Lower Miocene Macrofossils from CRP-1 Drillhole, Cape Roberts (Victoria Land Basin, Antarctica)

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Abstract - Macrofossil content from the Miocene part of CRP-1 core, Cape Roberts (Victoria Land Basin) is scant and mostly limited to a few pectinid bivalves and serpulid polychaetes. Selective diagenesis has seriously affected the Miocene sediments, probably biasing the fossil legacy which is dominated by a reduced number of calcitic tests. Pectinid bivalves pertain to two different taxa ascribed to "*Chlamys*". The serpulid is an undescribed species which likely lived gregariously. The macrofauna may have lived at a relatively shallow depth in a siliciclastic shelf under conditions that were probably somewhat warmer than those in the present Ross Sea.
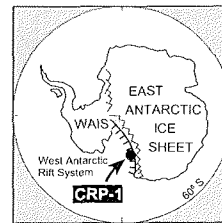
INTRODUCTION

Macrofossils are rare and sparse within the Miocene section of CRP-1 core, Cape Roberts (Victoria Land Basin) and have been observed from eleven levels in both unlithified and semilithified sediment, and within concretions (Fig. 1). The macrofossils recognized are entire or fragmented calcareous hard parts belonging to benthic bivalved molluscs, serpulid polychaetes, bryozoans and echinoids. Their preservation is highly variable, ranging from almost pristine to heavily recrystallized. Complete dissolution of skeletal material is documented by vugs and imprints. Macrofossils plainly visible in the sampling half-core normally have been removed and cleaned to assist determination. In one case, *i.e.* "*Chlamys*" sp. 1, from 62.19 metres below sea floor (mbsf), casts have been obtained from imprints left on the matrix surrounding the fossil for a better description of this important macrofossil.

The complete list of Miocene macrofossils from CRP-1 is as follows:
1 - 46.10 mbsf: serpulid polychaete tubes (concretion);
2 - 53.50 mbsf: echinoid spines;
3 - 59.58 mbsf: echinoid spines, bryozoan and unidentifiable (bivalve?) fragments;
4 - 62.19 mbsf: "*Chlamys*" sp. 1, echinoid spines;
5 - 62.34 mbsf: serpulid polychaete tube, ?"*Chlamys*" sp. 1 and dissolution vugs left after leaching of undetermined macroinvertebrates;
6 - 86.64 mbsf: serpulid polychaete tubes (semi-consolidated concretion);
7 - 95.08 mbsf: serpulid polychaete tube;
8 - 137.66 mbsf: "*Chlamys*" sp. 2 (imprint only);
9 - 138.82 mbsf: serpulid polychaete tubes, undetermined macrofossils (clast);
10 - 144.60 mbsf: echinoid spines;
11 - 145.92 mbsf: echinoid spines.

TAPHONOMY

The Miocene section has been affected by diagenetic processes, leading to significant carbonate dissolution (Baker & Fielding, this volume; Claps & Aghib, this volume). Thus, pectinids and serpulids are probably diagenetic relics since their exclusively or prevalently calcitic skeletons are quite durable with respect to other calcareous taxa. Strong selective dissolution is also supported by foraminiferal data (Strong & Webb, this volume). "*Chlamys*" sp. 1 from 62.19 mbsf is the only well preserved shell, since it still retains some aragonite in its shell, as shown by x-ray diffractometry (Taviani & Zahn, this volume). In places, however, even pectinid shells are completely dissolved ("*Chlamys*" sp. 2 from 137.66 mbsf), calling for extreme care in deriving environmental conditions for the Miocene part of CRP-1 based on absence of calcareous fossils.

It is worth mentioning the rare occurrence of serpulid-bearing calcareous concretions at different stages of lithification, which indicates significant recrystallization, accompanied by the formation of carbonate cements in vugs and fissures (Cape Roberts Science Team, 1998a).

Most macrofossils appear to have been influenced by post-mortem processes, such as displacement of serpulid tubes, which in most cases are roughly parallel to bedding (*i.e.*, not in life position). Pectinid shells (*e.g.* "*Chlamys*" sp. 1 from 62.19 mbsf) within poorly sorted diamictite are disarticulated, also indicating some degree of displacement.

TAXONOMIC NOTES

Phylum Mollusca
Class Bivalvia
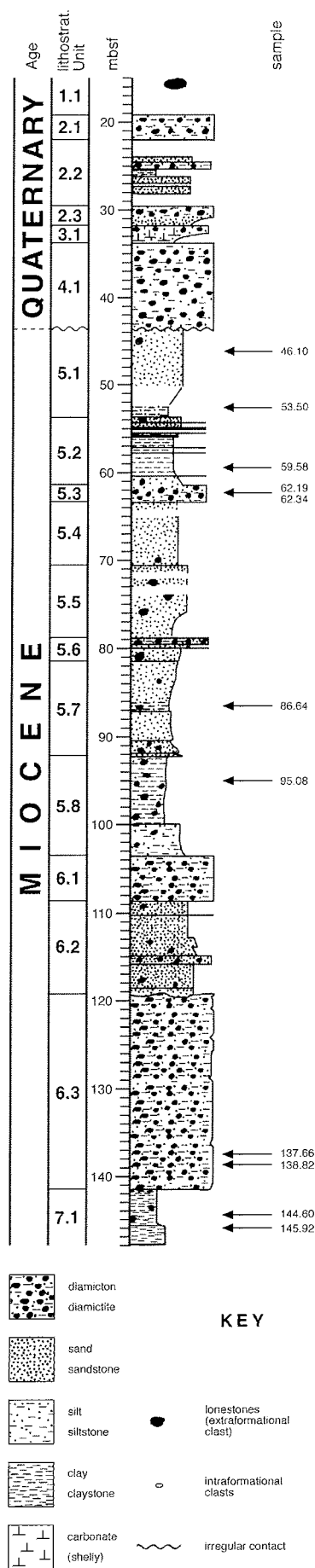Family Pectinidae
Genus *Chlamys*

Fig. 1 - Lithostratigraphic column (with lithostratigraphic subdivisions after Cape Roberts Science Team, 1998b), showing the position of Miocene macrofossils.

The bivalve fossils listed below are tentatively assigned to *Chlamys* Röding. The type species of this genus, *Chlamys islandica* (Müller, 1776), forms part of a species complex which probably originated in the northern Pacific during the Miocene; modern members of this complex currently live in the northern Atlantic and Pacific oceans (Waller, 1991).

The name *Chlamys* has been used for various similar species groups in other parts of the world, but as more details about their evolutionary history become available, such groups are now being assigned to separate genera (*e.g.* Waller, 1991; Beu, 1995). The Antarctic and sub-antarctic Pectinidae are at present the subject of taxonomic revision.

"*Chlamys*" sp. 1.

Three shelly pectinid fragments were recovered from 62.19 mbsf and recorded as "*Chlamys* (s.l.) sp." by the Cape Roberts Science Team (1998a). The largest and best preserved fragments measure 21.6 x 21.5 mm and 15.5 x 14.7 mm, and together represent the anteroventral disc part of a presumably left valve (Fig. 2); 14.2 mm of the anteroventral disc margin is preserved in the larger fragment. Estimated valve height of the complete shell is *c*. 50 mm. Shell thickness is *c*. 0.5 mm. The macrosculpture consists of radial, arcuate plicae which, along the disc margin, range in width between 0.8 and 1.8 mm. The plicae are relatively widely spaced, with interspaces 1.0 to 3.2 mm wide. Smaller-scale sculptural features are closely spaced commarginal frills and antimarginal ("*Camptonectes*") microsculpture (Figs. 3 & 4). Another fragment of 14.3 x 6.5 mm, with similar ribbing, has no visible microsculpture; this was used in Sr-isotope dating (Lavelle, this volume). X-ray diffractometry performed on a fragment of this scallop reveals that both aragonite and calcite contribute to its mineralogical composition (Taviani & Zahn, this volume).

The microsculptural characteristics are reminiscent of those of modern "*Chlamys*" *natans* (Philippi, 1845; syn. *Pecten vitreus* King & Broderip, 1831 [nom. inval. Art. 59b, International Code of Zoological Nomenclature: T.R. Waller, personal communication]) from southern South America, a moderately large species, with valve height of mature individuals exceeding 70 mm. Valves of about 50 mm high have 30-35 ribs. No estimate can be given for "*Chlamys*" sp. 1, but the comparatively narrower plicae and wider interspaces suggest a somewhat lower rib number.

Another fossil, apparently belonging to the same species group, was recovered from the Miocene section at DSDP Site 272 (Leg 28) in the Ross Sea, and designated "*Chlamys* (*sensu lato*) n. sp. aff. *natans* (Philippi)" by Dell & Fleming (1975). Microsculptural details were said not to be preserved on this fossil, but re-examination revealed microsculpture similar to that of "*Chlamys*" *natans*, and to that "*Chlamys*" sp. 1 in particular. As far as can be judged from the single, incomplete left valve, of which the beak part is missing and which is estimated to be only about 30 mm high, the chief difference between the DSDP fossil and "*Chlamys*" *natans* appears to be the smooth posterior disc flank of the fossil. As the dorsal portion of "*Chlamys*" sp. 1 is missing, full sculptural details of this fossil are not
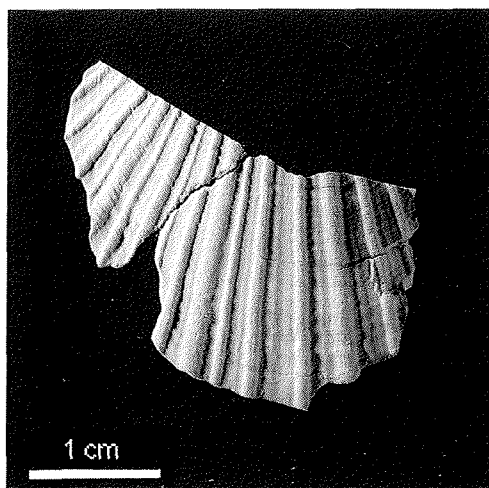
Fig. 2 - External shell surface of *"Chlamys"* sp. 1 from 62.19 mbsf. Ventral is towards the bottom of the photo. Specimen coated with ammonium chloride.
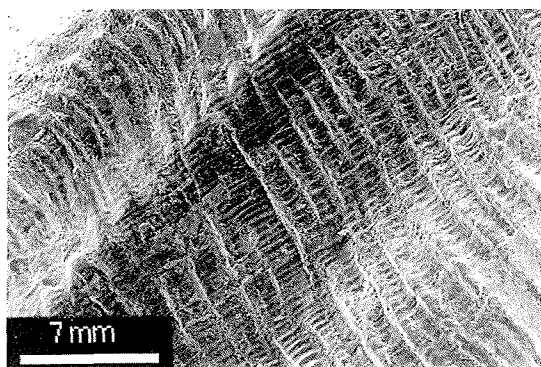

Fig. 3 - SEM micrograph showing parts of two plicae in anteroventral part of the disc of *"Chlamys"* sp. 1 (same specimen as in Fig. 1), and rib interspace with well-developed commarginal growth ridges and antimarginal microsculpture. Disc margin is to the lower left.
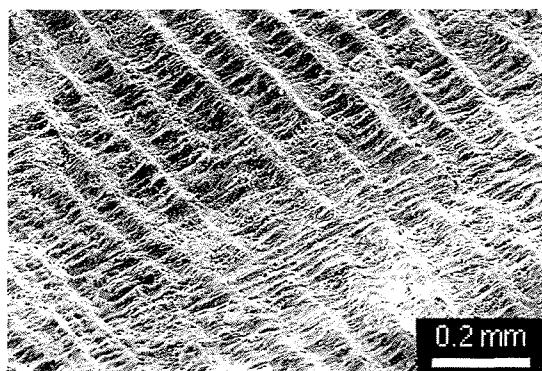

Fig. 4 - Detail of growth ridgelets and antimarginal microsculpture of *"Chlamys"* sp. 1 (same specimen as in Figs. 1 & 2). Disc margin is to the upper right.

known and thus it is uncertain whether both Miocene fossils are conspecific.

"Chlamys" sp. 1 differs from Antarctic *Zygochlamys* in ribbing pattern: interspaces of the latter are entirely occupied by secondary (and occasionally tertiary) ribs. In addition, the prominent (in well-preserved specimens scaly) growth ridges are comparatively widely spaced in

the Antarctic *Zygochlamys* species, and antimarginal microsculpture is usually not visible.

Growth ridgelets and antimarginal microsculpture somewhat similar to that of the *"Chlamys" natans* group are also present in the Antarctic scallop *Adamussium colbecki* (Smith, 1902). However, that species differs in shell shape, is much thinner-shelled, and its auricles are totally dissimilar to those of *"Chlamys" natans*. *Adamussium* does not seem to be closely related to the *"Chlamys" natans* species group.

"Chlamys" sp. 2

Two small areas on pieces of silty mudstone from 137.66 mbsf, measuring about 9.1 x 3.5 mm and 8.7 x 4.2 mm, bear imprints of closely spaced ribs, which in all probability belong to a pectinid bivalve here tentatively assigned to *"Chlamys"*. Shell material was not preserved and the imprints show no microsculpture. These fossils differ from *"Chlamys"* sp. 1 by their closely set, narrow ribs, which are all *c*. 0.7 mm wide, and similarly narrow interspaces. In these respects they bear some resemblance to an undescribed scallop which occurs in abundance in the Polonez Cove Formation on King George Island, South Shetland Islands (Jonkers, 1998a). The age of this deposit is probably Oligocene (*c*. 30 Ma; Dingle et al., 1997), although an age range straddling the Oligocene-Miocene boundary (24-21 Ma) has recently been suggested by Smellie et al. (1998).

Phylum Annelida
Class Polychaeta
Family Serpulidae

Calcareous worm tubes belonging to an undetermined serpulid polychaete represent the most common macrofossil in the Miocene section of the core (Cape Roberts Science Team, 1998a). The tubes are thin-walled, conical, straight or slightly curved (Fig. 5). A distinct annular ornamentation (growth stages?) is obvious in the few, well-preserved specimens (Figs. 5 & 6). These tubes are circular in section, although some of them show a variable degree of compression and fragmentation. The largest tube is 17 mm in length, 2.5 mm in width and 0.1 mm in thickness (46.10 mbsf). Most tubes are filled with sediment that is in places finer than the surrounding matrix. With a few exceptions, hollow tubes within concretions are almost invariably recrystallized by a late carbonate cement.

It is likely that the CRP-1 taxon represents an undescribed species but in consideration of the difficulty in establishing a solid taxonomy based on calcareous tubes, we prefer at present to leave the nomenclature open even at generic level.

BIOGEOGRAPHICAL ASPECTS AND PALAEOENVIRONMENTAL IMPLICATIONS

Pectinids. Current knowledge of Antarctic Miocene scallops is very limited, which is partly due to the lack of
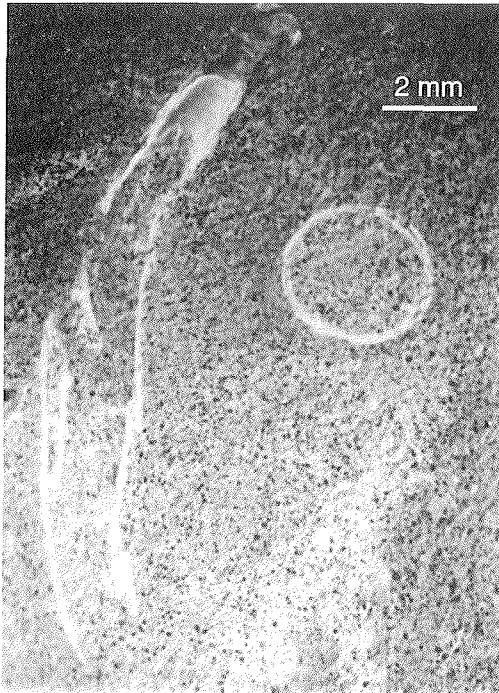
Fig. 5 - The largest serpulid tube (1.7 cm) recovered in CRP1 (46.10 mbsf): note filling by fine-grained sediment and recrystallization accompanied by precipitation of carbonate cement.
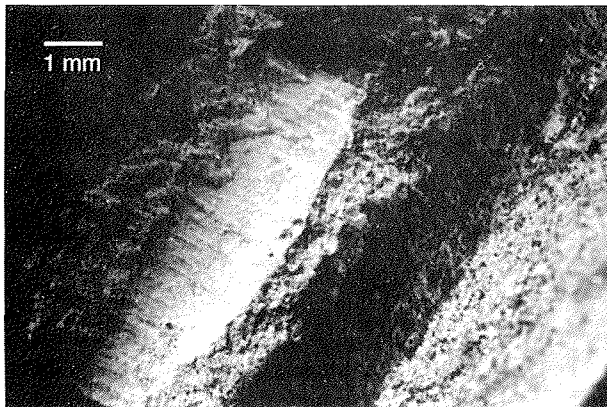

Fig. 6 - Serpulid tube showing annular ornamentation (62.34 mbsf).

suitable deposits of that period in outcrop and to poor recovery from drill cores; thus far only three taxa have been reported in the literature. The lower Miocene Cape Melville Formation on King George Island, dated at 20-23 Ma (earliest Miocene; Birkenmajer et al., 1985; Dingle & Lavelle, 1998), has yielded *Adamussium*? n. sp. of Beu & Dell (1989) (see Jonkers, 1998a), originally described from the Oligocene section of the CIROS-1 core, McMurdo Sound (Beu & Dell, 1989). No costate *Adamussium* are as yet known from the Miocene; the oldest-known Neogene costate representative, very similar to *A. colbecki*, occurs in the upper Pliocene Cockburn Island Formation on Cockburn Island, James Ross Island group (Jonkers, 1998b), and is c. 3 Ma old (Jonkers & Kelley, 1998). Thus, there is a huge time gap between the occurrences of *Adamussium* and its putative, non-costate ancestor, but it

may well be that the range of true *Adamussium* extends much further back in time, and that moulds or imprints of the wafer-thin shells (which themselves have a low preservation potential) in earlier Pliocene and Miocene deposits have escaped the attention of geologists in the field. *Adamussium colbecki* is the only surviving member of the Pectinidae in Antarctic waters.

The second Miocene taxon, which might be conspecific with "*Chlamys*" sp. 1, is the scallop allied by Dell & Fleming (1975) to "*Chlamys*" *natans*, a species now restricted to the Magellan region of South America (Waloszek, 1984). These authors identified further Miocene molluscs from the Ross Sea that have taxonomic affinities with species in the modern fauna of South America. Neogene representatives of this group of pectinids are not as yet known from the incomplete fossil record of South America, nor have they been reported from New Zealand (Beu & Maxwell, 1990), or from pre-Neogene rocks in Antarctica (*cf.* Stilwell & Zinsmeister, 1992).

The youngest Miocene Antarctic scallops, possibly conspecific with the Pliocene *Zygochlamys anderssoni* (Hennig, 1911), only appear first in upper Miocene conglomerates of the Hobbs Glacier Formation on James Ross Island, Sr-dated at about 10 Ma (Jonkers, 1998a). The genus most likely originated in South America, with its earliest members appearing there during the late Eocene-early Oligocene (Waller, 1991; Beu, 1995). *Zygochlamys* became extinct in Antarctica in late Pliocene times (around 2.4-2.5 Ma; Jonkers, 1998a), but extant species are found living off southern South America and New Zealand.

The palaeoclimatic implications of Antarctic fossil pectinids are somewhat equivocal. Since *Chlamys*-like taxa are absent from today's Southern Ocean south of the Antarctic Convergence, their presence in Antarctic Neogene deposits has been interpreted to indicate past climates that were milder than at present (*e.g.* Speden, 1962). However, accumulating evidence now suggests that such taxa thrived equally under glacial conditions. For example, abundant representatives of *Zygochlamys* are found in close association with diamictites on James Ross Island (Jonkers, 1998a). Conversely, costate *Adamussium*, now living in waters often covered by multi-year sea ice (Berkman, 1994), and possibly even under shelf ice (Hain & Melles, 1994), also occur in the interglacial Pliocene Cockburn Island Formation, together with faunal elements indicative of water temperatures higher than those of today (Jonkers, 1998b). Thus, it may well be that the distribution of the various scallop species was primarily governed by environmental factors other than temperature, such as food availability and substrate. The genus *Laternula*, with *L. elliptica* (King & Broderip, 1831) being one of the most ubiquitous species around Antarctica (Powell, 1965), and with several species in Australia and the tropical Indo-Pacific (Dell, 1972), is another example of a group of bivalves for which water temperature does not seem to be the principal factor for its survival; similar to Antarctic *Chlamys*-like Pectinidae, the genus has inhabited a variety of palaeoenvironments in the Antarctic since the Oligocene (unpublished data).

The Miocene CRP-1 pectinid material is inadequate to make any pertinent statements on the species' lifestyle.

"*Chlamys*" *natans*, possibly allied to "*Chlamys*" sp. 1, is normally associated with fjords that have a glacier flowing out into them; juveniles of this species live in kelp beds (L. Guzmán, personal communication). However, more complete shells are required to assess the palaeoecology of the Miocene scallop. The oxygen stable isotope composition of the shell of "*Chlamys*" sp. 1 seems to rule out true polar conditions (*i.e.*, frigid ambient temperature and dry climate), suggesting instead somewhat milder and wetter environmental conditions at the time of deposition (Taviani & Zahn, this volume).

Serpulids. The Miocene serpulid from CRP-1 does not appear to have analogy with any present-day worm tube of the Antarctic region (*e.g.* Hartmann, 1966; Knox & Cameron, 1998). Tertiary serpulids have been recorded from various oucrops in Antarctica (*e.g.* Ball, 1960; Gaździcki & Pugaczewska, 1984; Macellari, 1984; Karckewski, 1987), but the CRP-1 taxon shows instead some affinity with the Miocene worm tubes reported by Dell & Fleming (1975) from DSDP Site 270.

Judging from the recurrence of clusters of individuals, this unattached species appears to have been gregarious in life. The rare occurrence of mud within some tubes found in concretions in silty-sandy matrix, and no longer in life position, is taken as a possible indication that this species settled on fine-grained bottoms enriched in organic matter, perhaps in turbid waters.

CONCLUSIONS

All recognizable macrofossils are marine invertebrates belonging to extinct taxa, thus palaeoenvironmental deductions are necessarily highly speculative. Nevertheless, macrofaunas seem to be indicative of silted shelf environments with estimated depths shallower than 100 m, possibly in the range of 20-80 m. Input of siliciclastic particles may have been very high at times, as suggested by the dominance of gregarious serpulid worms, by analogy with some Recent environments characterized by similar worm-tube assemblages (*e.g.* Hong, 1984; Gambi, 1986; ten Howe & Smith, 1990).

The scant macrofauna seems to be homogeneous throughout the core, a possible indication that the lower Miocene section represents a relatively short time span during which environmental parameters in an open, shallow-marine highly silted shelf setting did not change much. Clastic input may have been the predominant environmental variable. Shelf ice was likely absent and palaeotemperatures could have been somewhat higher than today's, but glacial influence was still much in evidence, as indicated by the abundance of ice-rafted material throughout the cored interval.

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