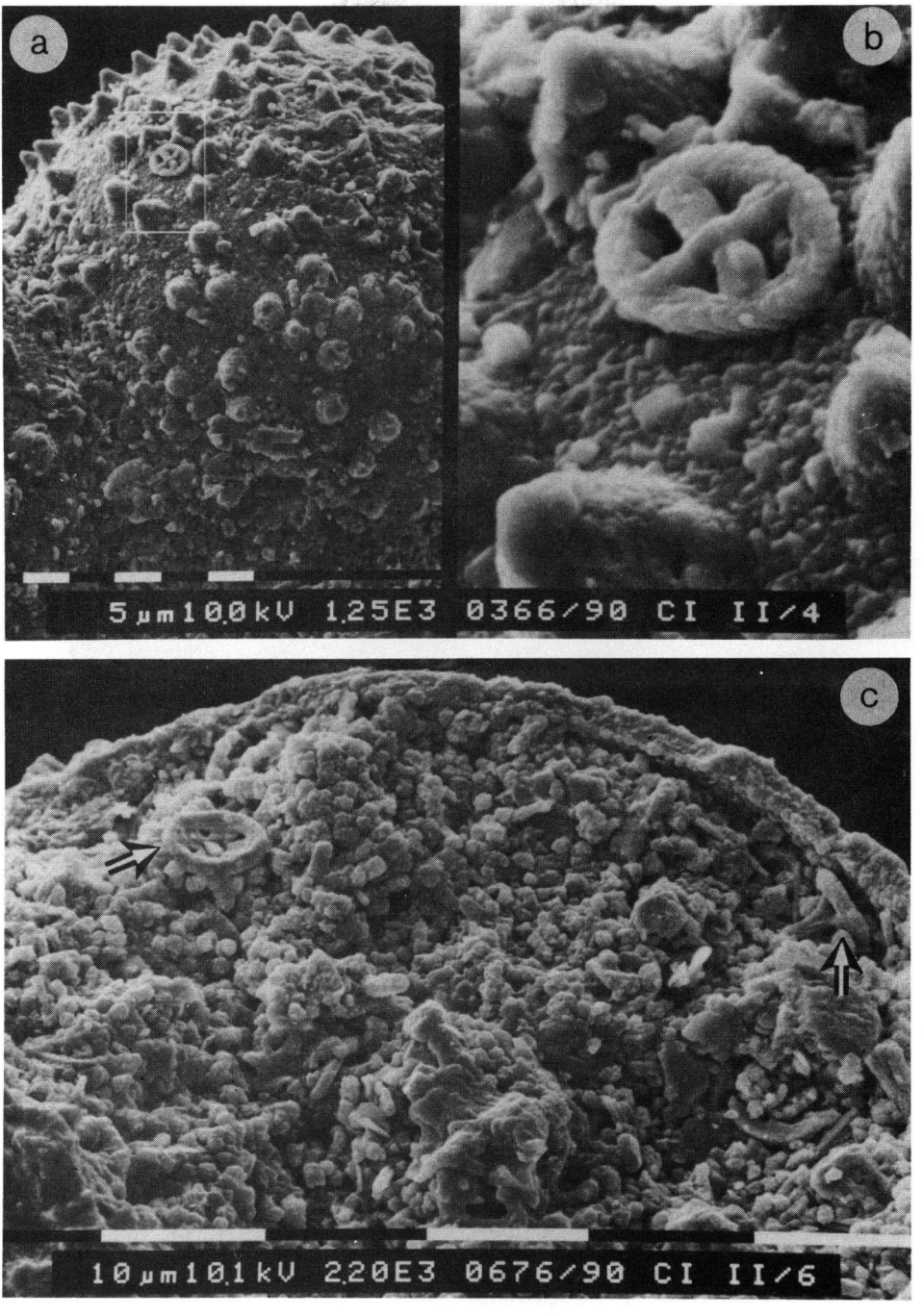


Fig. 4. Upper Cretaceous planktic foraminifers with coccoliths on the surface of the test (**a-b**) and within the test (**c**), recycled into the *Pecten* Conglomerate, Cockburn Island.

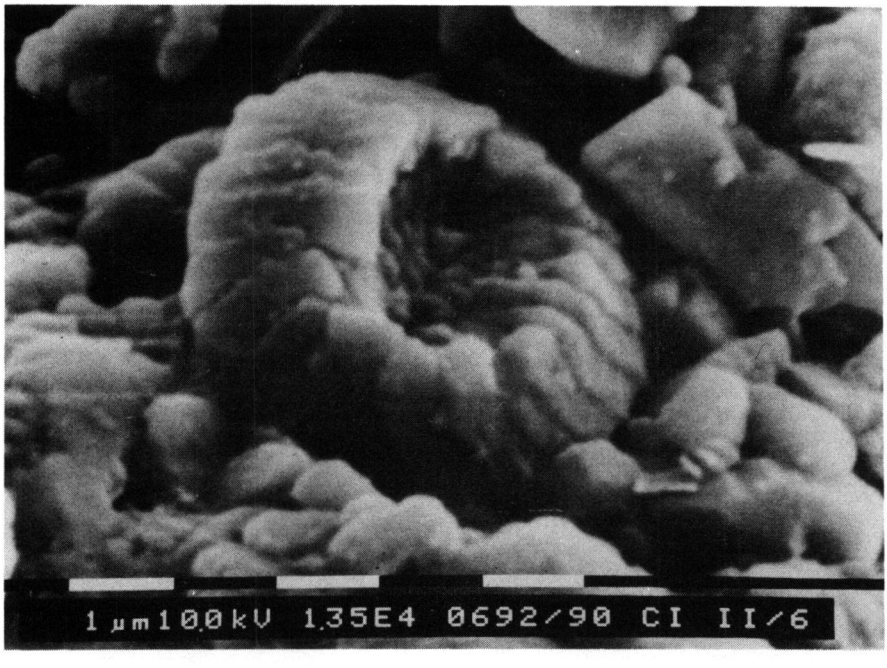


Fig. 5. *Biscutum magnum* Wind and Wise 1977 – an index species of the Lower Maestrichtian *magnum* Zone. *Pecten* Conglomerate, Cockburn Island.

Calcareous nannoplankton. A significant number of recycled Upper Cretaceous calcareous nannoplankton were recovered from the *Pecten* Conglomerate. Abundant coccoliths cover the globulose planktic foraminifer tests (Fig. 4a-b) and occur within the tests (Fig. 4c), diverse and well-preserved, permitting the identification at the species level. More than thirty species were recognized on SEM micrographs and some of them are illustrated (Pls 1 – 6). The diversity and preservation of coccolith assemblage suggest a shallow depth of primary deposition (above CCD) and a low degree of sediment diagenesis.

The assemblage is comprised of high-latitude provincial species, which have been referred to as austral taxa (Wise 1983, *see also* Watkins 1992, Huber and Watkins 1992) as well as cosmopolitan taxa. The dominant forms in the assemblage are species that are resistant to carbonate dissolution and mechanical abrasion such as *Arkhangelskiella cymbiformis, Cribrosphaerella ehrenbergii, Kamptenerius magnificus, Prediscosphaera cretacea* and *Watznaueria barnesae.* Fairly common is also the genus *Biscutum* which is represented in the studied material by four species: *B. constans, B. dissimilis, B. magnum* (Fig. 5), *B. notaculum* and some other forms that are difficult to identify.

Reworked Upper Cretaceous nannofossil taxa recovered from the Pliocene *Pecten* Conglomerate of Cockburn Island (*cf.* Figs 2 – 3) are listed below (arranged alphabetically by generic name) and their stratigraphical ranges are presented on Table 1.

Ahmuellerella octoradiata (Górka, 1957) Reinhardt, 1964 — Pl. 4, Fig. 1
Arkhangelskiella cymbiformis Vekshina, 1959 — Pl. 2, Fig. 2
Arkhangelskiella specillata Vekshina, 1959 — Pl. 2, Fig. 1
Aspidolithus parcus expansus (Wise and Watkins *In:* Wise, 1983) Perch-Nielsen, 1984 — Pl. 2, Fig. 3
Biscutum constans (Górka, 1957) Black *In:* Black and Barnes, 1959 — Pl. 3, Fig. 1
Biscutum dissimilis Wind and Wise *In:* Wise and Wind, 1977
Biscutum magnum Wind and Wise *In:* Wise and Wind, 1977 — Fig. 5
Biscutum notaculum Wind and Wise *In*: Wise and Wind, 1977
Biscutum sp.
Chiastozygus litterarius (Górka, 1957) Manivit, 1971 — Pl. 5, Fig. 3
Cretarhabdus surirellus (Deflandre *In:* Deflandre and Fert, 1954) Reinhardt, 1970 emend. Thierstein, 1971
Cretarhabdus sp. — Pl. 6, Fig. 4
Cribrosphaerella ehrenbergii (Arkhangelsky, 1912) Deflandre, 1952 — Pl. 6, Fig 5
Cyclagelosphaera margerelii Noël, 1965
Discorhabdus ignotus (Górka, 1957) Perch-Nielsen, 1968
Eiffellithus turriseiffeli (Deflandre *In:* Deflandre and Fert, 1954) Reinhardt, 1965 — Pl. 4, Fig. 2
Gartnerago obliquum (Stradner, 1963) Noël, 1970
Glaukolithus diplogrammus (Deflandre *In*: Deflandre and Fert, 1954) Reinhardt, 1964
Helicolithus sp. — Pl. 5, Fig. 1
Kamptnerius magnificus Deflandre, 1959 — Pl. 2, Fig. 4
Lithraphidites carniolensis Deflandre, 1963 — Pl. 1, Fig. 1
Lucianorhabdus arcuatus Forchheimer, 1972
Markalius inversus (Deflandre *In:* Deflandre and Fert, 1954) Bramlette and Martini, 1964 — Pl. 3, Fig. 4
Microrhabdulus decoratus Deflandre, 1959
Micula decussata Vekshina, 1959 — Pl. 5, Fig. 4

Neocrepidolithus sp.
Placozygus fibuliformis (Reinhardt, 1964) Hoffmann 1970 — Pl. 5, Fig. 2
Prediscosphaera bukryi (Perch-Nielsen, 1973) — Pl. 6, Fig. 1
Prediscosphaera cretacea (Arkhangelsky, 1912) Gartner, 1968 — Pl. 1, Fig. 2; Pl. 6, Fig. 2
Reinhardtites levis Prins and Sissingh *In:* Sissingh, 1977
Reinhardtites sp.
Rhagodiscus plebeius Perch-Nielsen, 1968
Stradneria limbicrassa Reinhardt, 1964 — Pl. 1, Fig. 2; Pl. 6, Fig. 3
Tranolithus exiguus Stover, 1966 — Pl. 4, Fig. 3
Tranolithus phacelosus Stover, 1966 — Pl. 4, Fig. 4
Vekshinella bochotnicae (Górka, 1957) Verbeek, 1977
Vekshinella crux (Deflandre *In:* Deflandre and Fert, 1954) Shafik and Stradner, 1971
Watznaueria barnesae (Black *In:* Black and Barnes, 1959) Perch-Nielsen, 1968 — Pl. 1, Figs 1—2, Pl. 3, Figs 2—3
Zygodiscus compactus Bukry, 1969

Age of the nannofossil assemblage

The nanno- and microfossils recycled into the Pliocene *Pecten* Conglomerate of Cockburn Island provide a paleontological record of the Upper Cretaceous strata in the James Ross Basin. For this reason the authors carried out the study of recycled calcareous nannoplankton and tried to determine their age. The incompleteness of coccolith assemblage makes this effort some difficult. However, the assemblage composition and the abundance of taxa in studied material make the biostratigraphical conclusion plausible.

Determination on the age of the recycled coccoliths from the *Pecten* Conglomerate is based on the stratigraphic distribution of calcareous nannoplankton in Upper Cretaceous sediments of the López de Bertodano Formation on Seymour Island (Huber *et al.* 1983, Concheyro *et al.* 1991) and in the circum-Antarctic and sub-Antarctic DSDP and ODP sites that contain the Upper Cretaceous strata (Wind and Wise 1983, Wise 1983, Pospichal and Wise 1990, Crux 1991, Watkins 1992).

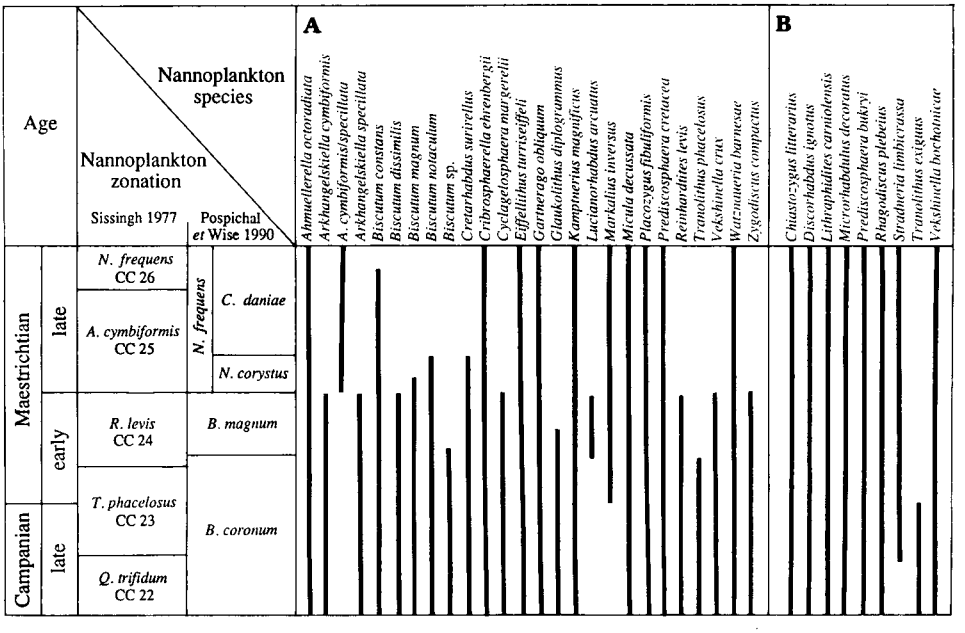
It is possible, that in the southern high-latitudes some nannofossil species occurred later (e.g. *Tranolithus phacelosus*) and others appeared earlier (e.g. *Markalius inversus*) than in other regions of the world.

The co-occurrence of: *Reinhardites levis, Tranolithus phacelosus, Biscutum dissimilis, B. magnum, B. notaculum* and *Markalius inversus* with the simultaneous lack of the genus *Nephrolithus* indicates the early Maestrichtian age of the studied assemblage (Table 1). That corresponds to the *Biscutum magnum* Zone in the Upper Cretaceous calcareous nannoplankton zonation for the Southern Ocean *sensu* Pospichal and Wise (1990), *see also* Huber and Watkins (1992, Fig. 4). Stratigraphic ranges of the remaining species (*see* Table 1) are concordant with this conclusion.

The exception is *Aspidolithus parcus expansus* found as a single specimen in the studied material. The last occurrence of this subspecies is in the lower

Table 1

Stratigraphic ranges of the nannofossils found as recycled forms in the *Pecten* Conglomerate of Cockburn Island: **A** – stratigraphic distribution in Antarctica (Weddell Sea, Maud Rise) *after* Pospichal and Wise (1990) and in sub-Antarctic region (Falkland Plateau) *after* Wise (1983), **B** – world ranges (*after* Perch-Nielsen 1985).



Campanian (Wise 1983). Although the presence of the other subspecies, *Aspidolithus parcus constrictus,* is also traditionally considered to be indicative of Campanian strata. Pospichal and Wise (1990) found it as a recycled form in the lower Maestrichtian sediments on Maud Rise, Weddell Sea (ODP Leg 113). *Aspidolithus parcus expansus* in the studied assemblage may also be precise as a recycled form in the lower Maestrichtian deposits. Watkins *et al. (in press)* have proposed new nannofossil zonation for the Southern Ocean. According to their recent compilation on stratigraphic ranges of coccolith taxa the studied recycled assemblage may be correlated with the late Campanian *Aspidolithus parcus expansus* Subzone of the *Biscutum coronum* Zone.

Concluding remarks

The provenance of the reworked Upper Cretaceous planktic assemblages (foraminifers along with calcareous nannofossils), which have been found in the *Pecten* Conglomerate of Cockburn Island, is probably from the Upper Cretaceous part of the López de Bertodano Formation (Marambio Group) in James Ross Basin, which crops out on James Ross, Vega, Humps, Cockburn, Seymour and Snow Hill islands (*cf.* Crame *et al.* 1991, Pirrie *et al.* 1992).

The recycled Campanian-Maestrichtian nannofossil assemblage in the *Pecten* Conglomerate presently provides the best paleontological record of this group of microfossils in the James Ross Island area. This assemblage is more abundant and diverse than any recovered from this area, and show some similarity to assemblages described by Huber *et al.* (1983) and Concheyro *et al.* (1991) from the Upper Cretaceous López de Bertodano Formation on adjacent Seymour Island. But the characteristic late Maestrichtian nannofossil species *Nephrolithus corystus* Wind, *N. frequens* Górka and *Braarudosphaera turbinea* Stradner recognized on Seymour Island (Huber *et al.* 1983) are absent from the studied recycled assemblage. The most common nannofossil species in the sediments of the López de Bertodano Formation on Seymour Island, *Braarudosphaera bigelowii* (*see* Huber *et al.* 1983, Concheyro *et al.* 1991) is also absent from the assemblage from Cockburn Island.

The studied nannofossil assemblage from Cockburn Island shares many features and is correlated with almost identical lower Maestrichtian assemblages from the southern high-latitude ODP sites: Maud Rise in Weddell Sea (Pospichal and Wise 1990) and Kerguelen Plateau in Australian Antarctic Basin (Watkins 1992).

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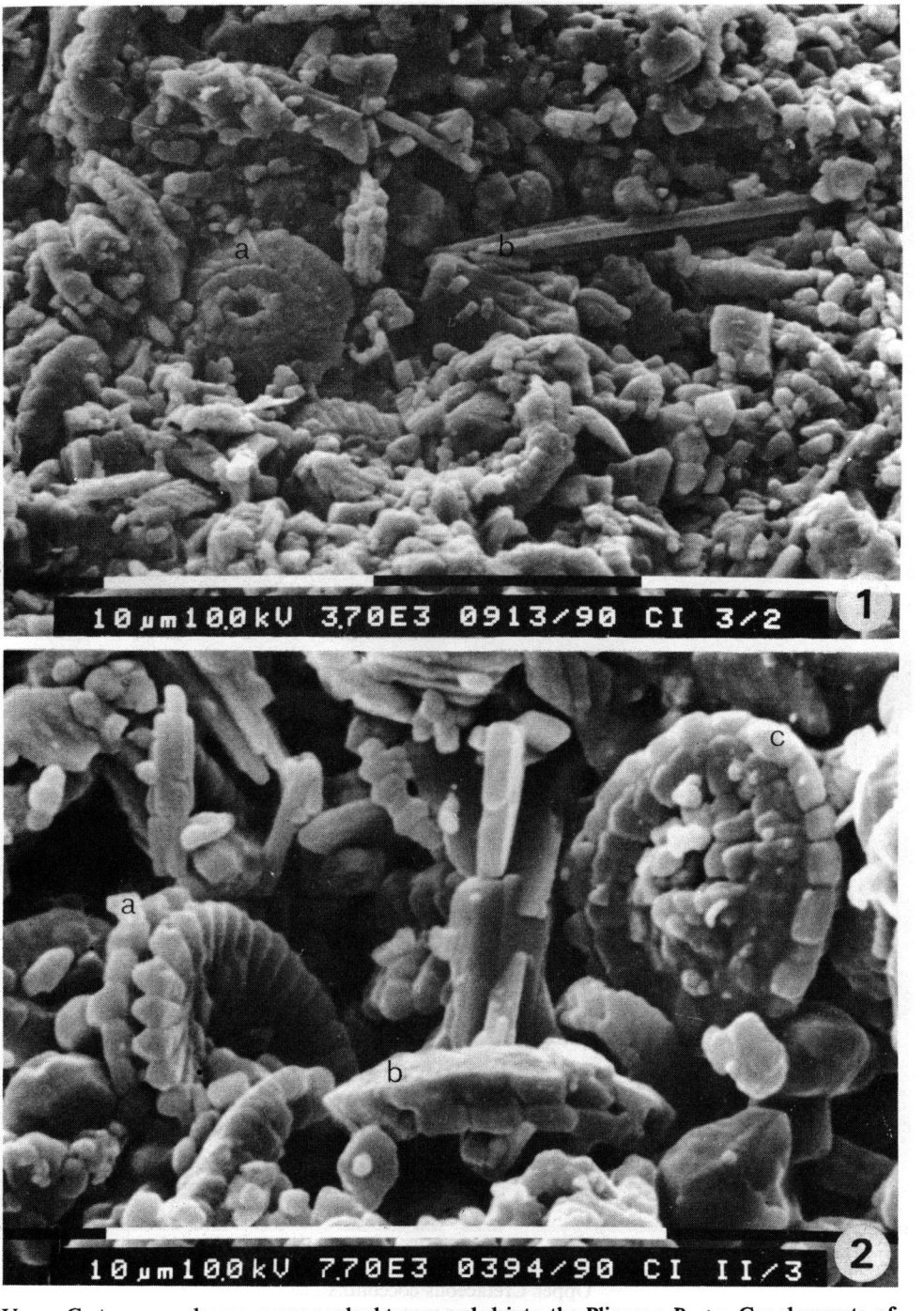
Streszczenie

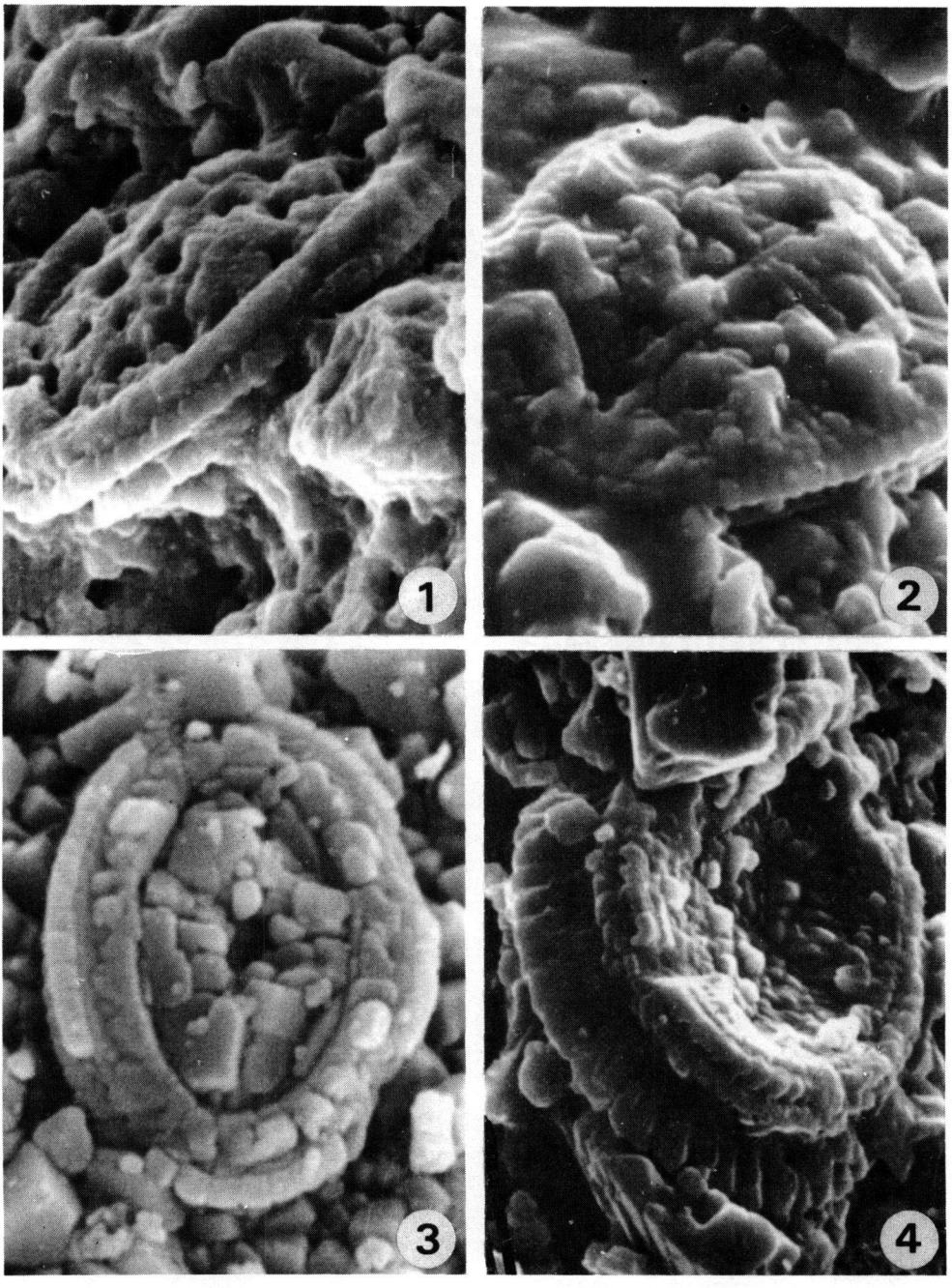
W plioceńskim zlepieńcu pektenowym Wyspy Cockburn położonej w pobliżu Półwyspu Antarktycznego (fig. 1—3) obok licznych makro- i mikroskamieniałości występujących *in situ*, stwierdzono obecność redeponowanego planktonu wapiennego (otwornice i nannoplankton) wieku górnokredowego. Nannoplankton wapienny zachowany jest na skorupkach otwornic planktonowych, z rodzajów *Heterohelix, Globigerinelloides, Hedbergella i Rugoglobigerina* (*zob.* fig. 4). Nannoplankton jest liczny i zróżnicowany pod względem taksonomicznym. Rozpoznano blisko 40 gatunków z których najliczniej reprezentowane są: *Arkhangelskiella cymbiformis, Cribrosphaerella ehrenbergii, Prediscosphaera cretacea, Kamptnerius magnificus* i *Watznaueria barnesae*, gatunki odporne na niszczenie chemiczne i mechaniczne (fig. 5, pl. 1—6). Określenie wieku redeponowanego zespołu planktonowego stwarza szereg trudności ze względu na możliwość eliminacji niektórych taksonów w czasie transportu lub wymieszanie flory kokkolitowej pochodzącej z utworów różnego

wieku. Jednakże obecność w zespole gatunków *Reinhardtites levis, Tranolithus phacelosus, Biscutum dissimilis, B. magnum, B. notaculum* oraz *Markalius inversus,* przy jednoczesnym braku rodzaju *Nephrolithus* pozwala wyciągnąć wniosek, że kokkolity te pochodzą z utworów dolnego mastrychtu. Zasięgi stratygraficzne pozostałych taksonów są w zasadzie zgodne z tym wnioskiem (*por.* tab. 1). Dobry stan zachowania kokkolitów wskazuje na stosunkowo krótki transport oraz pochodzenie ze słabo zdiagenezowanych osadów. Obszarem źródłowym redeponowanego planktonu mogły być górnokredowe utwory formacji López de Bertodano, grupy Marambio (Basen Jamesa Rossa).



Upper Cretaceous calcareous nannoplankton recycled into the Pliocene *Pecten* Conglomerate of Cockburn Island, Antarctic Peninsula

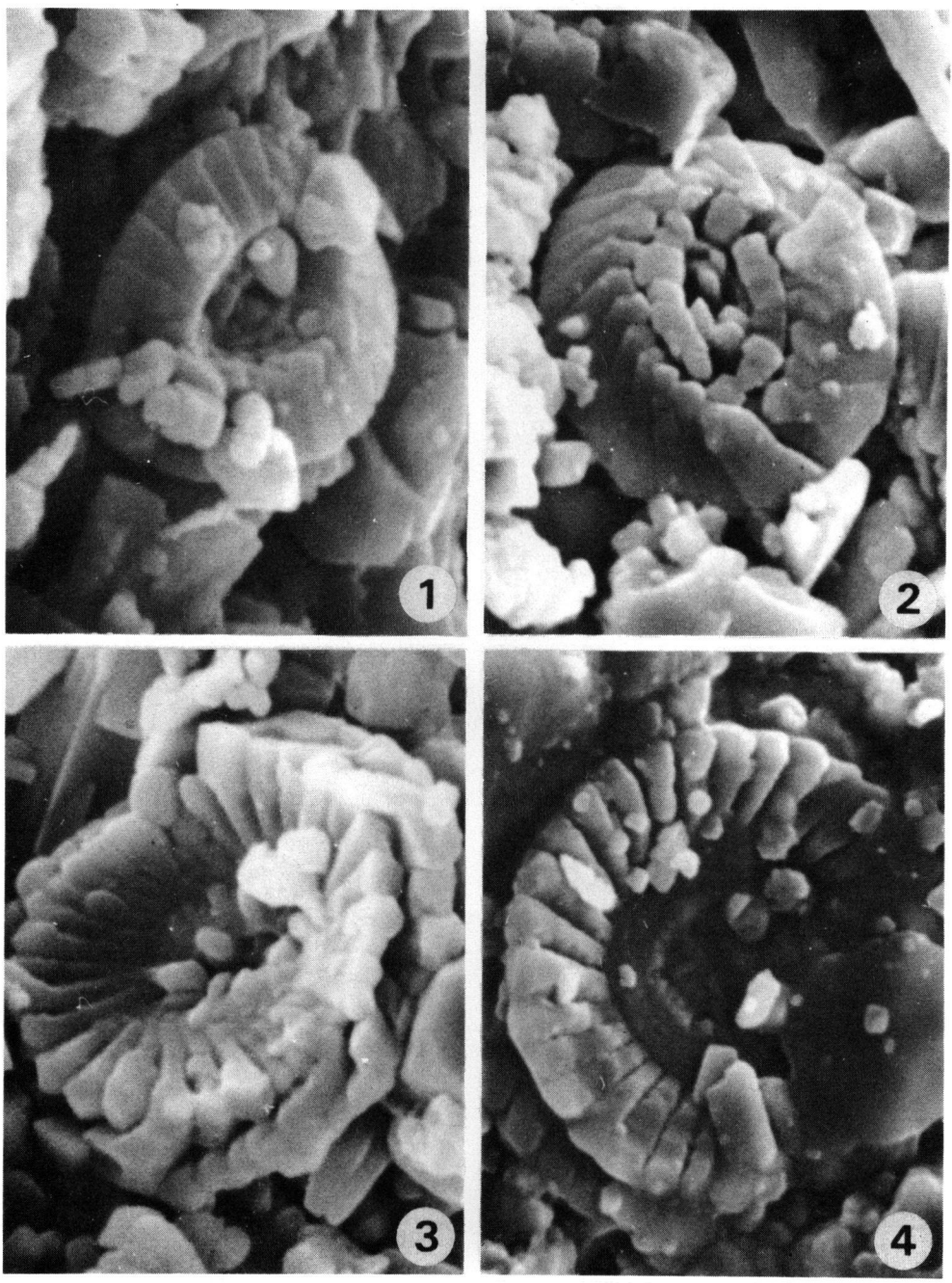
1. Coccolith assemblage of *Watznaueria barnesae* (Black) — **a,** and *Lithraphidites carniolensis* Deflandre — **b;** × 3700. 2. Coccolith assemblage of *Watznaueria barnesae* (Black) — **a,** *Predisco-sphaera cretacea* (Arkhangelsky) — **b,** and *Stradneria limbicrassa* Reinhardt — **c;** × 7700



Upper Cretaceous coccoliths

1. *Arkhangelskiella specillata* Vekshina, distal view; × 7400
2. *Arkhangelskiella cymbiformis* Vekshina, distal view; × 7400
3. *Aspidolitus parcus expansus* (Wise and Watkins), distal view; × 10 000
4. *Kamptnerius magnificus* Deflandre, proximal view; × 7700

Pecten Conglomerate, Cockburn Island



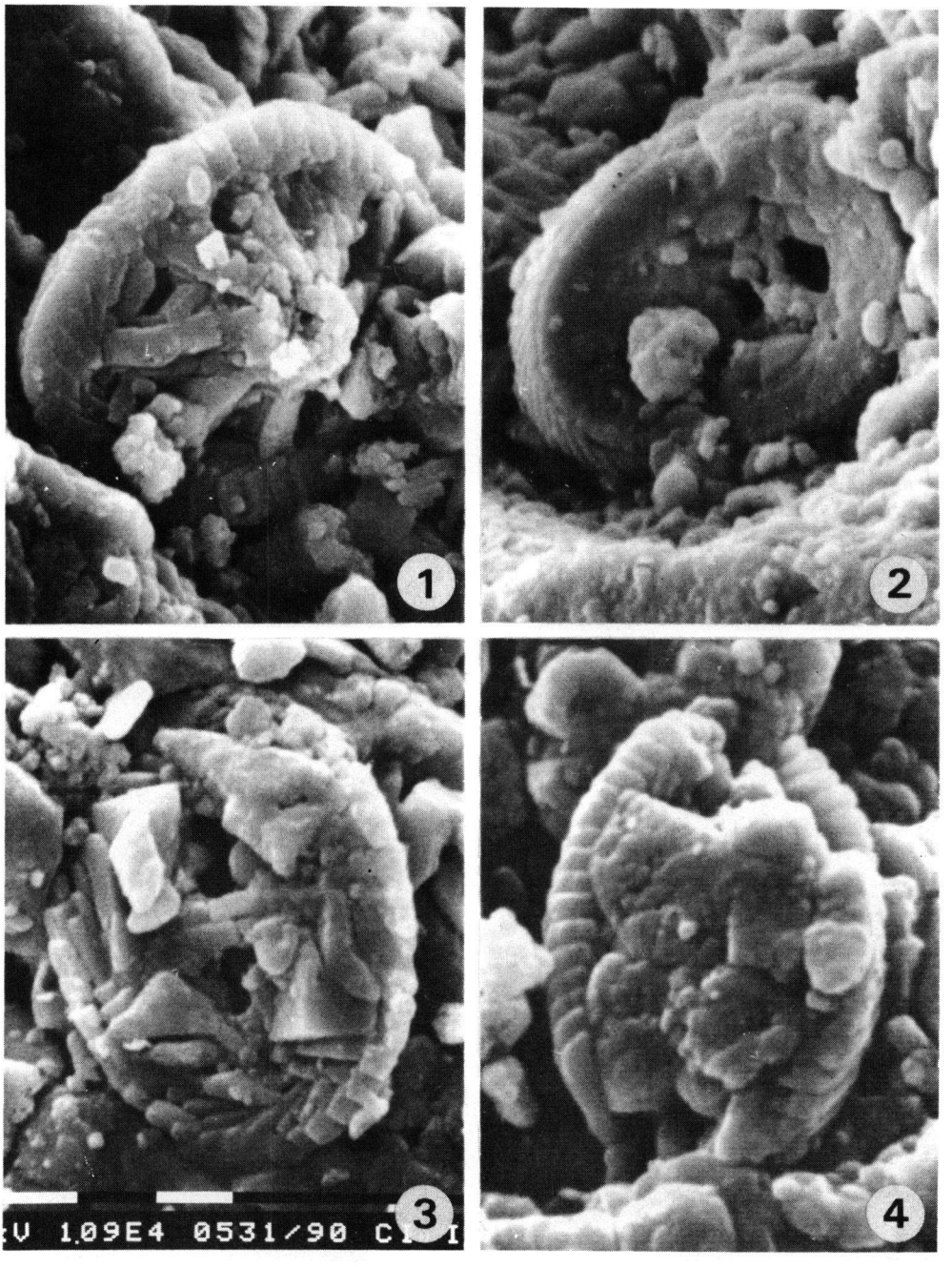
Upper Cretaceous coccoliths

1. *Biscutum constans* (Górka), distal view; × 13 000

2–3. *Watznaueria barnesae* (Black), 2 – distal view, 3 – proximal view; × 10 000

4. *Markalius inversus* (Deflandre), proximal view: × 8800

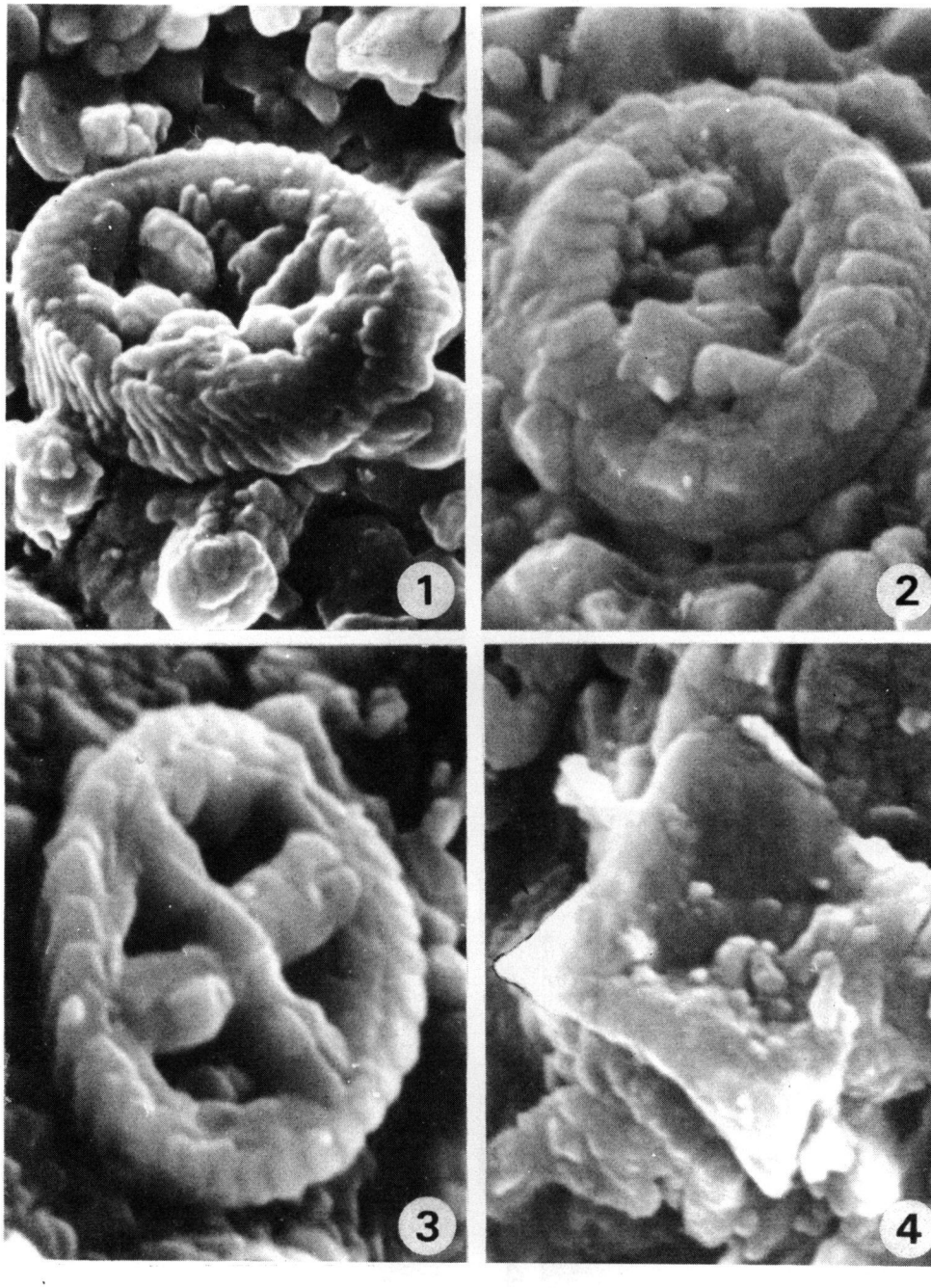
Pecten Conglomerate, Cockburn Island



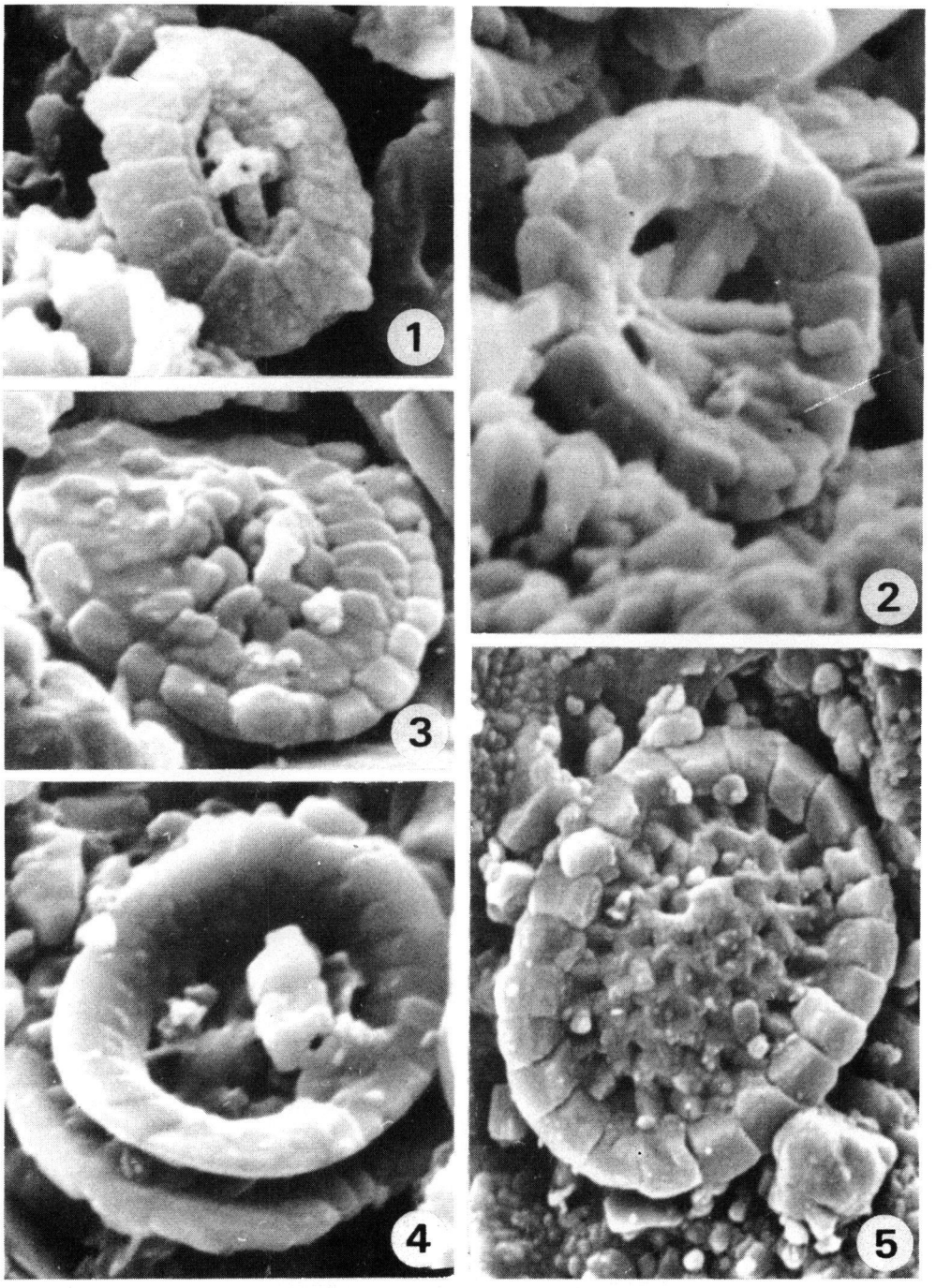
Upper Cretaceous coccoliths

1. *Ahmuellerella octoradiata* (Górka), distal view; × 10 000
2. *Eiffellithus turriseiffeli* (Deflandre), proximal view; × 6200
3. *Tranolithus exiguus* Stover, distal view; × 10 000
4. *Tranolithus phacelosus* Stover, distal view; × 10 000

Pecten Conglomerate, Cockburn Island



Upper Cretaceous coccoliths
1. *Helicolithus* sp., proximal view; × 10 000
2. *Placozygus fibuliformis* (Reinhardt), proximal view; × 13 000
3. *Chiastozygus litterarius* (Górka), distal view; × 15 000
4. *Micula decussata* Vekshina; × 14 000
Pecten Conglomerate, Cockburn Island



Upper Cretaceous coccoliths

1. *Prediscosphaera bukryi* Perch-Nielsen, distal view; × 15 000
2. *Prediscosphaera cretacea* (Arkhangelsky), proximal view; × 10 000
3. *Stradneria limbicrassa* Reinhardt, distal view; × 10 000
4. *Cretarhabdus* sp., proximal view; × 10 000
5. *Cribrosphaerella ehrenbergii* (Arkhangelsky), distal view; × 7400

Pecten Conglomerate, Cockburn Island