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11. OSTRACODA FROM SITES 910 AND 911[1]

Thomas M. Cronin[2] and Robin Whatley[3]

ABSTRACT

Ostracodes from Ocean Drilling Program Leg 151, Sites 910 and 911, were studied to provide biostratigraphic and paleoceanographic data on Pliocene and Quaternary sediments from the Yermak Plateau, Arctic Ocean. Preliminary results indicate the Yermak Plateau was inhabited by relatively thermophilic taxa (*?Hermanities, Muellerina, Pterygocythereis*) during the Pliocene and progressively more cryophilic taxa (*Cytheropteron, Elofsonella, Heterocyprideis*) during the Quaternary. Ostracode assemblages provide evidence that warm Atlantic water entered the Yermak Plateau region of the Arctic during the Pliocene, allowing temperate species to inhabit water depths of ~500–1000 m, and that oceanographic conditions varied during the Quaternary but were generally cooler than during the Pliocene.

INTRODUCTION

The importance of the Arctic Ocean on global climate has long been recognized (Clark, 1982, 1990). Hypotheses to explain the progressive global cooling of the last five million years, especially the enhanced growth of Northern Hemisphere ice sheets, however, have been plagued by a lack of direct paleoclimate data from well-dated sediments from the Arctic Ocean (Raymo et al., 1990; Crowley, 1991, Raymo, 1994). Although there is sedimentologic data from the Nordic Seas for late Neogene intensification of glacial activity (Jansen et al., 1990), most evidence from the Arctic Ocean proper that indicates Arctic climates were significantly warmer during the Pliocene than today comes from exposures around the margins of the Arctic that provide only "snapshots" of periods of warmth. For example, Funder et al. (1985), Bennike (1990), and Matthews and Ovenden (1990) provided strong palynological and paleobotanical evidence for a forested Arctic and greater numbers of temperate vegetation types in Canada and Greenland. Carter et al. (1986) and Brigham-Grette and Carter (1992) provided stratigraphic and paleontologic evidence for relatively warm shallow-water marine climates and high relative sea level in the northern Alaskan Coastal Plain Pliocene deposits. Cronin et al. (1993) documented a Pacific-to-Atlantic migration of temperate ostracodes along the margins of the Arctic Ocean during the Pliocene that required shallow marine summer water temperatures as high as 4°C. Yet with the exception of the CESAR cores from the Alpha Ridge in the Canada Basin (Scott et al., 1989), data on Pliocene and Quaternary paleoceanography from deeper water sediments in the Arctic are generally lacking.

Ocean Drilling Program (ODP) Leg 151 recovered Pliocene and Quaternary sediments from the Yermak Plateau that were reasonably well dated using calcareous nannofossils and magnetostratigraphy and that allow paleoceanographic inferences to be made based on sparse but well-preserved marine ostracodes. Sites 910 and 911 are located in the core of modern Atlantic Water at about 500–1000 m water depth, and they were therefore particularly important sites to test the hypothesis that relatively warm Atlantic Water flowed into the Arctic Ocean through the eastern side of the Fram Strait when warm oceanic temperatures existed along Arctic margins (Cronin et al., 1993). This paper describes the biostratigraphic and paleoenvironmental significance of Ostracoda found at Sites 910 and 911.

MATERIAL AND METHODS

We studied material from Site 910 (80°15.9′N, 6°35.4′E, 567 m water depth) and Site 911 (80°28.5′N, 8°13.6′E, 901.6 m water depth) on the Yermak Plateau (Fig. 1). Samples consisting of 10 cm^3 were washed through a 63-µm sieve and the size fraction >180 µm was examined for ostracodes. This report discusses ostracodes from 11 samples from Hole 910A, 26 samples from Hole 910C, 14 samples from Hole 910D, and 14 samples from Hole 911A (Tables 1–4).

Because this is the first ODP Leg to obtain sediments from the Arctic Ocean, it is important to comment on the preservation of ostracodes at Sites 910 and 911. Previous studies of ostracodes from

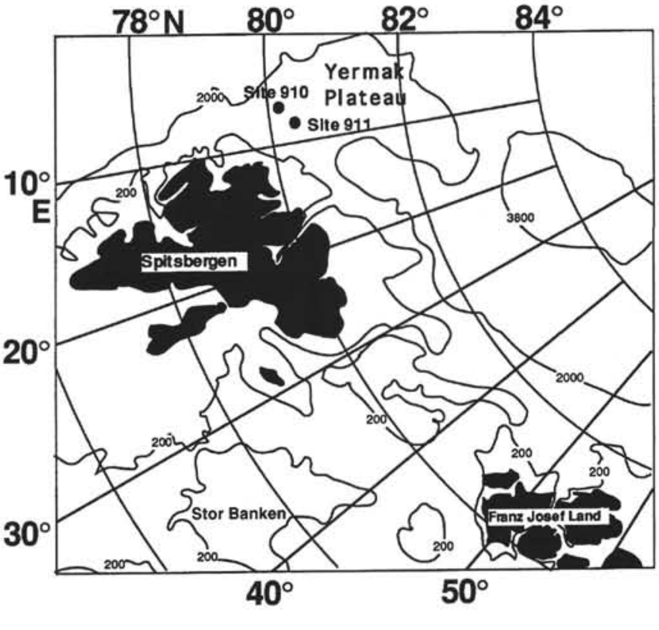

Figure 1. Map showing location of Sites 910 and 911 on the Yermak Plateau, eastern Arctic Ocean.

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[2]970 National Center, 2201 Sunrise Valley Dr., U.S. Geological Survey, Reston, VA 22092, U.S.A. tcronin@geochange.er.usgs.gov

[3]Institute of Earth Studies, University of Wales, Aberystwyth, Dyfed, Wales, United Kingdom.

Table 1. Hole 910A ostracode occurrences.

Core, section, interval (cm)	*C. alatum*	*C. arcuatum*	*C. carolinae*	*C. hamatum*	*C. inflatum*	*C. paralatissimum*	*C. pseudoinflatum*	*C. simplex*	*C. testudo*	*Elofsonella concinna*	*Eucytherura delineata*	*Krithe glacialis*	*Muellerina abyssicola*	*Polycope* spp.	*Pseudocythere caudata*	*Rabilimis* sp.	*S. punctillata*	*Sarsicytheridea bradii*	*Sclerochilus contortus*	*Thaerocythere crenulata*	Other
151-910A-																					
1H-3, 28–30				1																1	
1H-3, 104–106	1											2									
1H-4, 28–30		2						1	1												
2H-1, 93–95						1							2								
2H-3, 93–95																1					
2H-4, 93–95	2		2								1				1						2
2H-6, 93–95			1						2			1	1	1	1		1				1
3H-1, 114–116			1							2		1									1
3H-3, 84–86										1								1			1
3H-CC, 41–43							1						1								
4H-1, 125–127					1											1			1		1

Table 2. Hole 910C ostracode occurrences.

Core, section, interval (cm)	*Cytheropteron angulatum*	*C. carolinae*	*C. inflatum*	*C. psuedoinflatum*	*C. arcuatum*	*C. paralatissimum*	*Cluthia cluthae*	*Henryhowella asperrima*	*Heterocyprideis sorbyana*	*Krithe glacialis*	*Loxoconcha* sp.	*Muellerina abyssicola*	*Pterygo.* cf. *P. vannieuwenhuisei*	*Rabilimis* sp.	*Sarsicytheridea punctillata*	*Sarsicytheridea bradii*	*Thaerocythere* sp.	Other
151-910C-																		
1R-1, 5–7					1		3								2			
1R-CC, 8–10					1													
3R-1, 41–43	1								1					1		2		
12R-1, 62–65		1		1														
14R-1,131–133																	5	
17R-1, 38–40			1									2						1
17R-2, 38–40			1						1			2						1
19R-1, 35–37														1				1
19R-2, 35–37										2	1							2
20R-2, 46–49										2								1
20R-3, 134–136																		1
24R-1, 130–132																		1
26R-2, 80–82								1					1					1
26R-4, 80–83																		1
26R-CC																		1
27R-2, 82–84											2							
27R-CC								1						2				
29R-2, 79–81										1								
38R-CC														1				
39R-4, 80–82														1				
39R-CC								2										
43R-CC													1					
45R-CC													1	3				1
46R-2, 111–113										1								
52R-6, 80–83																		
53R-CC	2					2												

Leg 104 on the Voring Plateau showed ostracodes were very rare (Malz, 1989) and Mostafawi (1990) found them to be rare as well in a gravity core from the Fram Strait. Conversely, Cronin et al. (1994, 1995) found ostracodes abundant in sediments obtained from box-cores, multicores, and kastenlot cores throughout the Eurasian Basin, especially in sediments representing deglacial and interglacial periods. Ostracodes were quite common in Quaternary sediments from core PS-2212, located at a depth of 2485 m on the Yermak Plateau (Cronin et al., 1994).

We identified ostracode species and genera following the taxonomy of Cronin (1989, 1991), Brouwers et al. (1991), Penney (1993), and Maybury and Whatley (1990) and the reader is referred to these papers for scanning electron photographs of the key species. Almost all specimens could be easily assigned to species described from late Neogene sediments of the Arctic region or from modern faunas in the Arctic and subarctic. We also used the ecological and zoogeographical data available in Elofson (1941), Neale and Howe (1975), Joy and Clark (1977), Lord et al., (1988), Cronin et al. (1991), Hartmann (1992), and Cronin (in press) to make paleoceanographic inferences.

RESULTS

In samples from Sites 910 and 911 on the Yermak Plateau, ostracodes were sparse or absent; most Pliocene and Pleistocene sediments from this part of the Yermak Plateau are dominated by silici-

Table 3. Hole 910D ostracode occurrences.

Core, section, interval (cm)	*Argilloecia* sp.	*C. alatum*	*C. arcuatum*	*C. carolinae*	*C. hamatum*	*C. inflatum*	*C.* n. sp.	*C. simplex*	*C. testudo*	*Cluthia cluthae*	*Elofsonella concinna*	*Eucythere* sp.	*?Hermanities* sp.	*Heterocyprideis sorbyana*	*?Hirschmannia* sp.	*Krithe glacialis*	*Muellerina abyssicola*	*Pseudocythere caudata*	*Rabilimis* sp.	*S. punctillata*	*Sarsicytheridea bradii*	*Thaerocythere* sp.	Other
151-910D-																							
1H-CC	8	5		5	9	4			9			5		1		39	5	1					2
10X-2, 75–77											4		4	3		2	6		1		1	1	
10X-3, 74–76																	2						1
10X-CC	1			1	1	8	1							1					1		10	15	5
11X-1, 74–76																						4	
11X-6, 74–76																						3	
11X-CC					1	1	2	1			7		13	2		1	2		3	8	9	6	1
12X-4, 74–76																1							
12X-CC			1					4	1	1	1			6		2							8
13X-CC													1			1			1				
14X-CC						1																2	
15X-CC						1			1				5					1	2			7	
17X-CC															1		6						2
18X-CC								1															

Table 4. Hole 911A ostracode occurrences.

Core, section, interval (cm)	*Argilloecia* sp.	*Cytheropteron alatum*	*C. arcuatum*	*C. carolinae*	*C. hamatum*	*C. inflatum*	*C.* spp.	*C. paralatissimum*	*C. simplex*	*C. testudo*	*Cluthia cluthae*	*Elofsonella concinna*	*Krithe glacialis*	*Polycope* spp.
151-911A-														
11H-5, 29–31													1	
12H-3, 39–42						2		1					3	
12H-3, 72–75					2	3				2			2	
12H-4, 39–42						2	2							
12H-6, 39–42		1		1			2			1				
12H-6, 72–75					1									
13H-3, 39–41													3	
13H-4, 61–63			1										3	
13H-5, 39–41											2	1		
13H-5, 61–63											1		3	
13H-6, 39–41									2					
13H-6, 61–63	1										1			
13H-7, 41–44							1				1			2
13H-7, 61–63												1		

clastic material and have relatively few calcareous microfossils. However in those samples where ostracodes occur, notably at Hole 910D, the shells are very well preserved and, in fact, articulated carapaces of adult and juvenile individuals occur in many samples. Articulated juvenile carapaces indicate little or no post-mortem transport because the hinge which holds the two valves together in many ostracode genera is not well developed prior to the adult molt. The material examined was sufficient to meet the goals of examining long-term trends in ostracode assemblages during the Pliocene and Quaternary and establishing whether there is faunal evidence for warm Atlantic water at mid-depths in the Pliocene. Although the present report is considered preliminary, it presents new evidence for Pliocene warm oceanic currents in high latitudes and for progressive oceanic cooling during the last 5 million years. The data presented here also compliments ostracode data obtained from late Quaternary sediments in deeper water environments of the Eurasian Basin that show short term faunal changes in the Arctic Ocean associated with glacial-deglacial cycles (Cronin et al., 1994, 1995). This section summarizes the key elements of assemblages from Sites 910 and 911 with emphasis on the biostratigraphic and paleoceanographic significance of key elements of the faunas.

HOLE 910A

We examined material from Cores 151-910A-1H to 4H to obtain a general understanding of the late Quaternary faunas at this site. Ostracodes were scarce but well-preserved; sometimes articulated carapaces were found, indicating little or no post-mortem transport. The following list gives the most important species found:

Cytheropteron alatum Sars, 1866
Cytheropteron paralatissimum Swain, 1963
Cytheropteron testudo Sars, 1866
Elofsonella concinna (Jones, 1857)
Eucytherura delineata Whatley and Eynon, in press
Krithe glacialis (Brady, Crosskey & Robertson, 1874)
Muellerina abyssicola (Sars, 1866)
Pseudocythere caudata Sars, 1866
Rabilimis sp.
Thaerocythere crenulata (Sars, 1866)

This assemblage contains species typical of those found in modern coretop samples of the Eurasian Basin near Spitsbergen, the Yermak Plateau, and eastern Fram Strait at mid-depths (about 200–1000 m water depth). *Cytheropteron testudo* Sars and *Eucytherura delineata* Whatley and Eynon, in particular, represent species characteristic of modern Atlantic water in the Eurasian Arctic. It is important to note that more detailed stratigraphic sampling of this interval is necessary to determine if short-term faunal changes caused by glacial-interglacial cycles have occurred.

HOLE 910C

We examined samples from Cores 151-910C-1R to 3R and from 151-910C-12R to 53R-CC. Ostracodes were scarce and variably preserved. Among those species recovered, the following have biostratigraphic and paleoenvironmental significance:

Cytheropteron inflatum (Brady, Crosskey & Robertson, 1874)
Henryhowella asperrima (Reuss, 1850)

Krithe glacialis (Brady, Crosskey & Robertson, 1874)
Loxoconcha sp.
Muellerina abyssicola (Sars, 1866)
Pterygocythereis vannieuwenhuisei Brouwers, 1987
Rabilimis sp.

This assemblage includes the important species *P. vannieuwenhuisei,* which occurs in the Pliocene Kap Kobenhavn Formation of Northern Greenland (Brouwers et al. 1991) and the Lodin Elv Formation near Scoresby Sund, East Greenland (Penney, 1993). It indicates significantly warmer bottom water temperatures than those in the region today and an age of at least 2.5 Ma for Cores 151-910C-26R to 45R. The occurrence of *Loxoconcha,* probably a form conspecific or closely related to *L. venepidermoidea* Swain, 1963, also indicates relatively warm oceanic temperatures. The occurrences of *Muellerina abyssicola* (Sars, 1866) and *Cytheropteron inflatum* (Brady, Crosskey & Robertson, 1874) at this site in Sample 151-910C-17R-2, 38–40 cm, may represent the first stratigraphic occurrences in the Arctic of these two species.

HOLE 910D

We studied Cores 151-910D-1H-CC to 18X-CC in which ostracodes were more common than at Sites 910A and 910C and most specimens were well preserved; some carapaces were still articulated, indicating little or no post-mortem transport. We identified the following species:

Cluthia cluthae (Brady, Crosskey & Robertson, 1874)
Cytheropteron arcuatum (Brady, Crosskey & Robertson, 1874)
Cytheropteron hamatum Sars, 1866
Cytheropteron inflatum (Brady, Crosskey & Robertson, 1874)
Cytheropteron simplex Whatley and Masson, 1979
Cytheropteron testudo Sars, 1866
Cytheropteron n. sp.
Elofsonella concinna (Jones, 1857)
?Hermanites sp.
Heterocyprideis sorbyana (Jones, 1857)
?Hirschmannia sp.
Muellerina abyssicola (Sars, 1866)
Rabilimis sp.
Sarsicytheridea bradii (Norman, 1865)
Sarsicytheridea punctillata (Brady, 1865)
Thaerocythere sp.

The ostracodes in Cores 151-910D-10X to 18X show important changes suggesting frequent environmental changes. In general, most species in the fauna are typical of the modern Arctic Ocean at mid-depths, with two important exceptions: the species tentatively identified as members of the genera *Hermanites* and *Hirschmannia.* The former is closely related to the *H.* cf. *paijenborchiana* (Keij, 1957) lineage and perhaps to *Cletocythereis* cf. *jonesi.* The latter is an unknown species of *Hirschmannia.* Both taxa suggest relatively warm bottom waters, at least at certain times, in this interval. Although additional taxonomic and ecologic study are necessary to provide firm identifications and environmental interpretations, these two taxa are not known from this region or elsewhere in the Arctic, based on analyses of more than 400 coretops assemblages (Cronin et al. 1994; 1995). The existence of relatively warm inflowing Atlantic water is also supported by the presence in most samples from this interval of *M. abyssicola* and *Thaerocythere* sp., a species closely related to the living species *Thaerocythere crenulata.* It is important to note that several related species in these genera occur in the late Pliocene St. Erth beds of England (Maybury and Whatley, 1990) and the early to late Pliocene Tjörnes beds of northern Iceland (Cronin, 1991).

HOLE 911A

We examined ostracodes from Cores 151-911A-11H to 13H to obtain information on early Pleistocene faunas. Ostracodes were sparse but well preserved in these samples; *Cluthia* and *Argilloecia* have carapaces still articulated, indicating little or no post-mortem transport. The following taxa were found.

Argilloecia sp.
Cluthia cluthae (Brady, Crosskey & Robertson, 1874)
Cytheropteron arcuatum (Brady, Crosskey & Robertson, 1874)
Cytheropteron hamatum Sars, 1866
Cytheropteron inflatum (Brady, Crosskey & Robertson, 1874)
Cytheropteron simplex Whatley and Masson, 1979
Elofsonella concinna (Jones, 1857)
Krithe glacialis Brady, 1868
Polycope sp.

This assemblage consists predominantly of *Cytheropteron* and is typical of those living at mid-depths on the outer shelf and upper slope of the modern Arctic Ocean. Many of these species occur frequently in late Quaternary mid-depth assemblages.

SUMMARY

Preliminary analyses of Ostracoda from Leg 151 sediments from the Yermak Plateau yielded important biostratigraphic and paleoceanographic data on the late Neogene history of this region. The Ostracoda from Hole 910C provides biostratigraphic support that sediments recovered from Cores 151-910C-11R through 45R are Pliocene in age because several species (*?Hermanites* sp., *Pterygocythereis vannieuwenhuisei, Rabilimis* sp., *Thaerocythere* sp.) are known only from Pliocene sediments exposed on Greenland, North America, northern Europe, and England. The Leg 151 material also substantially improves the ostracode biostratigraphy in the Arctic because it provides additional stratigraphic data on the extinct species *Pterygocythereis vannieuwenhuisei* Brouwers, 1987 and *?Hermanites* sp. and on the stratigraphic ranges of extant species such as *Cluthia cluthae* (Brady, Crosskey & Robertson, 1874), *Elofsonella concinna* (Jones, 1857), *Heterocyprideis sorbyana* (Jones, 1857), *Muellerina abyssicola* (Sars, 1866), *Rabilimis* sp., *Sarsicytheridea bradii* (Norman, 1865), *Sarsicytheridea punctillata* (Brady, 1865), *Thaerocythere* sp., and several species of *Cytheropteron.*

Ostracodes from Sites 910 and 911 also indicate that Pliocene faunal assemblages were distinct from those that characterized the Quaternary. In general, there is evidence for warm water temperatures during the early and the late Pliocene from Site 910 and for cooler oceanic conditions at Site 911 by at least the early Quaternary. The preliminary data from Cores 151-910D-10X through 13X indicate that this interval records an important transition from warmer oceanic conditions to the relatively cold waters of today. However, additional studies of Leg 151 material are needed to determine the age of maximum Pliocene warmth and the timing of late Pliocene–Quaternary cooling.

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