

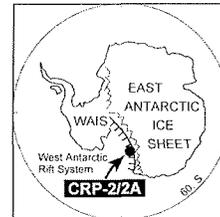
Ostracoda from CRP-1 and CRP-2/2A, Victoria Land Basin, Antarctica

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Abstract - Sparse, poorly preserved late Oligocene (3 species) and early Miocene (4 species) ostracod faunas have been recovered from CRP-2A, while relatively more abundant Quaternary faunas occur in CRP-1 (24 species). All taxa are marine. No definitive age assignments can be made on the two older faunas, which are not considered to be *in situ*, although the taxa identified are not at variance with sediment ages determined on other grounds. The Oligocene ostracods (Lithostratigraphical Unit, LSU 9.4) suggest deposition in cold, relatively shallow, shelf waters with faunal connections to the Antarctic Peninsula and South America, while the Miocene fauna (LSU 5.1) is considered to be a cool-cold, deeper water (?outer shelf) association with faunal connections to both New Zealand and the Antarctic Peninsula. The Quaternary faunas are primarily from LSU 3.1 (carbonate-rich layer), and suggest deposition in very cold, relatively quiet water that was at least 100 m, and possibly 130-200 m deep. None of the taxa are known from pre-Pleistocene sediments, and all occur in modern Antarctic/sub-Antarctic regimes, predominantly from south of 60° S. Specimens in the "carbonate-rich layer" probably have suffered minor penecontemporaneous fractionation, while the fauna in LSU 2.2 has suffered more extensive post-mortem transportation and possible reworking (though not necessarily from pre-Quaternary sources).



INTRODUCTION

Ostracod-bearing sediments have been encountered in boreholes completed by the Cape Roberts Project: CRP-1 (77.008° S, 163.755° E) and CRP-2A (77.006° S, 163.719° E) (Cape Roberts Science Team, 1998a, 1998b, 1999). Both sites lie in ~150-170 m of water, approximately 16 km SW of Cape Roberts on the McMurdo Sound side of the Ross Sea, Antarctica. In CRP-1, the sequence consisted of Quaternary and early Miocene glacial sediments, from which relatively abundant ostracods were recovered from two lithostratigraphical units in the Quaternary strata (LSU 2.2 and 3.1). In CRP-2A, the sequence consisted of Quaternary glacial sediments overlying an early Miocene to early Oligocene glacial succession from which a sparse ostracod fauna was extracted from LSU 5.1 and 6.3 (early Miocene) and LSU 8.4 to 9.7 (late Oligocene). In this publication, palaeoenvironmental aspects of the faunas will be dealt with, while a full taxonomic account will be published elsewhere. Specific points relating to the taxonomy and distribution of particular species are given under "Notes on Palaeobiology". Ages used here follow those assigned by Cape Roberts Science Team (1998b, 1999) for the two CRP boreholes.

LATE OLIGOCENE AND EARLY MIOCENE OSTRACOD FAUNAS OF CRP-2A

A total of 21 valves of marine, podocypid ostracods plus some indeterminate fragments, representing eight species from seven genera were recovered from the following nine levels of CRP-2A: early Miocene - LSU 5.1

(56.61-56.67, 64.67-64.75, 71.13-71.22 mbsf) and LSU 6.3 (96.79-96.84 mbsf); late Oligocene - LSU 8.4 (171.04-171.12 mbsf), LSU 9.4 (209.72-209.80 and 215.60-215.68 mbsf), LSU 9.5 (231.72-231.80 mbsf) and LSU 9.7 (260.04-260.18 mbsf) (Tab. 1). In contrast, no ostracods were reported from the early Miocene sediments of CRP-1 (Webb & Strong, 1998a).

Ostracods were recovered by Dr C.P. Strong (IGNS) during his examination of the foraminifera. Distribution of the samples in the CRP-2A borehole is shown in figure 1. Neither unwashed samples nor unpicked residues were seen by the present author.

REGIONAL COMPARATIVE DATA BASE

A selection of relevant studies from the area of the Southern Ocean which allows comparisons with the CRP-2A early Miocene - late Oligocene faunas includes: southern Australia and New Zealand (Swanson, 1969; McKenzie, 1974; Whatley & Downing, 1983; Ayress & Swanson, 1991; McKenzie et al., 1991, 1993; Ayress, 1993; Neil, 1994), Argentina (Echevarria, 1982, 1987a, 1987b, 1988, 1991a, 1991b, 1995; Kielbowicz, 1988; Wood et al., 1999), and the Antarctic Peninsula (Blaszyk, 1987; Szczechura & Blaszyk, 1996). In addition, publications cited in the section dealing with the Quaternary faunas provide further background data on stratigraphical ranges and comparative palaeoecology.

STRATIGRAPHICAL DISTRIBUTION OF SPECIES

Overall, ostracods in CRP-2A are sparse and only moderately- to poorly-preserved, with only one individual

Tab. 1 - Early Miocene and late Oligocene ostracods, CRP-2A.

			Early Miocene				Late Oligocene					
			LSU:	5.1	6.3	8.4	9.3	9.4	9.5	9.7		
			mbsf:	56.61	64.67	71.13	96.79	171.04	209.72	215.60	231.72	260.04
<i>Clinocythereis</i>	cf. <i>C. australis</i>	Ayress & Swanson 1991	2	2	2							
<i>Hemicytheridea</i>	aff. <i>H. kinggeorgeensis</i>	Blaszyk 1987						2				
<i>Orionina</i> ?	cf. <i>O.</i> sp.	Echevarria 1988						1				
<i>Munseyella</i>	sp. 4607 (= <i>Cusmanidea</i> sp.)	(Echevarria 1991)			3							
<i>Nodoconcha</i>	aff. <i>N. minuta</i>	Hartmann 1989			2							
Indet. Gen. & sp.							2					
<i>Copytus</i>	sp. 4631 aff. <i>C. malumiani</i>	Echevarria 1987						2				
<i>Copytus</i> ?	sp. 4628				4							
Indet. fragments						x				x		x
No. valves:			2	2	11		2	2	3			

assemblage amounting to more than 10 valves (LSU 5.1, 71.13 mbsf). The specimens are predominantly carapaces of relatively robust taxa, which are opaque and re-mineralised with brown-coloured staining. The very limited number of specimens renders any assessment of the palaeobiology of individual horizons speculative, but nevertheless the total fauna presents some interesting features. Details of the lithology of the various lithostratigraphical units are taken from Cape Roberts Science Team (1999).

Lithostratigraphical Unit 9.7 (250.40-262.90 mbsf)

Lithology. Dark greenish grey, weakly laminated, poorly-sorted sandy mudstone above 252.30 mbsf and massive, weakly stratified to moderately bioturbated mudstone to base. Fossiliferous below 254.00 mbsf.

Ostracoda. Contains only indeterminate fragments of ostracods at 260.04 mbsf.

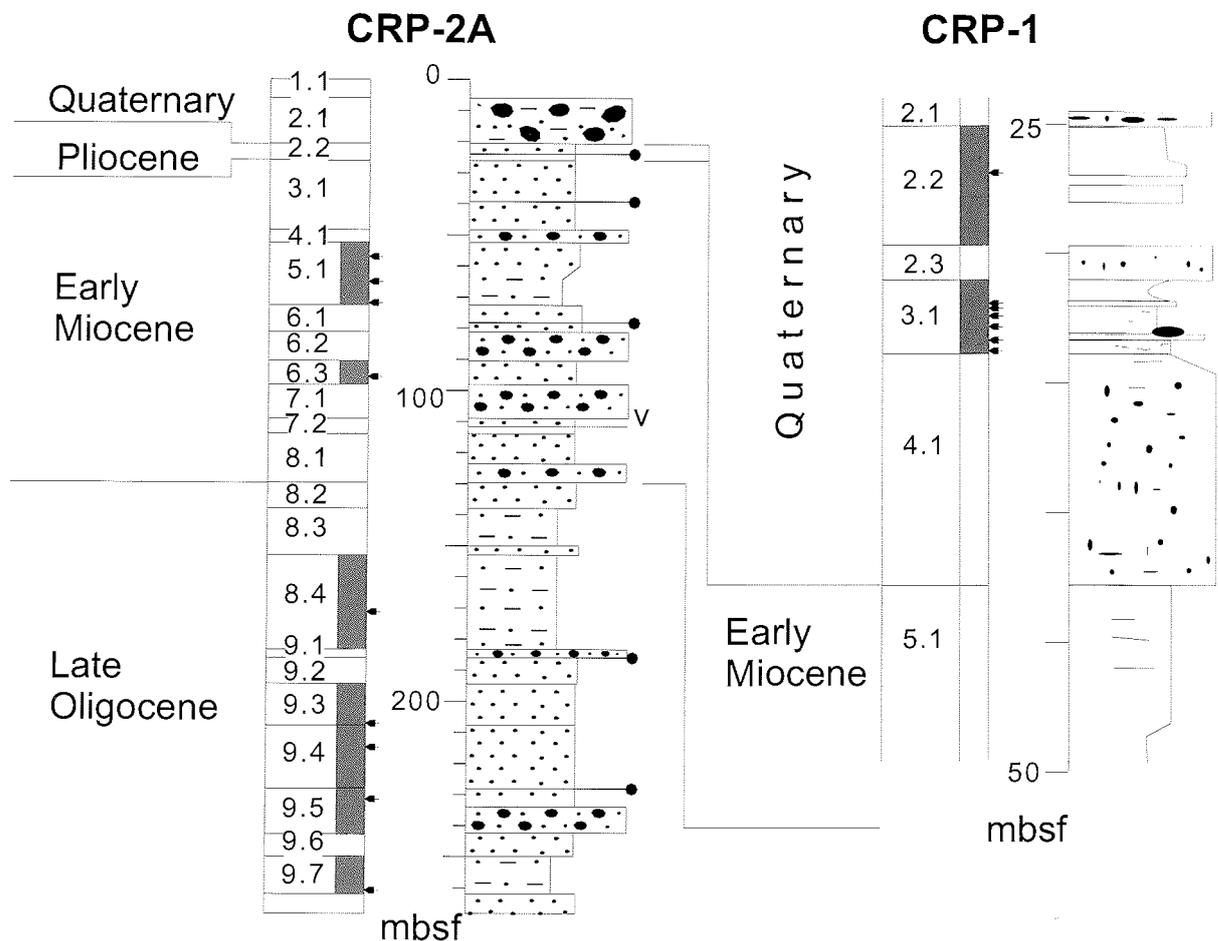


Fig. 1 - Distribution of ostracod-bearing samples in the CRP-1 and CRP-2A boreholes, Cape Roberts. Ages and lithostratigraphic units are taken from Cape Roberts Science Team (1998b, 1999), and the lithological sketches were supplied by M Lavelle, a member of the Cape Roberts Science Team. Lithostratigraphic units in which ostracod-bearing strata occur are shaded, while sample horizons are indicated by small arrows.

Lithostratigraphical Unit 9.5 (227.33-242.70 mbsf)

Lithology. Dark greenish grey, fine sediments: a muddy, fine, sandstone lying between two clast-poor, muddy (upper) and sandy (lower) diamictites.

Ostracoda. Contains only indeterminate fragments of ostracods at 231.72 mbsf.

Lithostratigraphical Unit 9.4 (207.76-227.33 mbsf)

Lithology. Dark greenish grey, fine muddy sandstone. Shelly fossils and fragments are relatively common, and the unit is bioturbated.

Ostracoda. Sample 215.60 mbsf contains two species, neither of which was encountered at other levels in CRP-2A. *Hemicytheridea* aff. *H. kinggeorgeensis* Blaszyk is a large and relatively well-preserved carapace whose only close relative is from the Polonez Cove Formation on King George Island in the northern Antarctic Peninsula (Blaszyk, 1987). The other species is a fragmentary carapace (probably a juvenile) which has some affinities with a Pliocene form described by Echevarria (1988) from Rio Negro Province of Argentina (*Orionina?* sp. Echevarria), although preservation is inadequate to take the comparison further. One carapace of *Copytus* sp. 4631 sp. nov. occurs at 209.72 mbsf. The genus *Copytus* has been widely reported from Cenozoic strata of South America, Antarctica, southern Australia, and New Zealand, but the shape of the anterior area and length/height ratio suggest that this specimen is closest to *C. aff. malumiani* Echevarria from southern Argentina.

Lithostratigraphical Unit 8.4 (153.39-183.85 mbsf)

Lithology. An olive-grey, massive to weakly laminated mudstone, above 163.03 mbsf interbedded with thin fine to medium sandstones. Sparsely fossiliferous throughout, including pteropods and serpulid tubes.

Ostracoda. One indeterminate carapace with heavy matrix cover at 171.04 mbsf.

Lithostratigraphical Unit 6.3 (90.67-96.85 mbsf)

Lithology. Massive, poorly-sorted, fine to medium sand interstratified with well-sorted fine sand above 92.42 mbsf, overlying interbedded massive medium to coarse sand, massive muddy, fine sand, and very fine sandstone. Overall, LSU 6.3 is sparsely fossiliferous with shell fragments distributed throughout.

Ostracoda. Contains only indeterminate fragments of ostracods at 96.79 mbsf.

Lithostratigraphical Unit 5.1 (52.36-72.84 mbsf)

Lithology. A black coloured unit with low abundances of clasts and shell fragments. It gradually fines down-core from a muddy, very fine sandstone with fine sandstone laminae above 57.33 mbsf, through a very fine sandy mudstone above 59.00 mbsf, to a massive mudstone with a few thin, fine sandstone beds to the base.

Ostracoda. The ostracods in LSU 5.1 are somewhat

better-preserved and represent a marginally more-diverse fauna than that of the underlying late Oligocene sediments of LSU 8.4 to 9.7. Three samples are ostracod-bearing and a carapace of *Clinocythereis* cf. *C. australis* Ayress & Swanson (= sp. 4626) was recorded from each. This is probably a new species, but its close relative is from New Zealand, western Australia and the adjacent oceans (Ayress & Swanson, 1991). The lowermost sample (71.13 mbsf) contains three additional species, one of which (*Munseyella* sp.) has a close relative from the Late Oligocene of southern Argentina (= *Cushmanidea* sp. Echevarria, 1991b). *Nodoconcha* aff. *N. minuta* Hartmann is probably a new species, but is very close to Hartmann's (1989b) taxon that occurs in the Quaternary LSU 3.1 of CRP-1, and which also occurs in modern Antarctic Peninsula faunas and in the Pleistocene Taylor Formation of Ross Island (Briggs, 1978). The third species is *Copytus* sp. 4628 sp. nov., which has a different lateral outline to a further species of the genus found in LSU 9.4. None of the species from LSU 5.1 is recorded from the underlying strata of CRP-2A.

AGE

The faunas are too sparse to be of significant value in determining the ages of the various lithostratigraphical units from CRP-2A, but some indications can be gleaned by comparisons with the Southern Ocean area and the Antarctic Peninsula.

Lithostratigraphical Unit 9.4 has been interpreted as part of a "highstand systems tract" (Sequence 10 of Cape Roberts Science Team, 1999), and it contains two species which allow a level of speculation on its age. Taken at face value, the presence of *Hemicytheridea* aff. *H. kinggeorgeensis* suggests a correlation with the early Oligocene Polonez Cove Formation of King George Island (Blaszyk, 1987). Species of *Copytus* are not well-defined from the South America-Antarctic region, and the preservation of the CRP-2A material does not allow a more accurate diagnosis than an affinity with *C. malumiani*. The latter has a range of late Oligocene to early (possibly late) Miocene in Argentina (Kielbowicz, 1988; Echevarria, 1991b). Together, these records suggest that LSU 9.4 of Sequence 10, or sediments from which it was derived, is late Palaeogene - early Neogene in age.

The fauna of LSU 5.1 consists of four species, three of which have some age connotations. *Clinocythereis* cf. *C. australis* Ayress & Swanson (1991) (a monospecific genus) has been recorded from the late Eocene to Recent of Australia and New Zealand, but significantly, two morphotypes which Ayress & Swanson (1991) suggest may represent a separate species, and which are very similar to the material from CRP-2A, have, to date, been recorded only from the Lower Miocene of South Island, New Zealand. *Munseyella* sp. 4607 is closest to *Cushmanidea* sp. Echevarria (1991b), which has a reported age range of late Oligocene to Pliocene in southern Argentina. The most distinctive species, *Nodoconcha* aff. *N. minuta* Hartmann (1989) has been recorded only from the Recent and Pleistocene of Antarctica, and there is no

record of any similar species from the Cenozoic of southern Australasia or South America (e.g. Wood et al., 1999). The presence of *Clinocythereis* cf. *C. australis* and *Munseyella* sp. 4607 are suggestive of a late Palaeogene - early Neogene age for LSU 5.1, or for sediments from which it was sourced.

Cape Roberts Science Team (1999) suggested an early Miocene age for LSU 5.1 and a late Oligocene age for LSU 9.4. Information from the ostracods supports these ages, but cannot attest to their veracity.

PALAEOENVIRONMENTS

With such limited faunas any conclusions must be considered tentative, bearing in mind that the provenance of individual specimens is uncertain. Additional explanatory information on particular species can be found in Notes on Palaeobiology of Selected Species.

Regional comparisons

The Regional Comparative Database, referred to above, contains information on ostracod stratigraphical distributions and palaeoenvironments from the Oligocene-Miocene of southern South America, Antarctica and Australasia, while Wood et al. (1999) have attempted a regional synthesis for the south-west Atlantic Ocean and adjacent Antarctic areas.

The late Palaeogene - early Neogene ostracod fauna of CRP-2A (effectively LSU 9.4) appears to have its strongest link with the northern Antarctic Peninsula through *Hemicytheridea* aff. *H. kinggeorgeensis* Blaszyk, which is an Early Oligocene species from the Polonez Cove Formation of King George Island (Blaszyk, 1987). No similar forms have been reported from the Palaeogene of South America (e.g. Wood et al., 1999) or Australasia, and the genus no longer occurs in high latitude areas. There is a weaker linkage to Argentina through *Copytus* aff. *C. malumiani* Echevarria, although the genus *Copytus* is widespread in Cenozoic strata in the southern median and high latitudes.

During Early Miocene time, the fauna at CRP-2A appears to have been a mix of taxa with both South American and Australasian affinities. *Clinocythereis* is widely (if sparsely) distributed in the Cenozoic of Australasia, but has not been recorded in any of the Argentinean/Chilean studies and is not extant in Antarctica (e.g. Wood et al., 1999). It occurs in all three early Miocene samples from LSU 5.1, and indicates that faunal connections between the Ross Sea area and New Zealand were more open than they are at present. However, *Munseyella* sp. 4607 is closest to South American forms, although the genus is well-presented in the Cenozoic of Australia (e.g. McKenzie, 1974), while in contrast, *Nodoconcha* has been recorded only in modern and Pleistocene Antarctic and modern sub-Antarctic (South Georgia) environments (e.g. Briggs, 1978; Hartmann, 1997). The latter seems to be a high southern latitude endemic genus, which has a northern high latitude Pliocene to Recent homeomorph in *Roundstonia* (e.g. Neale, 1973).

In summary, the evidence suggests that the closest faunal links of the Cape Roberts area during late Oligocene time (LSU 9.4) were with the Antarctic Peninsula and South America, but that during the early Miocene (LSU 5.1) there was an additional connection to New Zealand.

Depositional environments

The low diversity, discolouration, mildly abraded state of preservation, and lack of any small and/or fragile instars suggest that the ostracod faunas are not *in situ*. However, because of their relatively undiagnostic age characteristics it is not possible to suggest whether the fossils were derived penecontemporaneously, or from significantly older strata.

Dingle & Lavelle (1998) have shown that the Polonez Cove Formation is an early Oligocene (30 Ma) interglacial deposit formed adjacent to an ice-covered hinterland. The occurrence in LSU 9.4 at CRP-2A of a species closely related to the dominant taxon from the King George Island deposits (*Hemicytheridea kinggeorgeensis* Blaszyk) suggests that similar environments prevailed in the Ross Sea area during late Oligocene times. The indication of cold to cool water is reinforced by the fact that although *Hemicytheridea* no longer inhabits the modern Antarctic regime, a further abundant species with which it co-occurred in the northern Antarctic Peninsula (*Hemicytherura arctowski* Blaszyk) is probably synonymous with the modern cool-cold water form *H. splendida* recorded from littoral to shelf (155 m) environments of Tierra del Fuego and Patagonia by Whatley et al. (e.g. 1988, 1997). This admittedly tenuous evidence suggests that the water temperatures of the early Oligocene habitat of King George Island (and by analogy the late Oligocene of CRP-2A) were at least as cold as the modern northern Antarctic Peninsula, and that deposition occurred in relatively shallow (shelf) waters adjacent to glaciated regions.

LSU 5.1 has three taxa which provide some environmental information. *C. australis* s.l. has a known modern depth range of 123-1130 m in Australasia, while the Early Miocene strata from South Island, which contain the closest morphotype to the CRP-2A specimens, are considered outer shelf to upper slope deposits (Ayress & Swanson, 1991). Further evidence of relatively deep (and presumably cool) water habitats is provided by *N.* cf. *N. minuta*, which is known only from cold-water, high latitude glacial/interglacial environments with a depth range of ~200-370 m, (although it is suggested below that Quaternary LSU 3.1 of CRP-1, which carries *N. minuta*, may have been deposited at 130-200 m). In contrast, *Munseyella* (= *Cytheromorpha* sp. Echevarria, 1991b) occurs in late Oligocene sediments from southern Argentina that Echevarria (1991b) considered had been deposited in shallow seas at temperatures similar to those prevailing at the same latitude today (49° S, sea surface temperatures ~10-20° C). On balance, this slender and partly conflicting evidence suggests cool-cold, relatively deep water (perhaps outer shelf, ~200 m) during deposition of LSU 5.1.

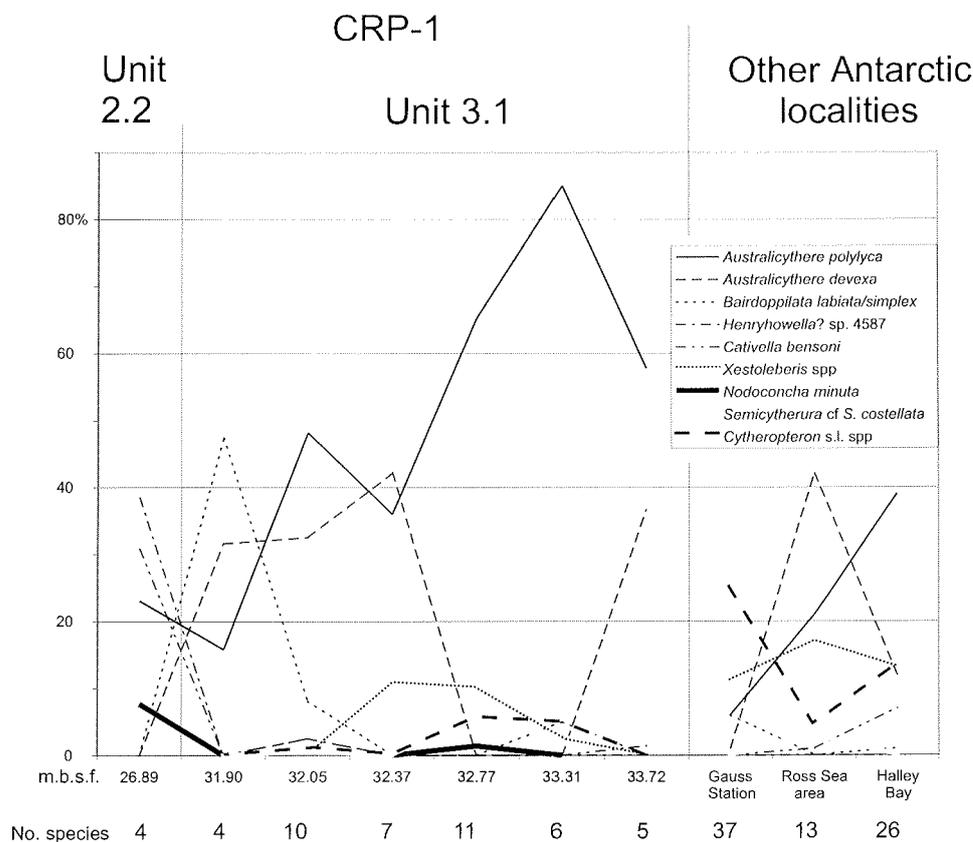


Fig. 2 - Stratigraphic distribution of Quaternary Ostracoda in LSU 2.2 & 3.1, CRP-1. Species are plotted that comprise >5% fauna in any sample. Total number of species in each sample are also given. In addition, the composition of modern faunas from three other Antarctic localities are shown for comparison: Gauss Station (65°S, 90°E, n ~ 700) (Müller, 1908), Ross Sea (n ~ 700) (Benson, 1964) and Halley Bay (75°S, 27°W, n ~ 1000) (Neale, 1967).

QUATERNARY OSTRACOD FAUNAS OF CRP-1

Ostracoda were reported from CRP-1 in two LSU (2.2 and 3.1) within the Quaternary sequence (Cape Roberts Science Team, 1998a, Tab. 3). Subsequently, seven fossiliferous samples were identified and a total of 436 specimens of marine benthic Ostracoda were recovered, representing 24 species from 18 genera (Fig. 2, Tab. 2). Overall, preservation of specimens is good to excellent, with a mix of single valves and carapaces of adults and juveniles. The exception is in the youngest sample (LSU 2.2), where shells are opaque and abraded.

Ostracoda were recovered by Professor P.N. Webb, during his examination of samples for their faunas of benthic foraminifera (Webb & Strong, 1998a). Distribution of these samples in the CRP-1 borehole is shown in figure 1. Neither unwashed samples, nor unpicked residues, were seen by the present author.

STRATIGRAPHIC DISTRIBUTION OF SPECIES.

Six, older, samples lie within the "carbonate-rich" layer (LSU 3.1), while the youngest sample is from LSU 2.2, which is a poorly-sorted muddy sand (Cape Roberts Science Team, 1998a, 1998b). None of the species are confined to LSU 2.2, where the fauna is relatively

impoverished and shows a distinctive composition and generally poor state of preservation, compared to the older assemblages. Details of the lithology of the various lithostratigraphical units are taken from Webb & Strong (1998a) and Cape Roberts Science Team (1998a).

Lithostratigraphical Unit 3.1 (carbonate-rich layer: 31.89-33.82 mbsf)

Lithology. This is a highly fossiliferous, very poorly sorted muddy gravelly sand. It is green-grey to olive-grey in colour, compact, uncemented and weakly stratified. The biogenic components include bryozoans (dominant), gastropods, foraminifera, bivalves, sponge spicules, echinoderm spines and worm tubes. Webb & Strong (1998a) have identified 41 genera and 72 species of benthic and one species of planktonic foraminifera from this unit.

Ostracoda. The ostracods from LSU 3.1 generally display transparent or translucent shells in which morphological features are well-preserved. Many of the smaller species, and instars, are of delicate construction. With the exception of level 31.90 mbsf, all samples have a proportion of shells containing small amounts of fine white/grey sediment infill which is characterised by the presence of small fragments of sponge spicules.

Twenty of the 24 species of ostracods recovered from

Tab. 2. Quaternary ostracods, CRP-1.

			LSU:	2.2		3.1				
			mbsf:	26.89	31.90	32.05	32.37	32.77	33.31	33.72
<i>Australicythere</i>	<i>polylyca</i>	(Müller, 1908)		3	3	77	23	45	34	41
<i>Cativalia</i>	<i>bensoni</i>	Neale, 1967		4		4				1
<i>Australicythere</i>	<i>devexa</i>	(Müller, 1908)			6	52	27			26
<i>Semicytherura</i>	cf. <i>S. costellata</i>	Brady, 1880				1		4	1	2
<i>Austrotrachyleberis</i>	<i>antarctica</i>	(Neale, 1967)				5				1
<i>Bairdoppilata</i>	cf. <i>B. simplex</i>	(Brady, 1880)			9	13			2	
<i>Xestoleberis</i>	cf. <i>X. rigusa</i>	Müller, 1908					4	7	1	
<i>Cytheropteron</i>	<i>fallax</i>	Müller, 1908						3	1	
<i>Cytheropteron</i>	<i>gaussi</i>	Müller, 1908							1	
<i>Nodoconcha</i>	<i>minuta</i>	Hartmann, 1989		1					1	
<i>Microcythere</i>	<i>frigida?</i>	Müller, 1908					2	1		
<i>Paradoxostoma</i>	<i>hypselum</i>	Müller, 1908						1		
<i>Hemicytherura</i>	cf. <i>H. anomala</i>	(Müller, 1908)						1		
<i>Cytheropteron</i>	sp. 4600							1		
<i>Krithe (Austrokrithe)</i>	cf. <i>K. (A.) magna</i>	(Hartmann, 1986)						3		
<i>Antarctiloxoconcha</i>	<i>frigida</i>	(Neale, 1967)						2		
<i>Hemicytherura</i>	<i>anomala</i>	(Müller, 1908)					2			
<i>Hemicytherura</i>	<i>irregularis</i>	(Müller, 1908)					1			
<i>Xestoleberis</i>	cf. <i>X. davidiana</i>	Chapman, 1916					3			
<i>Henryhowella?</i>	sp. 4587	(Hartmann, 1989)		5		4				
<i>Argilloecia?</i>	sp. 4586					1				
<i>Cytheropteron</i>	cf. <i>C. abyssorum</i>	Brady, 1880					2			
<i>Macroscapha</i>	cf. <i>M. tensa</i>	(Müller, 1908)					1			
<i>Pseudocythere</i>	cf. <i>P. caudata</i>	Sars, 1866			1					
No. valves:				13	19	160	64	69	40	71

the Quaternary sediments are restricted to the carbonate-rich layer of LSU 3.1 (Tab. 2). Of the five species that occur in the lowermost sample of LSU 3.1 (33.72 mbsf), all extend to the upper part (samples 31.90 and 32.05 mbsf): *Australicythere polylyca* (Müller), *Cativalia bensoni* Neale, *Australicythere devexa* (Müller), *Semicytherura* cf. *S. costellata* Brady and *Austrotrachyleberis antarctica* (Neale). In contrast, more than half of the species (15) occur in only one sample and most of these (9) are either small or relatively fragile species (or instars). These single occurrences are concentrated in the three samples (32.77 to 32.05 mbsf) immediately above the ice-rafted-dominated interval (Cape Roberts Science Team, 1998a, fig. 7). Finally, three species have a limited range within the central portion of LSU 3.1: *Xestoleberis* cf. *X. rigusa* Müller, *Cytheropteron fallax* Müller, and *Microcythere frigida?* Müller.

Overall, the dominant ostracod is *Australicythere polylyca* (85-16%), and in the lower part of LSU 3.1 this species comprises ~60% or more of the fauna. Its importance decreases sharply above sample 32.77 mbsf (<50%), where it forms a mixed dominant association with *Australicythere devexa* and/or *Bairdoppilata* cf. *B. simplex* (Brady). This suggests a faunal subdivision of LSU 3.1 into two parts: samples 33.72 to 32.77 and samples 33.72 to 32.77 mbsf. Further evidence of faunal differences between the lower three and upper three samples is suggested by the relatively high proportion of *Australicythere polylyca* in samples 32.77 to 32.05 mbsf, in which both *Semicytherura* cf. *S. costellata* and *Cytheropteron* spp. *s.l.* are at their most abundant, while *Bairdoppilata* cf. *B. simplex* is important only in samples 31.90 and 32.05 mbsf.

Sample 32.77 mbsf has the highest simple diversity (11 species, 10 genera), and contains two species which may have particular significance for drawing conclusions on the depositional environment: *Krithe (Austrokrithe)* cf. *K. (A.) magna* (Hartmann) and *Nodoconcha minuta*.

Lithostratigraphical Unit 2.2 (22.00-29.49 mbsf)

Lithology. Olive-black, moderately- to poorly-sorted, muddy, fine to medium sand. It is compact, uncemented and locally fossiliferous.

Ostracoda. One sample from this unit contained ostracods (26.89 mbsf), with a relatively sparse fauna (4 species and 13 specimens) of *Henryhowella?* sp. 4587 sp. nov., *Cativalia bensoni*, *Australicythere polylyca*, and one valve of *Nodoconcha minuta*. All specimens have a light brown hue, are opaque, have relatively poor preservation of fine morphological features, and are infilled with a sediment matrix composed of relatively coarse, lithic-rich grains, in which no sponge spicules were observed. This assemblage contrasts strongly with that recovered from LSU 3.1 in its relative importance of two taxa which occur only sparingly in the carbonate-rich sequence (*Henryhowella?* sp. 4587 sp. nov. and *Cativalia bensoni*), and the non-occurrence of *Australicythere devexa*. In addition, there are none of the small and/or fragile species that occur throughout LSU 3.1. Coupled with the state of preservation of those valves present, it is concluded that these specimens have suffered significant penecon-temporaneous transport, or are reworked from older strata. All the species in LSU 2.2 also occur in LSU 3.1.

AGE

The stratigraphical ranges of extant Antarctic ostracod species are not known, and none of the taxa from the Quaternary sequence of CRP-1 are allocated to a species that is not recorded from modern assemblages. Consequently, it is not possible to draw conclusions of age from the ostracod fauna, and in particular, to assess the degree of re-working of ostracod shells from possible Pliocene material, as suspected, for example, amongst the benthic foraminifera (Webb & Strong, 1998b; Cape Roberts Science Team, 1998a, 1998b). Szczechura & Blaszyk (1996) recorded four extant ostracod taxa from the Pliocene Cockburn Island Formation (as defined by Jonkers, 1998) in the northern Antarctic Peninsula. Of these, only *Australicythere polylyca* occurs in the Quaternary of CRP-1, but on the basis of their illustrations, their record appears to be a mis-identification.

Given the generally excellent state of preservation of ostracod specimens from LSU 3.1, there is no evidence to suggest that any are not *in situ*, or at least that they lived penecontemporaneously close by. It is probably significant that of the six samples from which ostracods were recovered and described herein, only 33.31 and 31.90 mbsf were suspected by Webb & Strong (1998b) to contain pre-Quaternary foraminifera (in both instances small numbers of *Ammoelphidiella antarctica*). Worn and/or sediment encrusted ostracods were mentioned by Webb & Strong to occur in sample 32.98 mbsf (1998b, p.473), but this sample was not supplied to the author.

In LSU 2.2, ostracod specimens show signs of mechanical abrasion and size fractionation, but none of the species are known to occur in rocks older than Quaternary. Webb & Strong (1998b) concluded that the benthic foraminifera from the sample investigated by the present author (26.89 mbsf) indicated a Quaternary : pre-Quaternary species ratio of 32 : 15, with a census count of 61% : 39%. In the ostracod assemblage, I suspect that none of the specimens were *in situ*, but there is no *prima facie* evidence for a pre-Quaternary source.

PALAEOENVIRONMENTS

Regional comparisons with modern faunas

Modern ostracod faunas from Antarctica are well-known from four regions: the Antarctic Peninsula (mainly from Hartmann, 1988, 1989a, 1989b, 1990, 1992, 1993, 1997; but also Whatley et al., 1998), Halley Bay in the eastern Weddell Sea (Neale, 1967; Whatley et al., 1988), the Ross Sea area (Edwards Peninsula and McMurdo Sound - Benson, 1964; Briggs, 1978) and "Gauss Station" off eastern Antarctica (~90° E: Müller, 1908). Except for two possibly new species (*Argilloecia?* sp. 4586 and *Cytheropteron* sp. 4600), all of the ostracod species recorded from the Quaternary succession in CRP-1 have been previously recorded south of 60° S. Ten of these (*Antarctiloxoconcha frigida* (Neale), *Australicythere polylyca*, *Cytheropteron fallax*, *Hemicytherura anomala* (Müller), *H. irregularis* (Müller), *Microcythere frigida?*, *Paradoxostoma hypselum* (Müller), *Pseudocythere* cf. *P.*

caudata Sars, *Xestoleberis* cf. *X. davidiana* (Chapman) and *X. rigusa*) do not occur north of 60° S, and five have been reported from around South Georgia, as well as in the Antarctic proper (*Australitrachyleberis antarctica*, *Krithe* (A.) cf. *K. (A.) magna*, *Henryhowella?* sp. 4587, *Macroscapha* cf. *M. tensa* (Müller) and *Nodoconcha minuta*). The range of three further species extends to southernmost South America (*Cytheropteron gaussi* Müller: deep-water off the SE Falkland Plateau, and *Cativella bensoni* and *Australicythere devexa* in the Magellan Strait [Whatley et al., 1996]), while there are three species which appear to be widely distributed in the Southern Ocean. The latter were described originally from isolated sites by Brady (1880) from the HMS *Challenger* expedition, but given the uncertainty surrounding their current taxonomic status, it would be premature to draw any firm conclusions from their distribution [*Bairdoppilata simplex* (Brady) - Heard Island, *Semicytherura costellata* Brady - Kerguelen archipelago, *Cytheropteron abyssorum* Brady - deep-water, Great Australian Bight].

In our database (unpublished) there are ~1400 records of podocopid ostracods for localities south of 60° S (247 species in 82 genera), and we find a strong southward decrease in simple species diversity: 60-62° S (Peninsula) - 54 spp.; 65° S (Gauss Station) - 37 spp.; 75° S (Halley Bay) - 26 spp.; ~77° S (Ross Sea area) - 13 spp. By comparison, the upper (*Australicythere polylyca*/*A. devexa*-dominated) and lower (*A. polylyca*-dominated) faunas from LSU 3.1 have 16 and 15 species, respectively. This suggests that the faunal diversity in LSU 3.1 was similar to that in the modern Ross Sea, but, by contrast, distinctly lower than currently found in the northern Antarctic Peninsula. A further similarity between the fauna of LSU 3.1 and modern locations south of 75° S, is that at both Halley Bay and in the Ross Sea area, the combination of *A. polylyca* and *A. devexa* dominates the modern faunas. At present, *A. polylyca* is confined to Antarctica proper, while *A. devexa* extends to the southernmost islands in South America and South Georgia.

There are some points of difference, however, notably that while both *Xestoleberis* spp. and *Cytheropteron* spp. *sensu lato* are relatively poorly-represented in CRP-1, they are relatively important elements of the modern faunas at Halley Bay and in the Ross Sea area. A further difference is the occurrence in LSU 3.1 of *Nodoconcha minuta* (it also occurs in LSU 2.2, and a closely-related species is found in LSU 5.1 from CRP-2A). There are only six previous records of this relatively rare species from modern samples in South Georgia and the Antarctic Peninsula (Hartmann, 1988, 1989a, 1989b, 1990), and the Pleistocene Taylor Formation from the Ross Sea area (Briggs, 1978).

In contrast, the sparse, unusual faunal mix in sample 26.89 mbsf from LSU 2.2 does not seem to have a modern analogue. In particular, *Henryhowella?* sp. 4587 is a relatively unusual component of modern Antarctic continental shelf faunas: Briggs (1978) found it in the Pleistocene Taylor Formation, and Hartmann (1989a) recovered it living from South Georgia. However, the genus has been reported widely from Danian to Pliocene strata in South America, and in modern shallow and deep-

water South American and sub-Antarctic regions (*e.g.* Whatley et al., 1996, 1997a). *Cativella bensoni* is currently widespread in Antarctica, but not in the proportions found in this sample, while it has been recorded in very small numbers in 143-270 m in the Magellan Strait (Whatley et al., 1996). It is concluded that this is a re-worked assemblage.

Palaeo-water depths, energy and temperatures

Known water depth ranges for ostracods from modern sites south of 60° S, based on reliable identifications of the species found in LSU 3.1 and 2.2, are presented in figure 3. While this can only serve as a rough guide to water depth preferences for particular species (maximum number of records for any species is ~40 and for most it is less than 10, and because many records are of valves in which soft anatomy was not preserved), several of the species have not been recorded in the literature from depths shallower than 100 m, and in particular, there are over twenty records of *Cativella bensoni*. In addition, there is equivocal evidence that this depth may have been exceeded at 32.77 mbsf, where *Krithe (Austrokrithe) cf. K. (A.) magna*, *Nodoconcha minuta* and *Antarctiloxoconcha frigidum* (Neale) all co-occur. None have been recorded (albeit in small data bases) shallower than 138 m, and species in the *Krithe* complex (the status of Hartmann's Antarctic subgenus *Austrokrithe* is uncertain) are generally deeper water forms. These limited data suggests that LSU 3.1 was deposited in water at least 100 m deep, and that the depth may have increased to 130-200 m during the accumulation of samples 32.77 and 32.37 mbsf. As a cautionary note,

however, cognizance should be taken of the depth distributions of several normally deeper-water ostracod species that have been collected from medium and even littoral depths in the Magellan Strait in southernmost Chile. Whatley et al. (1996, 1997b) account for these records by invoking coastal upwelling of very cold, deep water, although specific temperature details at the sites are not cited. Such taxa recorded in our present study are: *Austrotrachyleberis antarctica*, *Australicythere devexa* and *Bairdoppilata cf. B. simplex*.

With the exception of the sample 26.89 mbsf (LSU 2.2), all ostracod assemblages contain a proportion of instars (juvenile, moult stages). The ratio of instars to adults preserved in sediments has been used to assess palaeoenvironments (*e.g.* Brouwers, 1988; Whatley, 1988; Dingle, 1993), and given "ideal" conditions (*i.e.* no sediment-grain partitioning by currents), this should be 8:1, although as Brouwers (1988) has pointed out, predation, dissolution and crushing are likely to reduce this to 5 or 6:1 even under quiet conditions. Only *Australicythere polylyca* is present in all the samples studied, and figure 4 shows that the instar: adult ratio of valves of this species remains low through the sequence in LSU 3.1, suggesting that a proportion of instars was consistently winnowed from the site during deposition. Discounting sample 31.90 mbsf (which contained only three valves), the data suggest that the highest-energy environment occurred during deposition of sampled 33.31 mbsf, and the quietest conditions coincided with level 32.37 mbsf. This is also a level where we suspect relatively deeper water conditions prevailed. The lack of instars in sample 26.89 mbsf (*i.e.* there is no evidence for a life

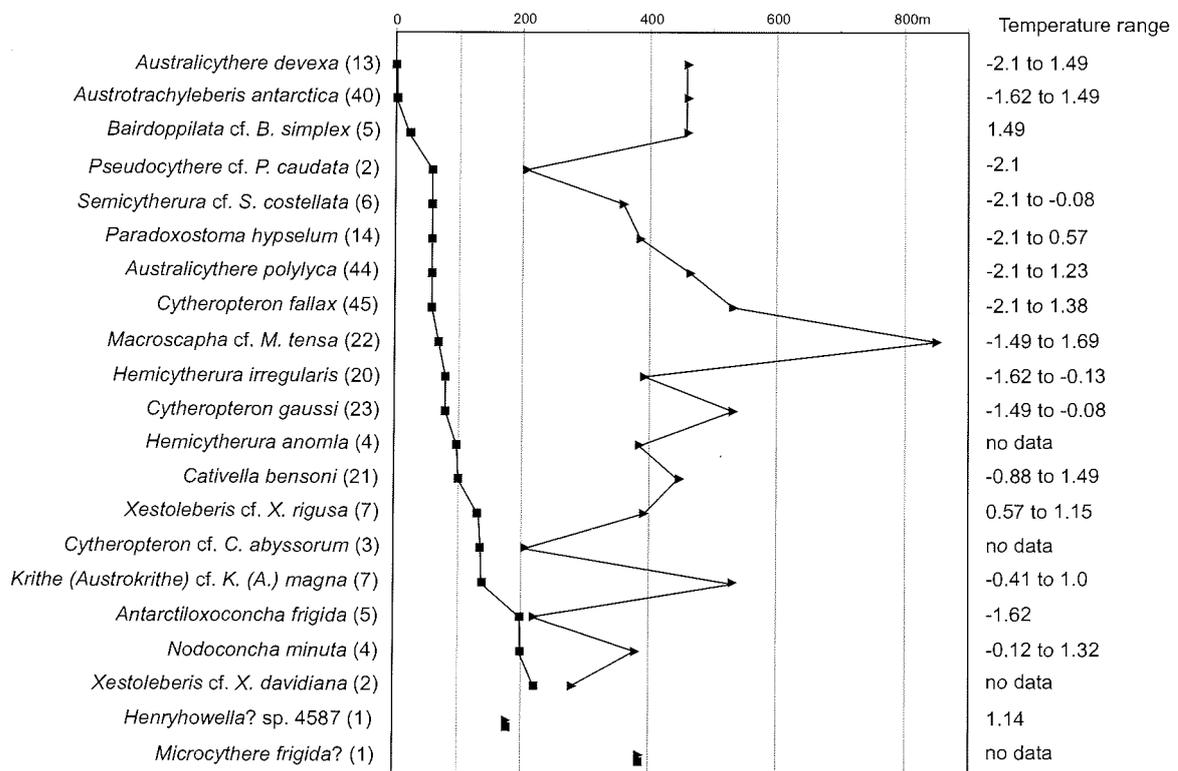


Fig. 3 - Depth and temperature ranges of modern Antarctic Ostracoda. Left panel gives number of depth records in unpublished database.

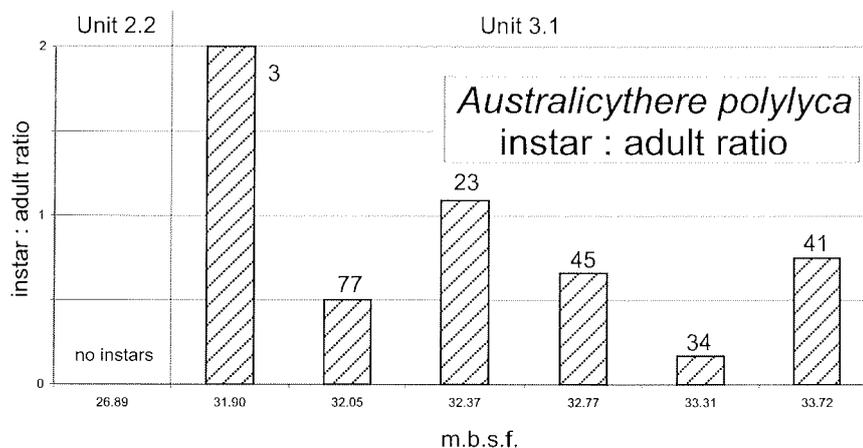


Fig. 4 - Instar: adult ratio of valves of *Australicythere polylyca* (Müller) in LSU 3.1, CRP-1. Number of valves available is shown above each column. Sample numbers along x-axis.

assemblage), further reinforces the suggestion that it contains only a re-worked fauna.

The extent and quality of data with which to assess water temperature tolerances for individual ostracod species is very variable. Apart from single determinations which do not allow a range to be calculated, values for twelve species from our data base (Fig. 3) show that only *Xestoleberis rigusa* and *Bairdoppilata simplex* (Brady) have not been recorded in water below 0°C, but crucially, Neale (1967) did not have temperature values for his sample site in Halley Bay (where *X. rigusa* was recorded, and *B. labiata* (Müller) is probably synonymous with *B. simplex*). This limited evidence supports Webb & Strong's (1998, p. 468) contention that no major water temperature changes in relation to modern conditions occurred during the deposition of LSU 3.1, because even including the relatively higher water-temperature values from the non-Antarctic sites in the ranges, maximum water temperatures no higher than approximately 0°C would be necessary to sustain the ostracod fauna found in LSU 3.1 (and 2.2).

SUMMARY OF CONCLUSIONS

LATE OLIGOCENE OSTRACOD FAUNA OF CRP-2A (LSU 9.4)

1. The fauna is marine, but very sparse and poorly preserved.
2. Affinities are closest to late Palaeogene faunas from the northern Antarctic Peninsula.
3. The only known faunal analogue is from the Polonez Cove Formation, an interglacial environment adjacent to glaciated terrains, with water temperatures probably at least as cold as for the modern northern Antarctic Peninsula.
4. Water depth was probably relatively shallow-shelf.
5. No definite age connotation: closest affinities with Early Oligocene of King George Island.
6. The fossils are not *in situ*, but degree of allochthonism is not known.

EARLY MIOCENE OSTRACOD FAUNA OF CRP-2A (LSU 5.1)

7. The fauna is marine, but very sparse and poorly preserved.
8. Closest faunal affinities are with Neogene Australasia (especially New Zealand) and southern Argentinean, and Quaternary Antarctic Peninsula and Ross Sea areas.
9. Water temperatures were cool-cold, and certainly as low as in the modern sub-Antarctic region.
10. Relatively deep-water (?outer shelf, possibly in excess of 200 m).
11. No definite age connotation: closest affinities with Early Miocene of South Island, New Zealand.
12. The fossils are not *in situ*, but degree of allochthonism is not known.

QUATERNARY OSTRACOD FAUNA OF CRP-1 (LSU 2.2 & 3.1)

13. The fauna is entirely marine, with no evidence of hyposalinity-tolerant species.
14. The fauna is relatively sparse at certain levels, but overall richness of LSU 3.1 (18), in terms of the ratio of total number of specimens picked to species recovered, compares favourably with previous studies of modern Antarctic faunas from the Ross Sea (54), Halley Bay (39) and Gauss Station (19).
15. The composition of the fauna in LSU 3.1 varies from *A. polylyca*-dominant in the lower part (samples 33.72 to 32.77 mbsf), similar to the modern Halley Bay fauna, to *A. polylyca/A. devexa*-dominant in the upper part (samples 32.37 to 31.90 mbsf), more akin to the modern Ross Sea fauna. This change presumably reflects an alteration in glacial conditions.
16. The faunas of LSU 3.1 are composed entirely of taxa which currently inhabit the Antarctic region (*i.e.* south of 60° S), and suggest palaeotemperatures in the region of a maximum of ~0°C.
17. The faunas suggest water depths of at least ~100 m, possibly deepening to 130-200 m in samples 32.77 & 32.37 mbsf. Sample 32.37 mbsf probably represents

the lowest energy depositional environment of the samples studied.

18. No refinement can be offered on the age of the samples - all contain extant species, none of which have been recorded from Antarctic or sub-Antarctic pre-Quaternary sites.
19. The good preservation of specimens in all the samples examined from LSU 3.1, together with lack of known fossil types, does not suggest reworking from pre-Quaternary strata, although this possibility cannot be ruled out. However, the state of preservation, unusual faunal mix, and lack of instars suggests that the fauna of sample 26.89 mbsf from LSU 2.2 is re-worked, but not necessarily from strata older than Quaternary in age.

ACKNOWLEDGEMENTS

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NOTES ON PALAEOBIOLOGY OF SELECTED SPECIES

Species which may be new, or cannot be assigned to existing taxa are given a unique number which corresponds to that species' identification in the author's sequential SEM-image numbering system. Selected species are illustrated in figure 5. Environmental data have been extracted from an unpublished data base comprising 4300 entries culled from an extensive literature, much of which is not specifically cited in the reference list.

Australicythere devexa (Müller, 1908) (Fig. 5b). The second-most abundant species in the CRP-1 Quaternary fauna. It is extant in southern-most South America (Hartmann, 1962; Whatley et al., 1996), South Georgia (Hartmann, 1989b, 1993) and throughout Antarctica (Hartmann, 1997). Hartmann (1962) recorded a closely related species from a relatively low latitude in the Chilean littoral (35.3° S). Although there are numerous records of this species, its depth range is relatively restricted (50 - 385 m), with the notable exception of the few littoral sites mentioned by Whatley et al. (1996, 1997b) in the Magellan Strait. This species is restricted to Pleistocene and younger sediments. Briggs (1978) recorded it in the Taylor Formation.

Australicythere polylyca (Müller, 1908) (Fig. 5a). The most abundant taxon in the CRP-1 Quaternary fauna. Widely recorded from the modern Antarctic region, and not found north of 60° S. Noted by Briggs (1978) in the Taylor Formation. Pre-Quaternary records from the Pliocene Cockburn Island Formation (Szczechura & Blaszyk, 1996) are probably mis-identifications.

Austrotachyleberis antarctica (Neale, 1967). First recorded as *Cythere cristatella* Brady, 1880 by Chapman (1919) from ~67° S and ~94-140° E, Neale (1967) described the species as *Robertsonites antarctica* sp. nov. from Halley Bay. It has been recorded subsequently by Hartmann (1988) in his monospecific

genus from South Georgia and several localities in the northern Antarctic Peninsula (Hartmann, 1997), while Whatley et al. (1996) have noted it in the Magellan Straits area of southernmost Chile as *Abyssocythere antarctica*. The latter localities involved depth ranges of 1 - 456 m.

Bairdoppilata cf. *B. simplex* (Brady) (Fig. 5c). First recorded from modern sediments of Heard Island (~150 m) by Brady (1880). It has not been satisfactorily discriminated from *B. labiata* (Müller, 1908), with which it is probably synonymous. In one of these guises it has been widely recorded from modern sediments around the Falkland Islands (Whatley et al., 1995), the Antarctic Peninsula (Hartmann, 1989a, 1983), Halley Bay (Neale, 1967), Gauss Station (Müller, 1908), in the Magellan Strait (18-456 m) (Whatley, 1996) and as far north as ~40° S in the Argentinean littoral (Whatley et al., 1997a); and in the Pleistocene Taylor Formation (Briggs, 1978). Benson (1964) did not note it in the modern fauna of the Ross Sea area.

Cativalva bensoni Neale, 1967 (Fig. 5e). Widely reported from the modern Antarctic Peninsula, Halley Bay, from the southern tip of the continental shelf off the Falkland Plateau (see summary in Hartmann, 1997), from the Magellan Strait (Whatley et al., 1996), and from South Georgia and Prince Edward Island in the wider southern Ocean (as *Cythere polytrema* Brady, 1880). A very similar species occurs in the late Oligocene of southern Argentina (as *C. aff. C. bensoni* Echevarria, 1991b). Previous records have not established that it is extant in the Ross Sea area: Benson (1964) reported it off the Edwards Peninsula, but suggested that it might not have been from a recent sample, while Briggs (1978) found it in the Taylor Formation. Benson (1964) suspected that Chapman (1916) found it in elevated sediments around Mt Erebus, Ross Island, McMurdo Sound. All modern records suggest that this is a relatively deep-water species (range 100-448 m).

Clinocythereis cf. *C. australis* Ayress & Swanson (Fig. 5j). Original definition of the species implied wide geographical (SE Indian Ocean to New Zealand), temporal (Eocene to Recent) and environmental ranges (outer shelf to deep-sea: 123 to 1130 m). The morphotype which is probably the same as the CRP-2A specimens is from the Early Miocene Rifle Butts Formation from South Island, New Zealand, considered an outer shelf to upper slope deposit (Ayress & Swanson, 1991, fig. 8i-j).

Copytus aff. *C. malumiani* Echevarria 1987a (= sp. 4631). *C. malumiani* has a range of late Oligocene to early Miocene in the Austral Basin of Argentina (Echevarria, 1982, 1987a, 1991b). Both the Argentinean and CRP species have a slight flattening in the antero-ventral region, and although the CRP-2A specimen is larger (0.83 mm vs 0.64 mm), both have similar length/height ratios (2.8 vs 3.0-3.1). ?*C. ezcurraensis* Blaszyk 1987 from the early Oligocene of the northern Antarctic Peninsula also appears very close, with similar dimensions and length/height ratio (2.6), but all the illustrations of Blaszyk's material show crushed specimens and further comparison is not possible. Modern species have a different anterior outline (*C. caligula* Skogsberg) or lower length/height ratio (*C. elongata* Benson, 1964). *Copytus rara* McKenzie, 1967 from the Eocene to Recent of New Zealand is a larger, more slender species (l/h: 3.5).

Henryhowella? sp. (= sp. 4587) (Fig. 5d). This is a relatively rare genus in modern shelf environments of Antarctica, although the species occurring in LSU 2.2 and 3.1 of CRP-1 is also known from the Taylor Formation (Briggs, 1978). Hartmann (1989a) probably recorded the same species (as *Echinocythereis?*) from around South Georgia, although the intricate pattern of secondary spines on the CRP-1 specimens cannot be discerned in his illustrations. Whatley et al. (1996, 1997a) have reported *Henryhowella dasyderma* (Brady) and *H. asperrima* (Reuss) from littoral to medium depths (527 and 214 m, respectively) in

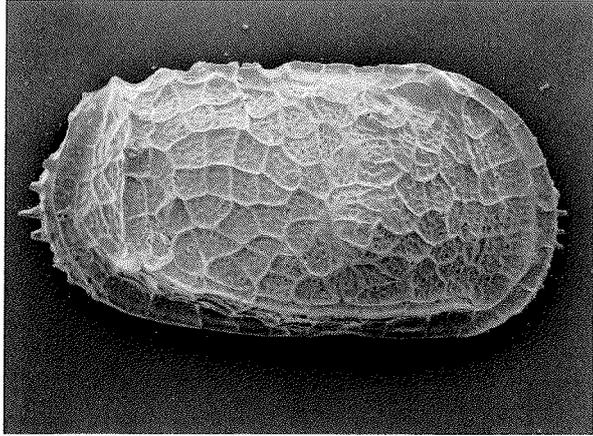
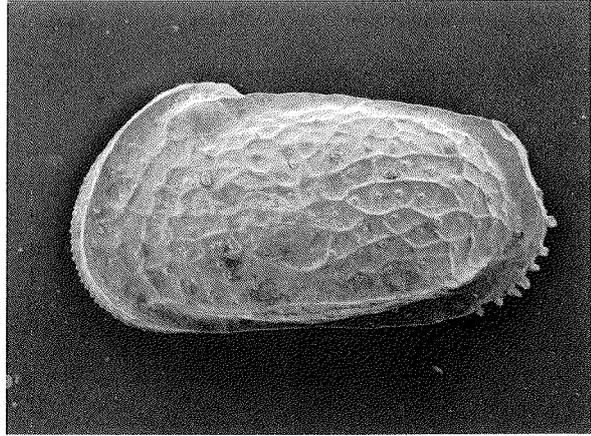
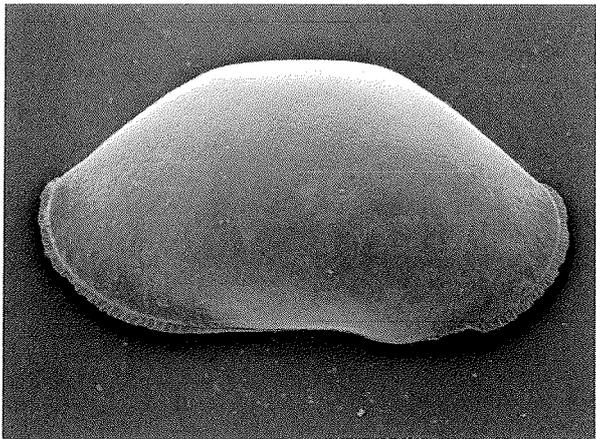
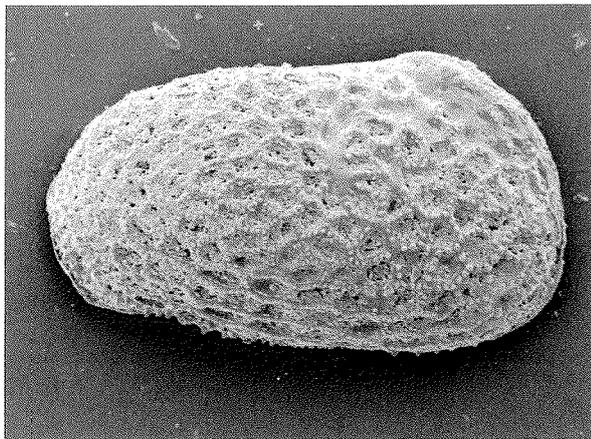
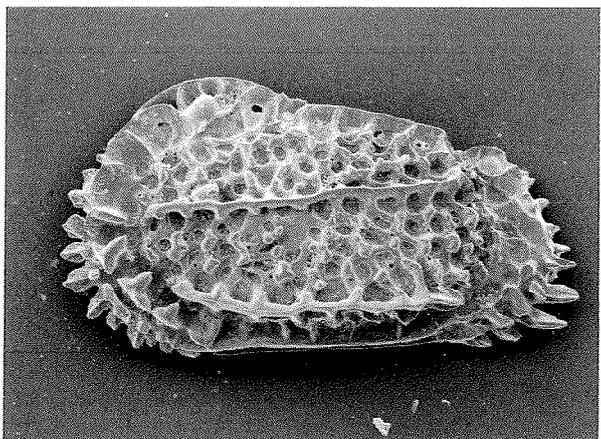
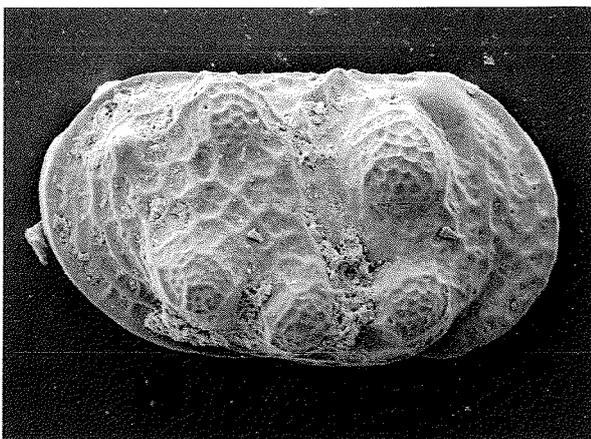
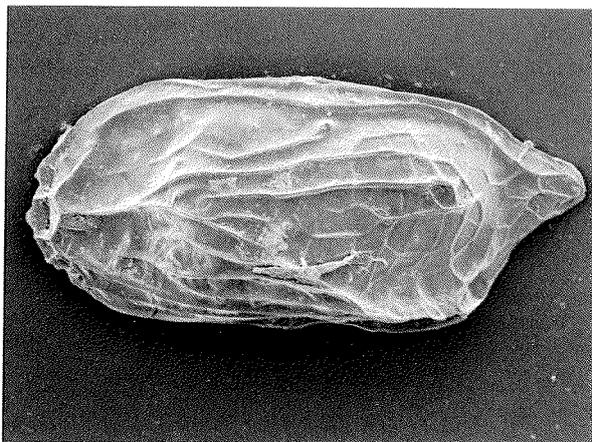
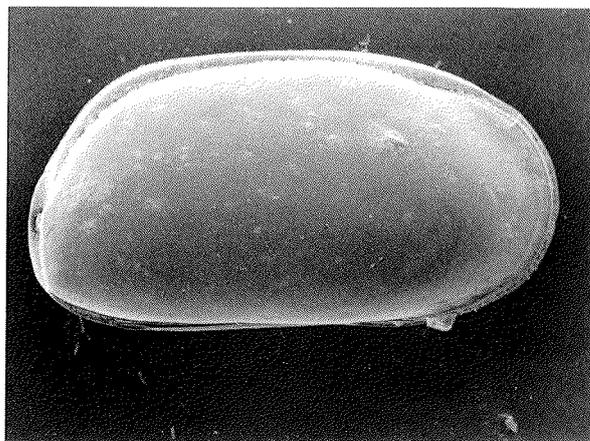
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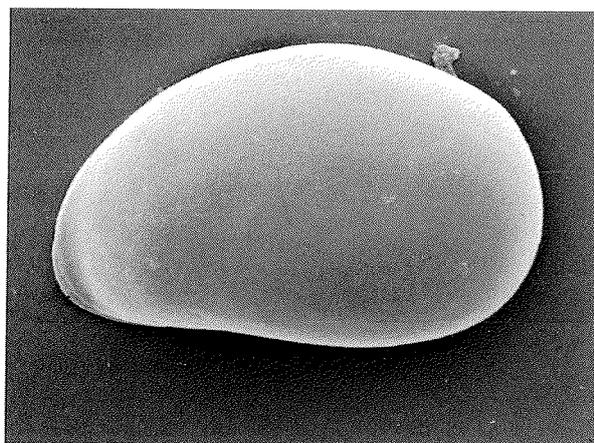
Fig. 5 - Selected Ostracoda from CRP-1 and CRP-2A. Scale in microns below each print. RV = right valve, LV = left valve. **A.** *Australicythere polylyca* (Müller, 1908), RV, Quaternary, 32.05 mbsf, LSU 3.1, CRP-1. **B.** *Australicythere devexa* (Müller, 1908), LV, Quaternary, 32.05 mbsf, LSU 3.1, CRP-1. **C.** *Bairdoppilata* cf. *B. simplex* (Brady, 1880), RV, Quaternary, 32.05 mbsf, LSU 3.1, CRP-1. **D.** *Henryhowella?* sp. 4587 (= *Echinocythereis?* sp. Hartmann, 1989b), RV, Quaternary, 32.05 mbsf, LSU 3.1, CRP-1. **E.** *Cativella bensoni* Neale, 1967, LV, Quaternary, 32.05 mbsf, LSU 3.1, CRP-1. **F.** *Nodoconcha minuta* Hartmann, 1989, RV, Quaternary, 26.89 mbsf, LSU 2.2, CRP-1.



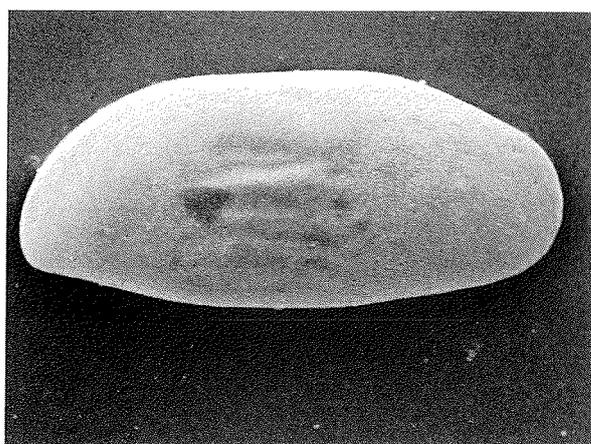
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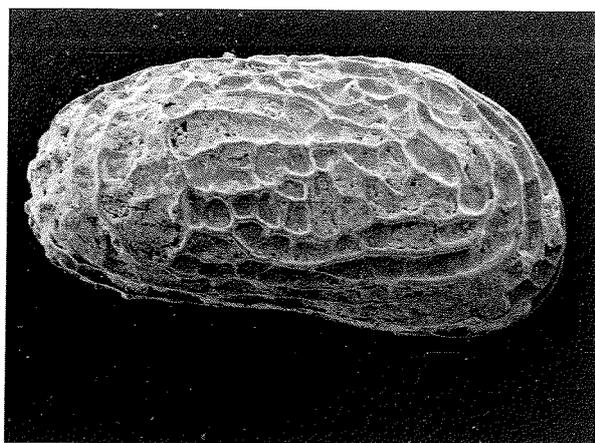
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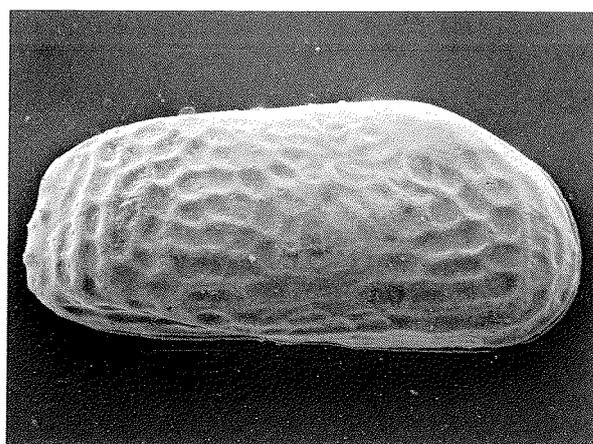
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Fig. 5 - continued. G. *Semicytherura* cf. *S. costellata* (Brady, 1880), LV, Quaternary, 32.77 mbsf, LSU 3.1, CRP-1. H. *Krithe* (*Austrokrithe*) cf. *K. (A.) magna* (Hartmann 1986), RV, Quaternary, 32.77 mbsf, LSU 3.1, CRP-1. I. *Xestoleberis* cf. *X. rigusa* Müller, 1908, LV, Quaternary, 32.77 mbsf, LSU 3.1, CRP-1. J. *Clinocythereis* cf. *C. australis* Ayress & Swanson, 1991, RV, early Miocene, 64.67 mbsf, LSU 5.1, CRP-2A. K. *Hemicytheridea* aff. *H. kinggeorgeensis* Blaszyk, 1987, RV, late Oligocene, 215.60 mbsf, LSU 9.4, CRP-2A. L. *Munseyella* sp. 4607 (= *Cushmanidea* sp. Echevarria, 1991), RV, early Miocene, 71.13 mbsf, LSU 5.1, CRP-2A.

the Magellan Strait, although in a comparative study, Bonaduce et al. (1999) do not consider *H. asperrima* to be extant in the modern Atlantic. In contrast, the genus *Henryhowella* (and the closely related *Echinocythereis*) is widely reported (~ 15 spp.) from the Eocene to Oligocene of southern South America (e.g. Malumian, 1968, 1970; Becker, 1964; Rizzolo, 1969; Bertels, 1975; Echevarria, 1988, 1991a, 1995), and from modern deep-sea environments in the sub-Antarctic southern oceans (e.g. Brady, 1880; Benson, 1964; Whatley & Ayress, 1988).

Hemicytheridea aff. *H. kinggeorgeensis* Blaszyk 1987 (Fig. 5k). This genus was originally described from the tropical Far East, and most of the subsequent records have been from this region. McKenzie (1967) made a tentative identification from several modern sites in southern Australia, but there have been no records from South America. The specimen from CRP-2A cannot be directly compared with Blaszyk's species as there are no internal views, but its ornamentation and general architecture are very similar. *H. kinggeorgeensis* is one of two dominant taxa in the King George Island, Early Oligocene Polonez Cove Formation samples examined by Blaszyk (1987).

Krithe (*Austrokrithe*) cf. *K. (A.) magna* (Hartmann, 1986) (Fig. 5h). Species recorded from eastern Ross Sea (274 m, Sulzberger Bay) by Benson (1964), and Briggs (1978), although it is not clear from the latter reference whether this is a modern or Pleistocene record. It inhabits the northern Antarctic Peninsula in water depths ranging from 133-4354 m (Hartmann, 1987, 1989b, 1990, 1992), while Whatley et al. (1998) have recorded the species from six deep-water sites to the south east of the Falkland Islands and South Orkney Islands in the Scotia Sea (1550-3928 m). Setty (1984) records a species of *Krithe* (*K. tumida*) from the south-east terrace at Deep Lake in the Vestfold Hills, but it is not possible to confirm the identification, or that of Briggs' (1978) record of the same species from the Ross Sea. The status of Hartmann's subgenus *Austrokrithe* is uncertain, and Whatley et al. (1998) do not consider that this species can be distinguished from *Krithe*. It indicates mid-shelf to deeper environments, and the three specimens found in sample 32.77 mbsf do not appear to have been re-worked significantly.

Munseyella sp. 4607 (Fig. 5l). This species is very similar to one described by Echevarria (1991b) as *Cushmanidea* sp. from the late Oligocene Centinela Formation of the Austral Basin in southern Argentina [which itself is very close to two of her other species from the same area: the early Miocene *Munseyella fuegoensis* (1987b) and Pliocene *M. sanmatiasensis* (1988)]. It is not the same as the species also allocated to *Cushmanidea* sp. by Echevarria (1988) from the Pliocene Rio Negro Formation. None of these species has the strong anterior marginal rim that characterises most species of *Munseyella* recorded from Australasia (e.g. Whatley & Downing, 1983; McKenzie et al., 1993). One of the CRP-2A specimens was a single valve, and although extensive calcite overgrowth has obscured most internal details, the marginal areas are wide and the hinge typical for the genus.

Nodoconcha minuta Hartmann, 1989b (Fig. 5f). The only previous records of this rare species south of the northern Antarctic Peninsula is from the Pleistocene Taylor Formation adjacent to McMurdo Sound, where Briggs (1978) recorded it as "*Roundstonia*" sp. Neale's (1973) genus *Roundstonia* and Hartmann's (1989) *Nodoconcha* are superficially similar, but vary significantly in posterior lateral outline and in their hinge structures (see also Hartmann, 1997). Modern specimens of *N. minuta* are known only from South Georgia, South Orkney Islands and the Antarctic Peninsula, where it has a depth range 199-379 m. It has so far not been recorded around South America proper (see Wood et al., 1999). It was found in CRP-1 in samples 32.77 mbsf (LSU 3.1) and 26.89 mbsf (LSU 2.2). The latter is considered to be a re-worked fauna. The taxon found in sample

71.13 mbsf in LSU 5.1 of CRP-2A (herein referred to as *N. aff. N. minuta*) is very close to Hartmann's species but differs in lacking the prominent vertical ridge that crosses the exterior surface. It is probably a new species.

Semicytherura cf. *S. costellata* (Brady, 1880) (Fig. 5g). This species has been recorded from modern environments in three widely-separated areas in the Antarctic to sub-Antarctic region. Brady (1880) first described it from 20-50 fathoms in the Kerguelen archipelago, while Hartmann (1989b, 1990, 1992, 1993) has recorded it over a wide depth range (79-358 m) from a few localities at the northern extremity of the Antarctic Peninsula. It also occurs in the Ross Sea area, where Benson (1964) found it in McMurdo Sound (57 m) and Briggs (1978) noted it in the Taylor Formation. However, it was reported neither from Halley Bay (Neale, 1967) nor Gauss Station (Müller, 1908). The Antarctic material is very close to that illustrated by Puri & Hulings (1976) from the Challenger Collection, although Brady's type has more prominent longitudinal ridges.

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