Micropaleontology and Sedimentology of the PB Borehole Series, Prudhoe Bay, Alaska

U.S. GEOLOGICAL SURVEY BULLETIN 1598

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By Kristin McDougall, Elisabeth Brouwers, and Peggy Smith

Three major sedimentary units are recognized in the late Quaternary strata of the Arctic Coastal Plain. Benthic foraminiferal and ostracode assemblages in the marine deposits are correlated with four late Quaternary marine transgressions

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Micropaleontology and Sedimentology of the PB Borehole Series, Prudhoe Bay, Alaska

By Kristin McDougall, Elisabeth Brouwers, *and* Peggy Smith

Abstract

Sedimentologic and micropaleontologic (foraminiferal and ostracode) characterisitics of seven short boreholes were examined to develop a stratigraphic framework for the late Quaternary of the Arctic Coastal Plain and Beaufort Sea. Three major sedimentary units are recognized: alluvium, glacial outwash, and marine deposits. Data are not sufficient to develop a detailed stratigraphy or geochronology of the alluvium and outwash sequences. For the marine sediments, a moderately detailed stratigraphy is possible.

Marine sediments range from beach sand and sandy gravel to clay and silty clay typical of shallow to mid-shelf environments. Three benthic foraminiferal and ostracode assemblages are recognized in the clay and silty clay sediments. The sediments and faunas are correlated with four late Pleistocene to Holocene transgressions: in ascending order, Pelukian, Simpsonian, middle Wisconsin, and Flandrian. The transgressive marine units consist of a basal pebbly sandy silt or clayey sand which grades upward to silty clay or clay as water depths increase. The initial faunal assemblage is composed of species which prefer low salinity, cool, shallow waters. These faunas are replaced by assemblages that prefer deeper, warmer waters as the transgression proceeds. Pelukian assemblages are characterized by species which indicate deeper and warmer marine conditions than presently occur in the study area (common Cassidulina, Stainforthia concava, Krithe glacialis, and Rabilimis mirabilis) as well as several Atlantic immigrants (such as Cluthia cluthae). Although indicative of slightly shallower, slightly cooler waters, the Simpsonian assemblages are similar to the Pelukian assemblages. Cassidulinids decrease in abundance while the shallow-water elphidiums increase. Immigrant species are from both the Bering Sea and the subfrigid to frigid Atlantic Ocean (such as Finmarchinella, Roundstonia, and Sarsicytheridea). Middle Wisconsin foraminiferal assemblages are recognized by low abundance, low diversity, and the dominance of Elphidium clavatum. Flandrian faunas are abundant with moderate to low diversities. Shallow inner neritic assemblages are characterized by Elphidium, Heterocyprideis, and other common genera. Deeper inner neritic assemblages are more diverse and include such species as Buccella frigida and Normanicythere leioderma. Middle Wisconsin and Flandrian faunas cannot be differentiated by ostracodes.

INTRODUCTION

During the past decade, considerable research has focused on the continental shelf of the Beaufort Sea as interest has risen in exploration and development of oil and gas resources in the region. This report is an outgrowth of studies on offshore permafrost undertaken by the U.S. Geological Survey (USGS), R. E. Lewellen of Arctic Research Inc., and the Cold Regions Research and Engineering Laboratory (CRREL) under the auspices of the Alaska Outer Continental Shelf Environmental Assessment Program (OCSEAP). Eight shallow boreholes were drilled through shorefast ice in the Prudhoe Bay area of northern Alaska during the spring of 1976 and 1977. Cores were sampled for stratigraphic, paleontologic, and geochronologic studies by the U.S. Geological Survey. The resulting data were utilized for thermal modeling and for developing models of offshore permafrost distribution. This study was part of OCSEAP, supported in part by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration.

Paleontologic and sedimentologic studies on the PB boreholes examined the possibility of developing a stratigraphic framework for Quaternary strata along the Arctic Coastal Plain and adjacent Beaufort Sea. A biostratigraphic framework based on benthic foraminifers and ostracodes is most useful because planktic foraminifers, radiolarians, and calcareous nannoplankton are absent from these shallow-water deposits. A few diatoms are present but are primarily long-ranging marine and nonmarine benthic forms that are not useful for detailed stratigraphic work (J. A. Barron, oral commun., 1980). Pollen analysis of selected samples from borehole PB-2 (Nelson, 1979) indicates that palynology can also provide stratigraphic information, but more detailed studies on the palynomorph assemblages have not yet been undertaken. Only a few first or last appearances or evolutionary trends are found in the Arctic Quaternary record for either the benthic foraminifers or the ostracodes, thus both groups must be used to establish a stratigraphic framework. Different source areas for the sedimentary units produce distinctive sediment types, or lithologies, permitting glaciomarine sediments to be distinguished from sediment sequences of more local provenance. These lithologies and sedimentary units can in turn be used to develop a lithostratigraphic framework.

This report documents our interpretations of the lithology and paleoenvironment of the transgressive sequences in the PB boreholes, suggests biostratigraphic and lithostratigraphic frameworks, and briefly considers the geologic history of the Beaufort Sea continental shelf during the late Quaternary. Available geochronologic data are included for each PB borehole.

MATERIALS, METHODS, AND LOCATION

Detailed lithologic logs were compiled for seven of the boreholes at the time of drilling. Core samples were recovered at intervals ranging from 0.5 m to 6 m; wash samples were taken in the coarse-grained intervals where no core sample was collected (appendix I). The cores were initially radiographed to identify sedimentary structures, lithologic changes, and the spatial distribution of mollusks and pebbles; subsamples were then taken for sedimentologic, paleontologic, and chronologic studies. Pebbles from the marine mud and clay were identified lithologically in order to determine whether they were derived from local sources (coastal bluffs and beaches) or from exotic sources (ice rafting from distant regions). Paleontological studies involved the identification and analysis of the foraminifer and ostracode faunas present in the cores. Geochronologic studies included radiocarbon dating of the younger fossil plant material and amino-acid racemization ratios of selected foraminifer and mollusk species.

All microfossil subsamples were air dried or dried in an oven at low temperatures (<50° C). One hundred grams (dry weight) of sediment was soaked for 4 to 12 hours in water and washed through a 250 mesh screen (63-micrometer opening). Foraminifers, ostracodes, and representative amounts of associated organic material were picked from the washed residues (appendix II). Slides and residues are on file with the Branch of Paleontology and Stratigraphy in Menlo Park, Calif. (residues and foraminifer slides) and Denver, Colo. (ostracode slides).

The seven boreholes used for this study are located on two cross-sectional lines originally established to study the engineering characteristics of subsea sediments (fig. 1). Borehole PB-4 was an engineering probe hole only, and no samples were collected for lithologic or paleontologic studies. Boreholes PB-1 and PB-5 were located 4 km and 8 km from land, respectively, on a line extending northwestward from the East Arco Dock to a point slightly beyond the shoal that separates Prudhoe Bay from Steffansson Sound. These two holes were located in very shallow water and were terminated at shallow depths within the sediments as well. Boreholes PB-6, PB-7, PB-3, PB-8, and PB-2 were drilled along a line extending north from the West Arco Dock to a point several kilometers beyond Reindeer Island. Boreholes

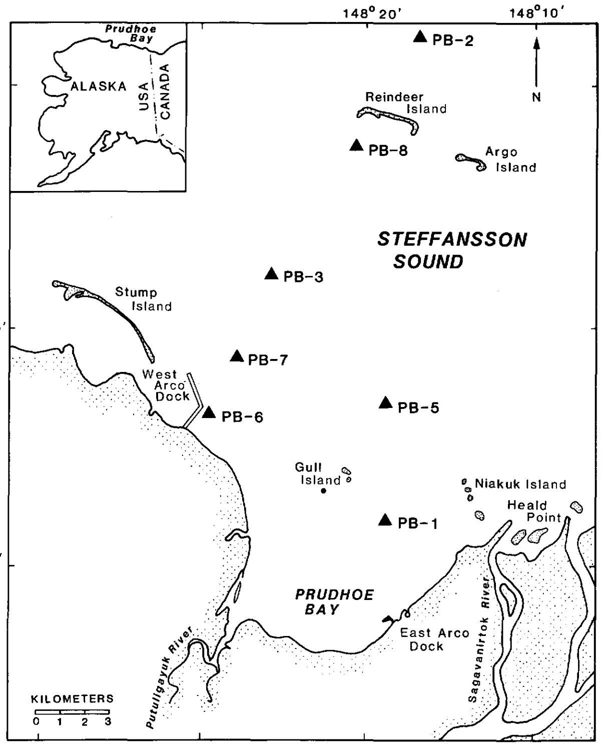


Figure 1. Prudhoe Bay showing locations of boreholes (triangles).

PB-6, PB-7, and PB-3 were situated 1, 3, and 6.5 km, respectively, north of the West Arco Dock; boreholes PB-8 and PB-2 were drilled 1 km shoreward and 3 km seaward of Reindeer Island, respectively. Water depths and the thickness of fine-grained sediment increase seaward along this line. Sample intervals and measurements of sea-ice thickness, water depth, and total depth of each hole are presented in appendix I.

LATE QUATERNARY TRANSGRESSIONS

The rapidly oscillating sea level of the Quaternary left terraces, wavecut cliffs, beach ridges, and fossiliferous marine deposits during high stands of the sea, and paleosols, subaerial deposits, and unconformities during the low stands over wide areas of the Arctic Coastal Plain. These transgressions were named by Hopkins (1967). Inferred climatic conditions, water depths, and temperatures have been discussed by Hopkins (1967) and McCulloch (1967), and more recently by Brigham (1984) and Brouwers and others (1984). Carter and Brigham-Grette (in press) have revised and suggested new names for many of these transgressions based on geologic data acquired since 1967 and new dating techniques (amino-acid racemization and thermoluminescence).

Four late Quaternary transgressions are recognized in the boreholes: in ascending order, Pelukian, Simpsonian, middle Wisconsin, and Flandrian. The Pelukian transgression defined by Hopkins (1967) refers to the marine transgression that occurred during the Sangamon interglacial (ca. 125 ka). Portions of the Gubik Formation were deposited during this transgression (Brigham, 1984; Brouwers and others, 1984; Carter and Brigham-Grette, in press). The Simpsonian transgression defined by Carter and Brigham-Grette (in press) occurred near the end of the Sangamon interglacial and continued into the early Wisconsin. The age of this transgression has been estimated as 70 to 80 ka (Carter and Brigham-Grette, in press) or 90 to 105 ka (Brouwers and others, 1984). The Flaxman Member of the Gubik Formation (Dinter, 1985) and some sediments previously referred to the Woronzofian transgression of Hopkins (1967) were deposited during this transgression (Brigham, 1984; Brouwers and others, 1984; Carter and Brigham-Grette, in press). The term middle Wisconsin transgression is here used for the transgression that occurred during middle Wisconsin time, about 24 to 50 ka. This transgression includes some deposits formerly assigned to the Woronzonfian transgression of Hopkins (1967). Similar age sediments and faunas have been identified on Baffin Island (Cape Broughten Interstadial; Andrews and Miller, 1972; Andrews, 1965; Feyling-Hanssen, 1976), Greenland (Jameson Land Interstadial; Funder and Hjort, 1973; Feyling-Hanssen, 1976), and Norway (Sandnes Interstadial; Feyling-Hanssen, 1971, 1974, 1976). These sediments range in age from 24 to 50 ka, and have been correlated with the middle Wisconsin interstadial of North America, Europe, and the Soviet Union (Flint, 1971; Feyling-Hanssen, 1976). A name for this transgression is not proposed at this time. The Flandrian transgression is a European term for the transgression that accompanied the deglaciation following the late Wisconsin maximum (Gignoux, 1950; Flint, 1971). This transgression represents the last 18 ka, and therefore ranges in age from late Pleistocene to Holocene. In North America, this transgression is often referred to informally as the Holocene transgression. Data available on these transgressive sequences are summarized in table 1.

BOREHOLE PB-1

Sediments

Borehole PB-1, which was drilled approximately in the middle of Prudhoe Bay, cored 28.5 m of Pleistocene and Holocene sediment. The basal 22.2 m of sediment (31.2 to 9.0 m below sea level) is outwash, which consists of 2.2 m of sandy gravel, 2.5 m of fine sand, 6.5 m of openwork gravel, and 11 m of pebbly

Table 1. Quaternary marine transgressions in Alaska. Data modified from Hopkins (1967), McCulloch (1967), Brigham (1984), Brouwers and others (1984), Carter and Brigham-Grette (in press).

[Sea level and temperature are relative to present conditions.]
<, less than; ±, plus or minus; +, plus

EPOCH	NAME	AGE	SEA LEVEL	CLIMATE
HOLOCENE	Flandrian	<18,000 yrs (late Wisconsin-Holocene)	present	present
LATE PLEISTOCENE	middle Wisconsin	ca. 25 ka (middle Wisconsin)	±2 m	Slightly cooler
	Simpsonian	ca. 80 ka (late Sangamon-early wisconsin)	+7 m	Same to slightly cooler
	Pelukian	ca. 125 ka (Sangamon)	+7-10 meters	Water warmer, air slightly warmer

sand in which several fining-up sequences from gravel to clayey silt were recognized. The upward fining of the sediment represents reduction in both sediment load and stream capacity as the main channel of the Sagavanirktok River moved eastward to its present position during late Wisconsin and early Holocene time. Above the outwash, sandy gravel fines upward into sand, silt, and pebbly clay over a 2.5-m interval, representing a change from a beach to a nearshore environment. The uppermost 3.8 m of sediment (6.5 to 2.7 m below sea level) consists of thinly bedded organic and inorganic silt and clayey silt, representing Holocene infilling of Prudhoe Bay (fig. 2). A radiocarbon age determination of 490±90 yr B.P. (USGS-132) for detrital peat at 6.5 m below sea level confirms the youthfulness of this sediment.

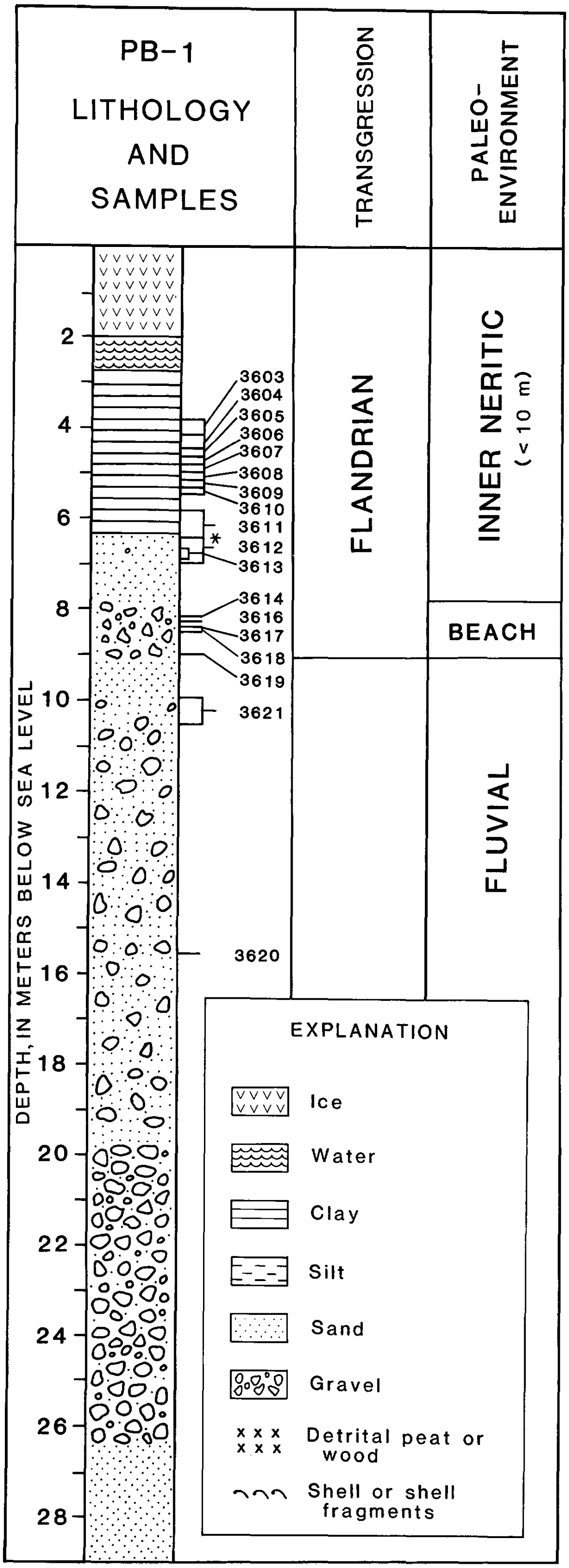
Benthic Foraminifers

Benthic foraminifers are present in samples from near the base of the gradational interval at 8.2 m below sea level (sample MF3614) to the top of the sediment column at 2.7 m below sea level. Samples MF3620 to MF3616, below 8.2 m, do not contain benthic foraminifers (figs. 3 and 4; table 2).

Although three species of benthic foraminifers are present in the oldest fossiliferous sample, MF3614, Elphidium orbiculare (87 percent) dominates. Modern distributions of E. orbiculare suggest an upper depth limit of less than 10 m and low salinity conditions (Andersen, 1963; Knebel and others, 1974; McDougall, 1982, and unpublished E and R reports, 1985). The high abundances of E. orbiculare and the presence of sandy sediment suggest that deposition was occurring at depths of less than 10 m in an area of low salinity like that near a delta. Sample MF3613 (6.7 m below sea level) contains a more diverse fauna with common Elphidium excavatum alba (36 percent) and abundant though slightly reduced numbers of E. orbiculare (55 percent). This faunal change indicates increasing water depths, slightly higher salinities, and warmer water temperatures upsection.

The foraminiferal diversity (species per sample) and foraminiferal number (specimens per 100 grams of sediment) in the upper silt and clayey silt of this borehole (samples MF3612 to MF3603, 6.8 to 3.8 m below sea level) indicate a slight increase in water depth and (or) salinity. The benthic foraminiferal assemblages are similar to the modern Prudhoe Bay assemblages (Lagoe, 1979b); thus the environment during the deposition of these assemblages and sediments is interpreted as being less than 10 m in depth, with highly variable salinities and water temperatures.

The foraminiferal data suggest that the entire fossiliferous section of this borehole is Holocene in age and represents the Flandrian transgression. The basis for this interpretation is (1) high abundances of Elphidium excavatum alba and moderate to high abundances of E. orbiculare, and (2) rare occurrences of E. clavatum, E. asklundi, and Elphidiella groenlandica (fig. 4; table 2). Elphidium excavatum alba evolved in or was introduced into the Arctic Ocean near the end of the Pelukian transgression, and



*Radiocarbon date 490±90 yr. B.P.

Figure 2. Lithology and paleoenvironment of transgressive sequences in borehole PB-1. Locations of samples (MF numbers) are indicated on the stratigraphic column.

increased rapidly in abundance throughout the Flandrian. Elphidium asklundi and Elphidiella groenlandica, however, appear to have become extinct or unable to tolerate the harsh Arctic environments during the latter part of the Pelukian or Simpsonian transgressions (K. L. Knudsen, University of Aarhus, Denmark, oral commun., 1979). These species have sturdy tests and their occurrence in Flandrian sediments is believed to result from reworking of older sediments; their tests are poorly preserved, whereas those of the other species are well preserved. The occurrences of Elphidium asklundi and Elphidiella groenlandica suggest erosion and reworking of older marine sediments in samples MF3613 to MF3608 and MF3606 to MF3603.

Ostracodes

The oldest sample (MF3616) in borehole PB-1 containing ostracodes is at 8.2 m below sea level (figs. 2 and 5; table 3). In this sample, the ostracode species indicate shallow nearshore waters, and slightly reduced or fluctuating salinity. Three species dominate the assemblage: Paracyprideis pseudopunctillata (50 percent), Heterocyprideis sorbyana (31 percent), and Loxoconcha elliptica (12 percent). The dominance of the first two eurytopic species, together with the inequitable distribution of individuals among the three species, supports the interpretation of reduced salinity. These conditions generally occur in nearshore areas, where a river contributes fresh water. Both the Sagavanirktok and Putuligayuk Rivers are currently within 6 km of PB-1, and could provide freshwater on a seasonal basis (summer and fall). The presence of the freshwater species Candona cf. C. candida further suggests a nonmarine influence. Perennial reduced salinity conditions, or at least seasonal reductions, are also indicated in sample MF3613 (6.5 to 6.7 m below sea level), where the euryhaline species Heterocyprideis sorbyana dominates the assemblage (94 percent).

The ostracode assemblage in sample MF3612 (6.2 to 6.8 m below sea level) shows the highest species diversity and suggests that more normal marine salinity probably prevailed at this time. Nonmarine species are not present in this ostracode assemblage.

Samples MF3611 to MF3603 (6.2 to 3.8 m below sea level) indicate an environment with seasonally fluctuating salinities, as seen in the variable species diversity and abundance (fig. 3). Shallow water conditions probably prevailed throughout this interval. Fluctuations in diversity and abundance in these samples suggests conditions similar to the present environment, which varies from somewhat hypersaline in the winter and spring to brackish in the summer and fall. Nonmarine species are not present in these assemblages.

Summary

The sediments in borehole PB-1 consist of Pleistocene outwash (31.2 to 9.0 m below sea level) overlain by Flandrian beach and nearshore deposits (9.0 to 2.7 m below sea level). Benthic foraminifers and

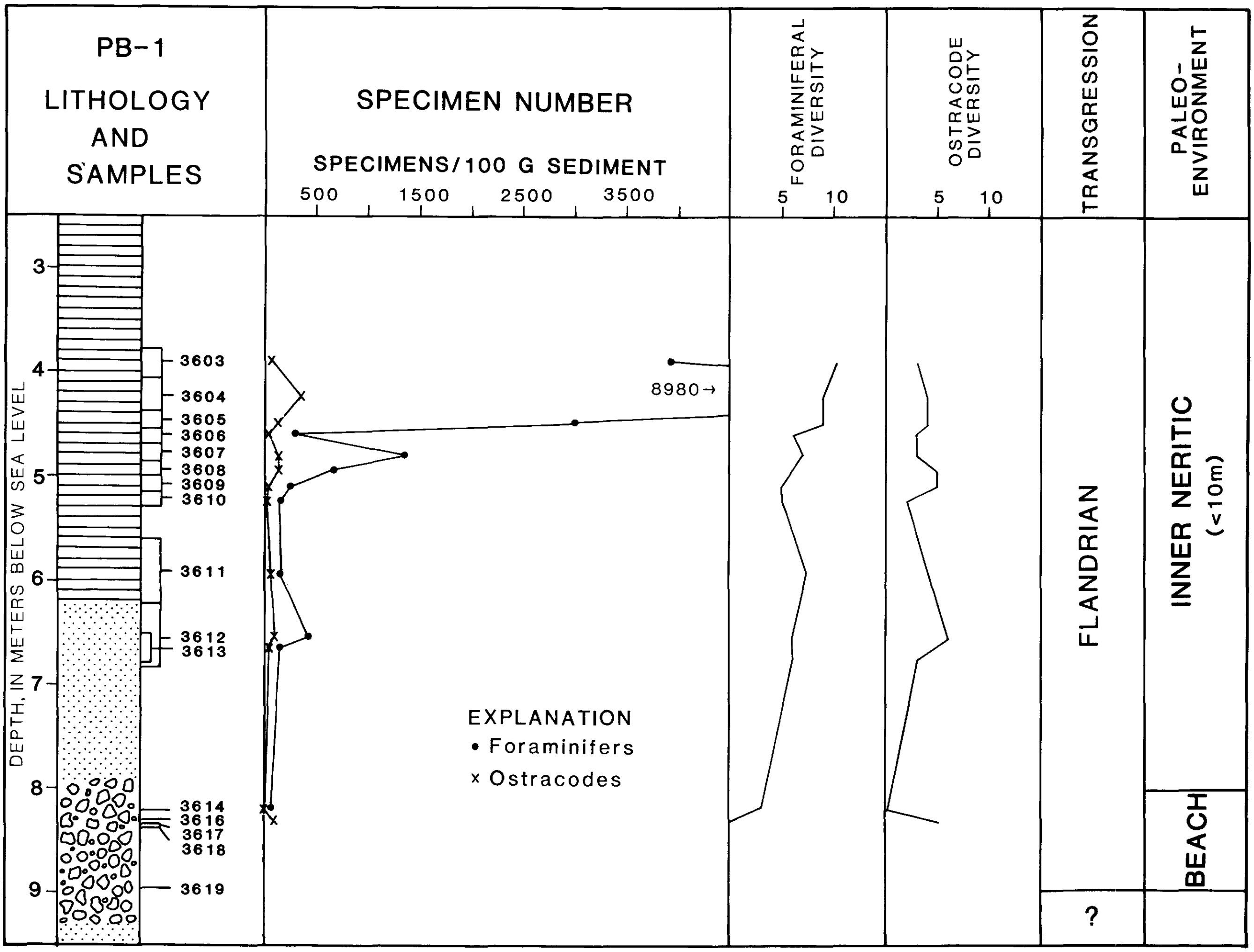


Figure 3. Benthic foraminiferal and ostracode abundance and diversity in borehole PB-1. Specimen number is the number of foraminiferal specimens or ostracode valves per 100 grams of sediment. Diversity is the number of species per sample. See figure 2 for explanation.

ostracodes from the sand to sandy silt at the base of the Flandrian section indicate that water depths were less than 10 m and salinities were low. Rare nonmarine ostracodes were probably introduced by a nearby river. The overlying silt and clay was also deposited at depths of less than 10 m, but salinities varied from hypersaline to brackish, and the nonmarine ostracodes are absent.

BOREHOLE PB-2

Sediments

Borehore PB-2, 3 km seaward of Reindeer Island (fig. 1), contains a record of recent westward and shoreward migration of the barrier island chain as well as a record of pre-Holocene marine transgressions. The basal section of the borehole (41.4 to 22.4 m below sea level) is outwash consisting of 4.5 m of gravel with a minor amount of fine plant debris and coal particles near the base, 4.2 m of sand with minor scattered gravel, and 10.3 m of interbedded sandy gravel, pebbly sand, and silt (fig. 6). Above the outwash, from 22.4 to 21.0 m below sea level, the sediments consist of sandy gravel with shell fragments, representing a beach deposit. Overlying the beach deposits is 9.2 m of predominantly fine-grained late Pleistocene and Holocene marine deposits which can be divided into three units. Paleomagnetic analysis showed that all samples had normal polarity, thus this entire marine sequence is younger than 700,000 years (Hillhouse, 1977).

The lowest unit clearly of marine origin (unit I) is 6.1 m thick (21.0 to 14.9 m below sea level). The lower 5.4 m of unit I consists of massive, gray to olive-gray clayey silt to silty clay with variable, though minor, proportions of fine sand and granules of granite, quartz, chert, and dolomite. Black organic matter, mostly peat or macerated plant fragments, occurs as clots and thin streaks or mottles throughout this part of the unit. The uppermost 0.7 m (15.6 to 14.9 m below sea level) is composed of dense, stiff, brownish-gray clay with thin beds and partings of black organic clay that suggest inclined bedding.

The second marine unit (unit II) is 1.6 m thick (14.9 to 13.3 m below sea level) and is composed of dense, stiff, greenish-black silt with faint mottling and laminations of black organic silt. A thin gravel stringer and masses of limonite suggestive of a paleosol mark the upper boundary of this unit.

The uppermost unit (unit III) is 1.5 m thick (13.3 to 11.8 m below sea level) and consists of interbedded fine sand and silt, overlain by poorly sorted medium sand with lumps of mud, shell fragments, and occasional pebbles. The coarser nature of the uppermost sediments reflects the construction and migration of Reindeer Island.

Two distinctive pebble suites occur in borehole PB-2. One suite, dominated by limestone, black chert, and sandstone, is derived from the nearby Brooks Range and composes the mainland beaches in the Prudhoe Bay area. This suite of pebbles is found in the pebbly sandy silt of unit I. Although the sediments are texturally similar to glaciomarine sediments, the pebbles are probably derived from ice which freezes to beaches during the winter, incorporates beach sediment, and floats away during the breakup. The other suite, dominated by dolomite, red granite, and pink to red orthoquartzite, is derived by ice rafting from northern Canada; this suite is found in Pleistocene gravel on Flaxman Island and composes the gravel of the Midway Island barrier chain (Rodeick, 1975). The dolomite suite makes up the pebble component of unit III as well as the gravel stringer at the top of unit II. Dolomite is also a minor component of the pebble suite near the base of unit I.

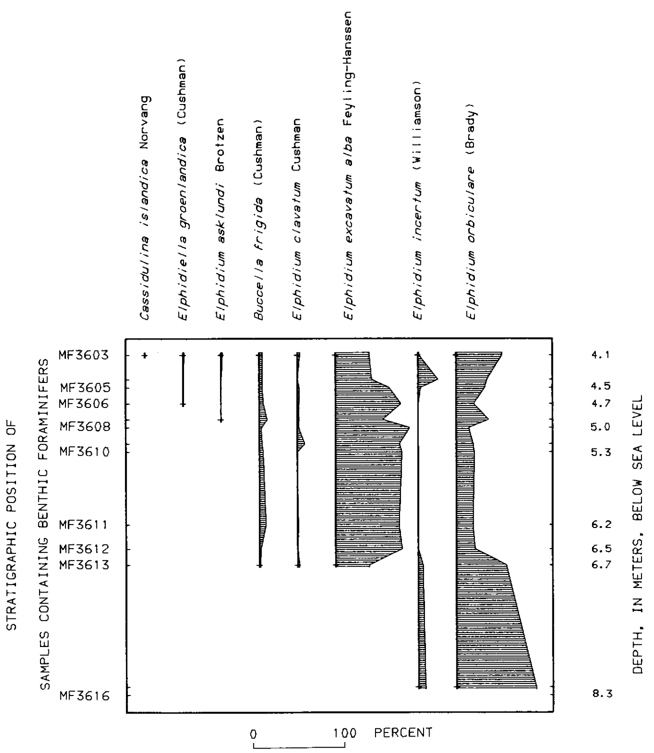


Figure 4. Distribution with depth and relative abundance of selected benthic foraminiferal species in borehole PB-1. Abundances are given as a percent of total foraminiferal fauna (see table 2 for actual values).

Benthic Foraminifers

At least three distinct benthic foraminiferal assemblages are present, indicating that sedimentation was not continuous in PB-2 (figs. 7 and 8; table 4). The three groups are (1) samples MF3641 to MF3633 (20.8 to 15.0 m below sea level); (2) samples MF3632 to MF3631 (14.3 to 13.7 m below sea level); and (3) MF3629 and MF3628 (12.9 to 11.9 m below sea level). Environmental conditions and age interpretations suggested by these faunal groups are (1) a middle neritic fauna representing the Pelukian transgression; (2) a cool inner neritic fauna typical of the Simpsonian transgression; and (3) a shallower inner neritic fauna representing the Flandrian transgression. The youngest faunal group is affected by the migration of a barrier island. Foraminifers are absent in samples MF3651 to MF3642 (39.7 to 20.7 m below sea level).

The oldest faunal group occurs in sediments described as unit I. The oldest sample in this faunal group, MF3641, contains a diverse neritic benthic foraminiferal fauna similar to middle neritic modern Arctic assemblages (Anderson, 1963; Cooper, 1964; Echols, 1974; Lagoe, 1979a, b, 1980; McDougall, 1982). Although species of Elphidium dominate, Cassidulina

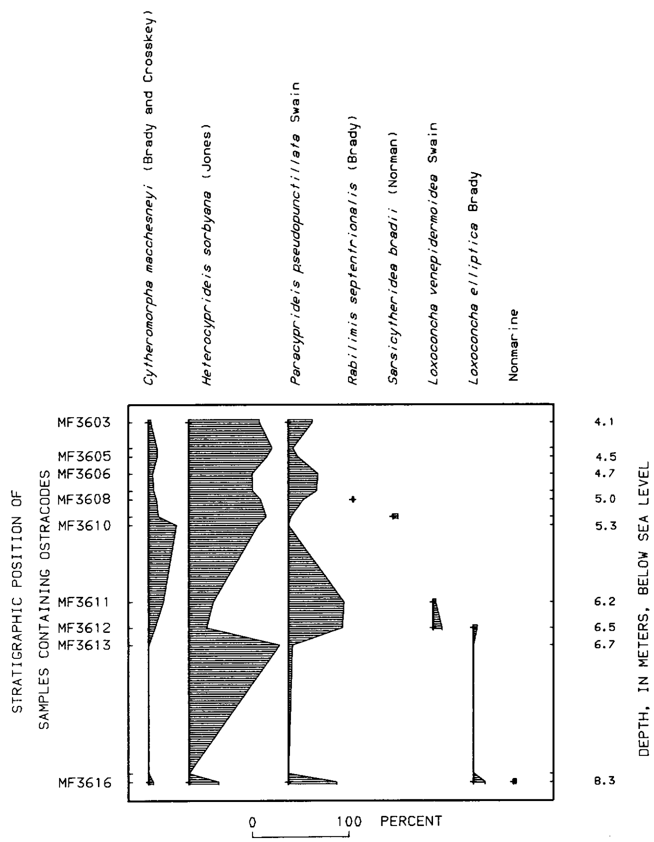


Figure 5. Distribution with depth and relative abundance of selected ostracode species in borehole PB-1. Abundances are given as a percent of total ostracode fauna (see table 3 for actual values); nonmarine species include a rare occurrence of Candona cf. C. candida.

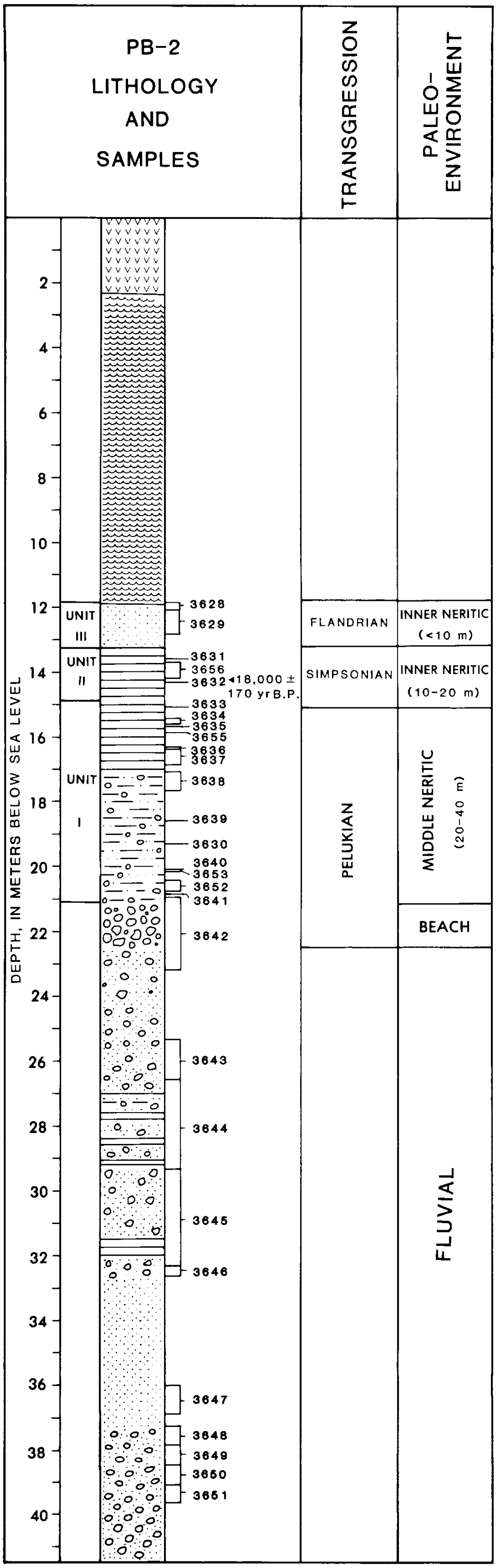


Figure 6. Lithology and paleoenvironment of transgressive sequences in borehole PB-2 (see fig. 2 for explanation).

islandica (average 12 percent) and Cassidulina norcrossi (average 19 percent) are common. The abundance of these two species suggests that water depths were between 15 and 40 m. The rare occurrence of Stainforthia concava (average 1 percent) suggests that depths were greater than or close to 40 m (Echols, 1974, and unpublished data). The increasing diversity (average 12) and foraminiferal number (average 207), and the consistent and slightly higher abundances of Cassidulina norcrossi, C. islandica, and Stainforthia concava indicate that water depths increased throughout the deposition of unit I. Rare species in this interval include many forms that prefer quiet (less turbid) bottom conditions and slowly accumulating mud or clay. Quinqueloculinids and some elphidiums (E. bartletti and E. excavatum alba) are present as rare species in the pebbly mud and are probably transported from a shallower, more turbid environment.

The next youngest faunal group, MF3632, MF3656, and MF3631, occurs in the upper part of the stiff clay. Samples MF3656 and MF3631 have moderate foraminiferal numbers (average 340) whereas sample MF3632 has a high foraminiferal number (2796 specimens). Diversity is low in all three samples (average 9). Benthic foraminifers indicate that deposition occurred at water depths between 10 and 20 m. This interpretation is based on abundant and diverse elphidiums, moderate abundances of Buccella frigida, and the absence of any diagnostic middle shelf species. The presence of Elphidium incertum suggests slightly cooler water temperatures than during the Pelukian or the Flandrian. The rare occurrence of E. excavatum alba indicates that temperatures were warmer than during the glacial cycles and that this assemblage is younger than Pelukian. These combined lines of evidence suggest that unit II, samples MF3632 to MF3631, represents the Simpsonian transgression.

Foraminiferal assemblages in the youngest faunal group, MF3629 and MF3628, suggest decreased water depths. Elphidiums dominate, Buccella frigida is absent, and cassidulinids appear rarely in sample MF3629, probably as the result of reworking of older sediments. Elphidium albiumbilicatum appears as a rare species (4 percent), and this occurrence plus the faunal characteristics described above suggest water depths of 10 m or less. The shallower water depths and the increase in the sand component are believed to be the result of the development of Reindeer Island during the Holocene.

Ostracodes

Samples MF3641 to MF3637 (from 20.8 to 16.2 m below present sea level) contain a distinct ostracode assemblage characteristic of deep (greater than 20 m) and (or) cold water (fig. 9; table 5). The oldest sample, MF3641 at 20.8 m, contains Krithe glacialis, an ostracode of Atlantic affinity, which occurs in open marine waters of normal salinity. Rabilimis mirabilis first appears in sample MF3652 (20.5–20.7 m below sea level); this species is representative of frigid to subfrigid climates of the modern Arctic region, and lives in waters deeper than 20 m with near-normal

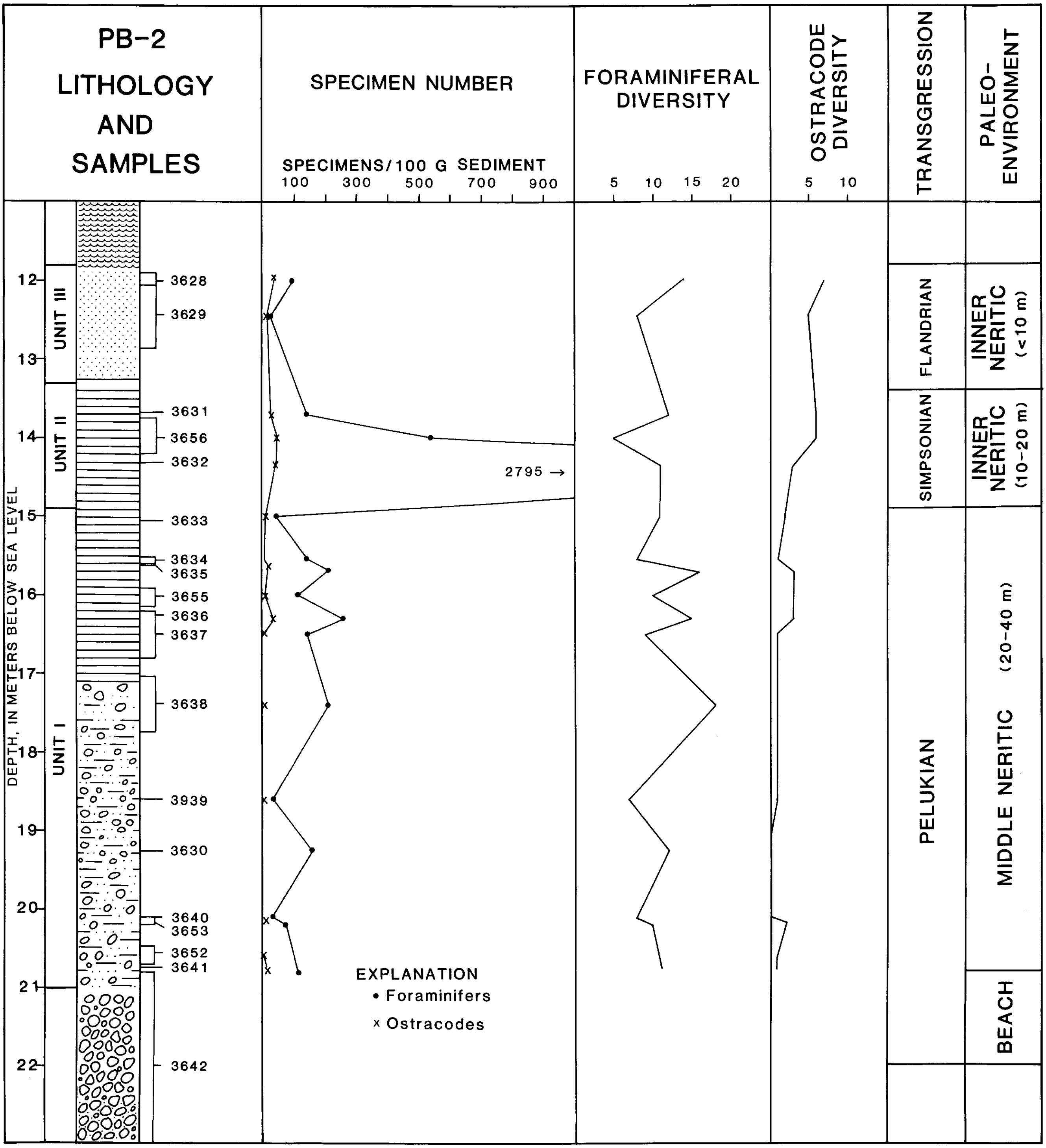


Figure 7. Benthic foraminiferal and ostracode abundance and diversity in borehole PB-2 (see figs. 2 and 3 for explanation).

salinity. This interval is therefore interpreted as representing the early part of the Pelukian transgression, when sea level was higher and temperatures were colder than at present and an Atlantic water mass invaded the Beaufort Sea.

The species diversity and abundance increases from one valve representing one species (sample MF3637) to 30 valves representing three species in sample MF3636 (16.2 m below sea level). These greater abundance values and higher diversities are also observed in samples MF3655 and MF3635 (16.2 to 15.7 m below sea level) which are just below the stiff clay of unit I. The species occurring in MF3636, MF3655, and MF3635 are the same as those species

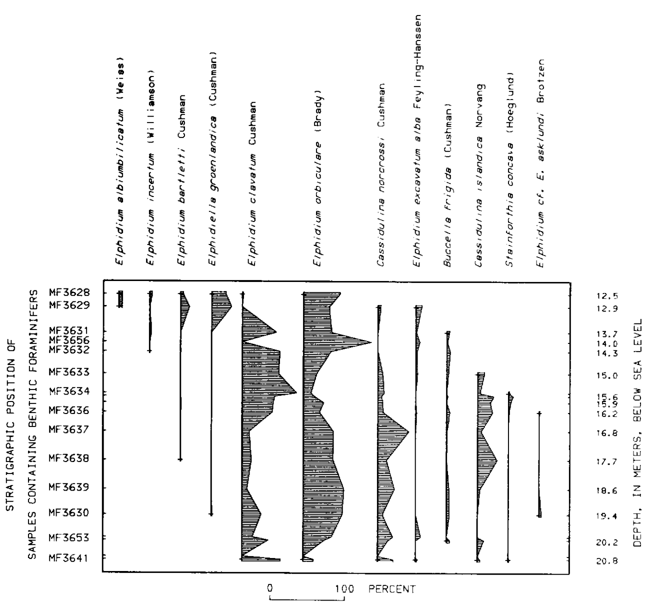


Figure 8. Distribution with depth and relative abundance of selected benthic foraminiferal species in borehole PB-2 (see fig. 4 for explanation). Species values are given in table 4.

reported in the older samples of this borehole, with the addition of Cytheropteron montrosiense. The latter species is characteristic of open marine conditions and inner to middle neritic depths. Samples MF3634 and MF3633 record a large drop in total abundance but the faunal composition remains characteristic of more open marine, deeper water with a strong Atlantic influence.

In sample MF3632 (14.3 m), a major faunal change occurs: abundance and diversity values shift markedly, and species composition is different. The new assemblage is similar to modern Arctic conditions: shallow water, nearshore, possibly with seasonally fluctuating salinities. Species diversity increases upsection from sample MF3632 and probably indicates a progressive increase in overall environmental stability. Such stability is often a function of increasing depth; in this case, it is probably related to a rise in eustatic sea level.

Ostracode taxa in the uppermost two samples, MF3629 and MF3628 (between 12.9 and 11.9 m below sea level), reflect slightly shallower water than the interval immediately below. The species diversity remains moderate (5 to 7), and the presence of more normal marine species (Normanicythere leioderma and Cytheropteron montrosiense) suggests fairly stable temperature and salinity conditions and water depths in the inner neritic depths.

Pollen

Pollen analysis of core samples provides some information on the age of the sediments. Nelson (1979) assigned samples below 14.7 m below sea level to the Sangamon interglacial (Nelson's zone i) and his two samples above 14.3 m to zone Q, which he called "questionably" Holocene, and argued that they more likely represent pre-Wisconsin sediments with some Holocene material mixed into them by bioturbation. Nelson's zone i corresponds to our unit I, and his zone Q to our unit II. Our unit III was not represented in his study. Unit I is thus assigned to the Sangamon interglacial and unit III to the Holocene. A bulk core sample from the top of unit II yielded a radiocarbon age of 18,000±170 yr. B.P. (USGS-192). If the radiocarbon date truly reflects the age of the sediments, no marine fauna should have been present, because sea level at that time would have been at least 90 m below present sea level, leaving this part of the shelf dry land. Hopkins (1978) instead interpreted this date as representing a mixture of Flandrian and older material. Unit II then probably represents the late Sangamon to early Wisconsin Flaxman Member of the Gubik Formation.

Summary

The basal sand and gravel of borehole PB-2 is interpreted as Pleistocene outwash. This unit is overlain by beach and nearshore deposits interpreted as Pelukian. Sediments in the upper part of the borehole are divided lithologically into units I, II, and III. Sedimentologic and microfossil interpretations indicate that unit I was deposited during the Pelukian transgression at middle neritic depths and that water depths, water temperatures, and salinity increased upsection. Unit II was deposited at inner neritic depths (10-20 m) during the Simpsonian transgression or some other transgression during the Wisconsin glacial. Water temperatures were cooler and salinities more variable during unit II time than during unit I time. The basal sample of unit II shows a dramatic peak in the abundance of both foraminifers and ostracodes, which may reflect a mixing of older and younger faunas or a reduction in the sediment influx. Unit III is Holocene in age. Benthic foraminifers and ostracodes suggest that deposition occurred at water depths of 10 m or less. Benthic foraminiferal assemblages reflect the local shallowing due to construction of a nearby barrier island chain whereas the ostracodes seem to reflect the regional position of this borehole outside the barrier island chain and the influence of more stable open marine conditions.

BOREHOLE PB-3

Sediments

Borehole PB-3 was drilled 6 km north of the West Arco Dock and penetrated 44.1 m of sediment. The basal 35.8 m is a coarse-grained, nonmarine sediment overlain by 3.4 m of beach deposits and 4.9 m of marine sand and mud (fig. 10). Detrital peat, wood chips, coal, and twigs are present in the sand to gravelly sand between 50.0 and 32.5 m below sea level, suggesting that this part of the gravel sequence is alluvium. Detrital peat from 47.1 to 46.5 m below sea level yielded a radiocarbon age of 34,000±2,100 yr. B.P. (USGS-210). The large counting uncertainty suggests that this is a minimum age for the enclosing

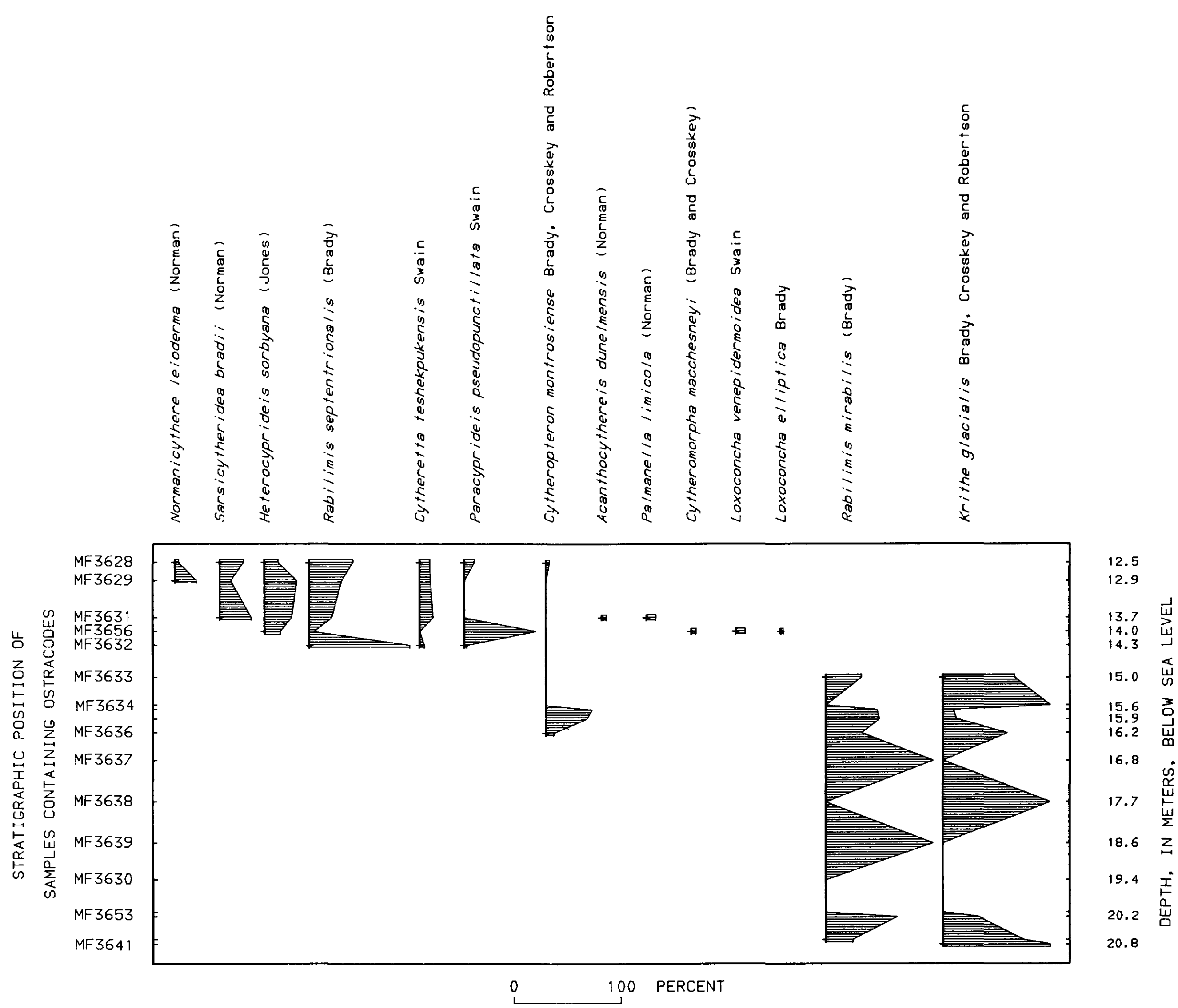


Figure 9. Distribution with depth and relative abundance of selected ostracode species in borehole PB-2 (see fig. 5 for explanation). Species values are given in table 5.

sediment, and the unit is beyond the range of radiocarbon dating. Muddy sandy gravel and gravelly sand fining upsection into pebbly sand and sand characterize the interval from 32.5 to 14.2 m. This interval is devoid of organic detritus and is interpreted as glacial outwash. This unit appears to be continuous with pre-Sangamon outwash in PB-2, supporting the antiquity of the underlying alluvium. Pebbly shelly sand found between 14.2 and 11.9 m is interpreted as beach sediments deposited during the Pelukian transgression on the basis of its similarity to the pebbly sand to pebbly clay at the base of the Pelukian sections in PB-2 and PB-8, and on the basis of the results of seismic interpretation. The base of the Flandrian is represented by a beach or lag deposit of muddy gravel to pebbly sand 1.1 m thick. Shell fragments are present throughout the gravel and sand, and a shell of Macoma balthica was collected near the top of the pebble sand. One meter of black bioturbated organic-rich sandy silt to sandy clay, overlain by 0.6 m of black shelly silt to clay and 3.3 m of laminated silty fine sand and organic silt with occasional interbeds of medium sand, make up the unit between 10.8 and 5.9 m below sea level. The presence of M. balthica, which prefers brackish environments, and the black, organic-rich nature of the sediments overlying it indicate that an estuarine or lagoonal environment existed at this site early in the Flandrian.

Benthic Foraminifers

The oldest benthic foraminiferal assemblage in PB-3 (MF3664, 10.7 to 10.9 m below sea level) contains only two poorly preserved specimens of Elphidiella groenlandica (figs. 11 and 12; table 6). Stratigraphically higher samples MF3662 and MF3663 contain E. groenlandica in association with a more diverse and abundant fauna. Reworked specimens and high abundances of E. groenlandica characterize the first foraminiferal fauna above the beach deposits in

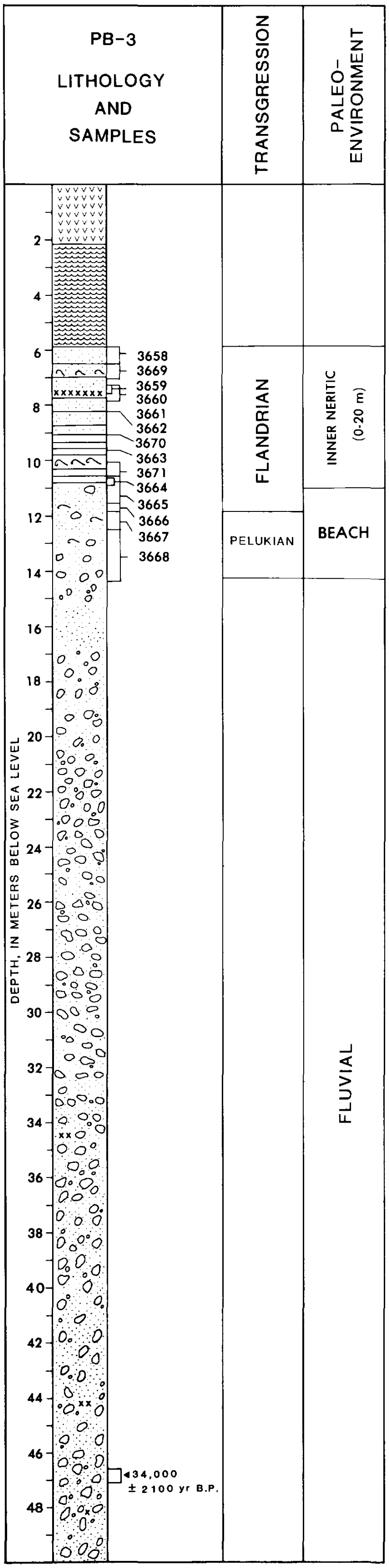


Figure 10. Lithology and paleoenvironment of transgressive sequences in borehole PB-3 (see fig. 2 for explanation).

PB-1, PB-5, PB-6, and PB-7. Thus, the presence of E. groenlandica is here interpreted as reworked from older sediments during the initial phase of the Flandrian transgression.

An abundant and diverse foraminiferal assemblage appears in sample MF3671 (10.6-10.8 m below sea level). Species dominance is distributed among several species of Elphidium (E. bartletti, E. clavatum, E. frigidum, and E. orbiculare), Elphidiella groenlandica (probably reworked), and Buccella frigida (10 percent). These abundances indicate that water depths were probably between 10 and 20 m.

Benthic foraminiferal assemblages throughout the remainder of the marine section (MF3663 to MF3658) are similar to the living faunas of Prudhoe Bay and the inner shelf areas of the Beaufort Sea (Echols, 1964; Lagoe, 1979b, 1980; McDougall, 1982). Elphidium orbiculare and E. excavatum alba dominate the assemblages, and E. clavatum is common in some of the samples. The abundance of the elphidiums indicates shallow nearshore waters with depths probably never much greater than 10 m. The rare occurrences of the lagenids, fissurinids, polymorphinids, and arenaceous foraminifers suggest that marine conditions were relatively quiet during the deposition of this interval. Moderate abundances of quinqueloculinids (24 percent) in sample MF3669, however, suggest more turbid water.

Ostracodes

Ostracodes in samples MF3664 to MF3660 (10.9 to 7.6 m below present sea level) indicate shallow marine conditions. In the oldest sample, MF3664, the ostracode assemblage is small, consisting of four valves representing three species: Rabilimis septentrionalis, Sarsicytheridea bradii, and Paracyprideis pseudopunctillata. From sample MF3664 to MF3663, the ostracode assemblage becomes more abundant and diverse (figs. 11 and 13; table 7) probably indicating more stable and normal salinities than in the previous samples. Samples MF3663 to MF3660 (10.1 to 7.6 m below sea level) reveal a progressive decrease in abundance and species diversity. All of the samples are dominated by two of four species, Paracyprideis pseudopunctillata and either Rabilimis septentrionalis, Sarsicytheridea bradii, or Heterocyprideis sorbyana. This fauna is typical of that found today in shallow, nearshore Prudhoe Bay with seasonally fluctuating salinities and water temperatures. Low species diversity, fluctuating abundance, and species composition suggest marginal to normal marine salinities in samples MF3660 to MF3663. The presence of nonmarine elements such as Chara, seeds, and plant debris suggests a fluvial influence. Borehole PB-2 is geographically close to the Putuligayuk and Sagavanirktok Rivers, which may account for the nonmarine elements and reduced salinity.

Species diversity and abundance are higher in the uppermost two samples, MF3658 and MF3669 (5.9-6.5 and 6.7-7.0 m below sea level), suggesting normal marine conditions. Normal marine salinity is implied by the presence of Cytheropteron montrosiense, Palmanella limicola, and Cytheropteron sp. B. The environment may have changed by a slight increase in

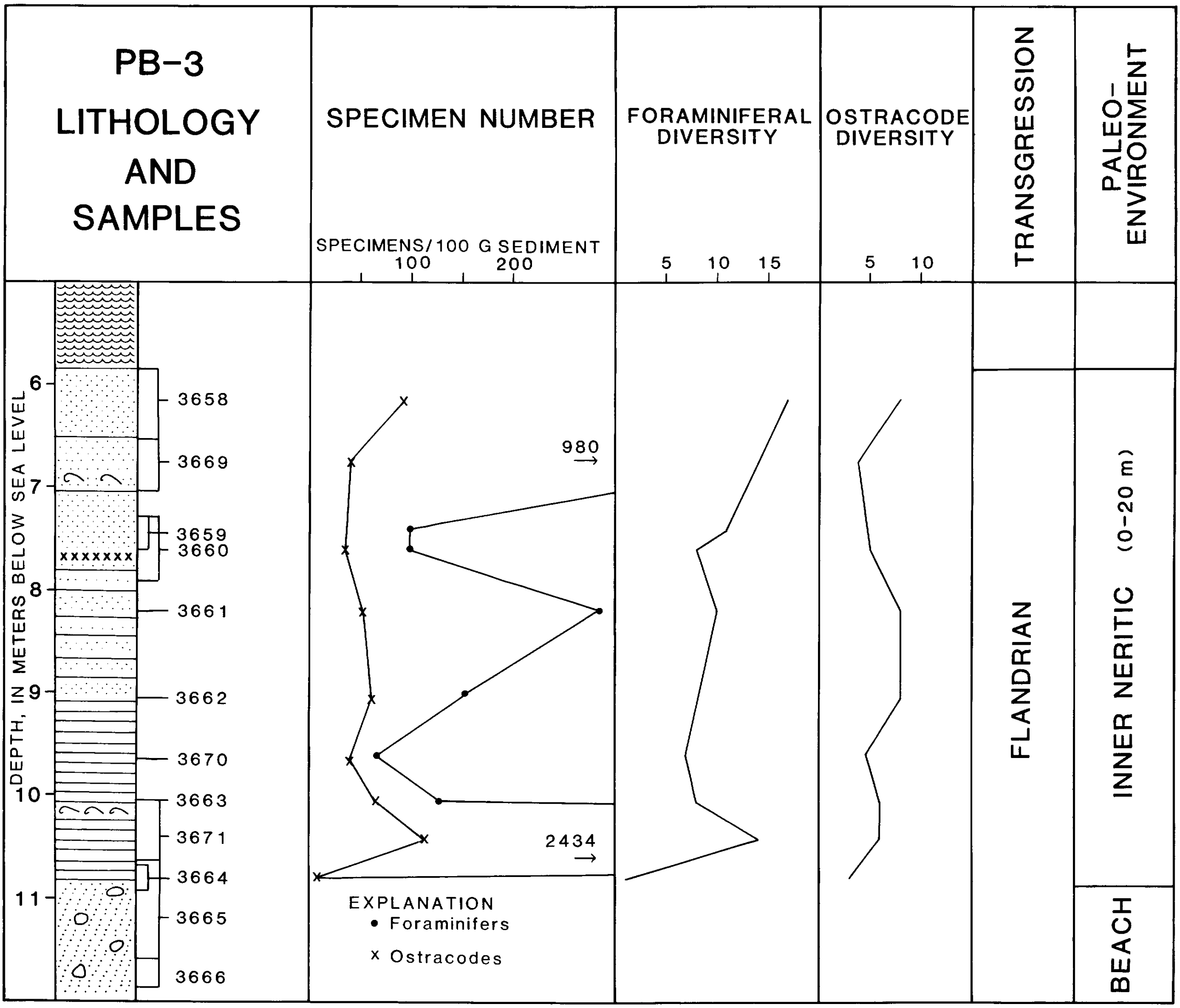


Figure 11. Benthic foraminiferal and ostracode abundance and diversity in borehole PB-3 (see figs. 2 and 3 for explanation).

water depth, or alternatively, by the loss of fluvial input due to changes in output or direction of nearby rivers.

Summary

The sand and gravel that make up the bulk of sediments in borehole PB-3 are interpreted as alluvium (50.0 to 32.5 m below sea level) and glacial outwash (32.5 to 14.2 m below sea level). Pelukian beach and nearshore pebbly sand to sand (14.2 to 11.9 m below sea level) and Flandrian beach or lag deposits (11.9 to 10.8 m below sea level) overlie the outwash. Overlying the beach deposits is a sequence of interbedded fossiliferous silt, clay, and sand deposited at inner neritic depths (0 to 20 m) under conditions of seasonally fluctuating salinities and temperatures similar to those found presently in Prudhoe Bay.

BOREHOLE PB-5

Sediments

Borehole PB-5 was located in shallow water slightly seaward of the shoal separating Prudhoe Bay from the Beaufort Sea (fig. 1), and penetrated 10 m of sediments (fig. 14). The basal unit, from 11.8 to 10.7 m, consists of sandy to muddy pebble gravel, interpreted as beach and nearshore deposits, overlain by 0.9 m of fine to medium sand with interbeds of black organic clay and silt. Based on seismic interpretations, the absence of characteristic Flaxman Member lithologies, and the similarity to basal deposits of unit I in PB-2, PB-3, and PB-8, this unit is believed to have been deposited during the Pelukian trangression.

From 9.8 to 8.8 m below sea level, the sediment consists of pebbly fine to medium sand with minute

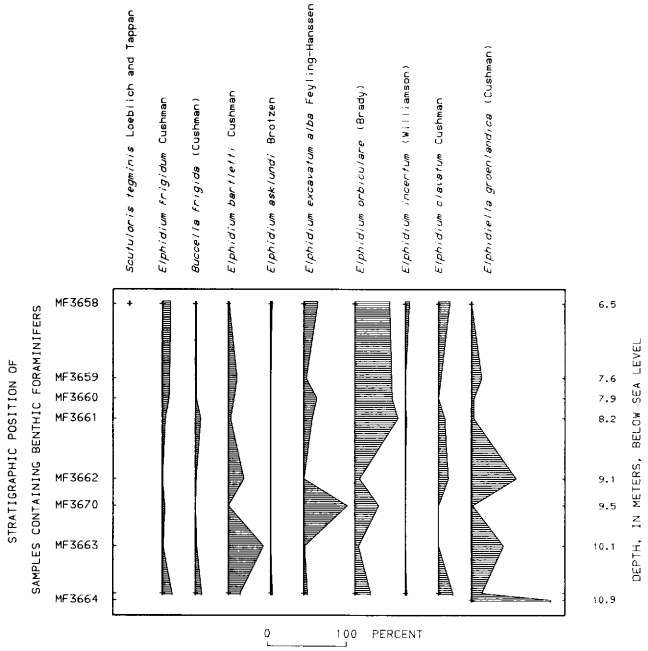


Figure 12. Distribution with depth and relative abundance of selected benthic foraminiferal species in borehole PB-3 (see fig. 4 for explanation). Species values are given in table 6.

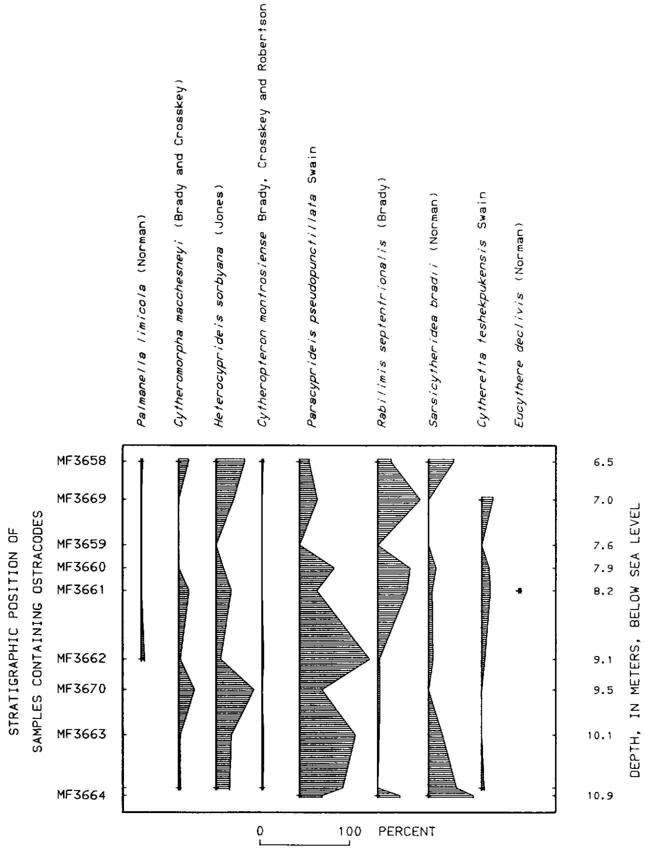


Figure 13. Distribution with depth and relative abundance of selected ostracode species in borehole PB-3 (see fig. 5 for explanation). Species values are given in table 7.

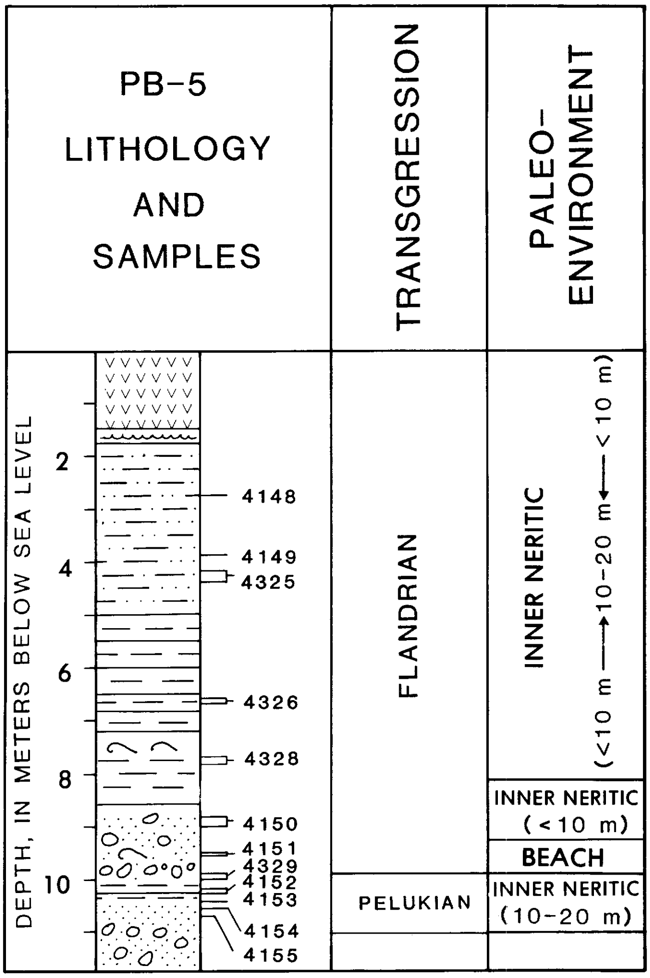


Figure 14. Lithology and paleoenvironment of transgressive sequences in borehole PB-5 (see fig. 2 for explanation).

mollusk fragments, interpreted as Flandrian nearshore deposits. The sand is overlain by laminated silt and clay with occasional sandy interbeds from 8.8 to 4.6 m, and fine sand with laminae of silty sand from 4.6 m to the top of the sediment column at 1.8 m below sea level. The increasing percentage of sand in the upper few meters reflects the growth of the present-day shoal.

Benthic Foraminifers

Foraminiferal assemblages form two distinct groups (figs. 15 and 16; table 8): MF4155 to MF4329 (10.7 to 9.8 m below sea level) and MF4151 to MF4148 (9.6 to 2.8 meters below sea level). The lower group of samples represents a deeper water foraminiferal assemblage than the upper group, and probably represents the Pelukian transgression. The upper group of assemblages represents the initiation of the Flandrian transgression (MF4150 and MF4328), a gradual deepening (MF4326), and finally a shallowing (MF4325, MF4149, and MF4148).

The lowest foraminiferal group, MF4155 to MF4329 (10.7 to 9.8 m below sea level), occurs in a clay unit. Elphidium orbiculare (average 57 percent)

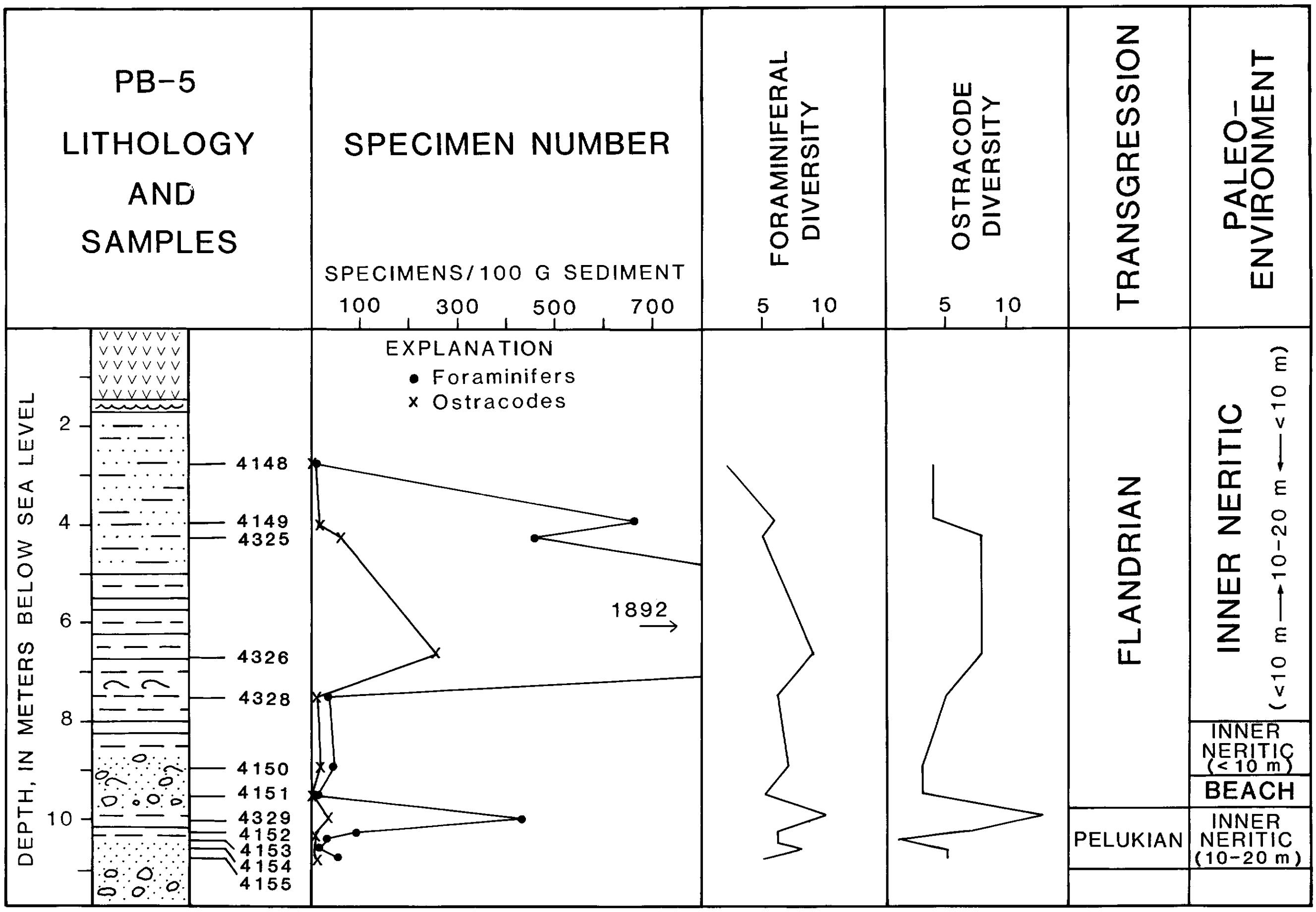


Figure 15. Benthic foraminiferal and ostracode abundance and diversity in borehole PB-5 (see figs. 2 and 3 for explanation).

dominates these assemblages and secondary species include other elphidiums such as E. excavatum alba, E. clavatum, and E. bartletti. Abundances of Buccella frigida (7 percent) and polymorphinids (6 percent) as well as the rare appearance of Cassidulina islandica and Lagena gracillima suggest that water depths were between 10 and 20 m. The low abundance of E. excavatum alba (averaging 10 percent) indicates that temperatures were slightly cooler than at present or that the sediments are Pelukian. The absence of E. incertum indicates temperatures were warmer and (or) salinities higher than during the Simpsonian or a middle Wisconsin transgression. Foraminiferal assemblages in samples MF4155 to MF4329 are therefore interpreted as representing the Pelukian transgression.

Above the beach deposits (9.0 to 8.3 m below sea level), Elphidium orbiculare dominates the fauna (samples MF4150 and MF4328), suggesting water depths of 10 m or less with low or variable salinities. Moderate abundances of poorly preserved Elphidiella groenlandica and Elphidium cf. E. asklundi indicate erosion and reworking of older sediments. Reworking may also explain the presence of Cassidulina teretis, which is normally associated with deeper, more stable (constant temperature and salinity) waters. Upsection, the benthic foraminiferal assemblages become more abundant and diverse, indicating an increase in water

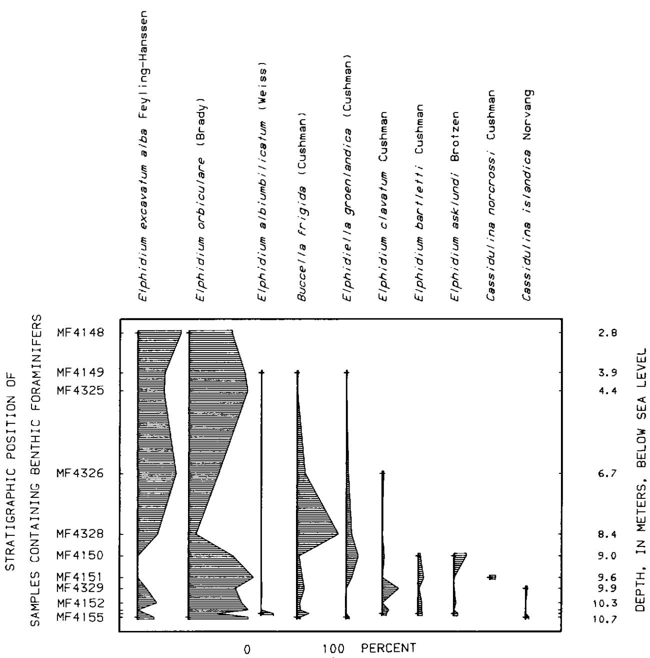


Figure 16. Distribution with depth and relative abundance of selected benthic foraminiferal species in borehole PB-5 (see fig. 4 for explanation). Species values are given in table 8.

depth, temperature and (or) salinity. The warmer water variant, Elphidium excavatum alba, and E. orbiculare dominate these younger assemblages. Buccella frigida (45 percent) becomes the dominant species in MF4328, and a few specimens of Quinqueloculina arctica appear. This change in faunal composition suggests that water depths probably increased to greater than 10 m and were of normal salinities and slightly turbid. Although the youngest samples (MF4326 to MF4148) contain progressively fewer specimens, the numbers of Elphidium increase and the sediments are sandier. These factors suggest a decrease in water depths, probably as the result of the growth of Gull Island and the associated shoal.

Ostracodes

The oldest sample containing ostracodes, MF4155, was taken at 10.6-10.7 m below sea level (figs. 15 and 17; table 9). Five ostracode species are present: Paracyprideis pseudopunctillata, Cytheromorpha macchesneyi, Pontocythere sp. A, Sarsicytheridea bradii, and Heterocyprideis sorbyana. This combination of species indicates shallow, nearshore water, probably with at least seasonally reduced salinity. Sample MF4154 (10.5-10.6 m below sea level) contains a similar assemblage, reflecting an essentially identical environment. The presence of the alga Chara in these samples suggests some nonmarine input.

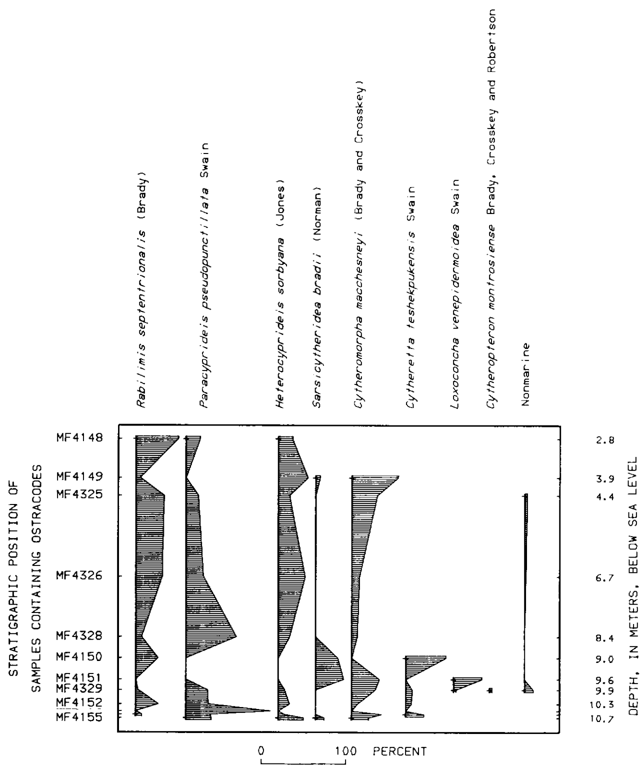


Figure 17. Distribution with depth and relative abundance of selected ostracode species in borehole PB-5 (see fig. 5 for explanation). Species values are given in table 9. Nonmarine ostracodes include Candona sp., Cyprid sp., Cyprinatus sp., Ilyocypris sp., Limnocythere liporeticulata, and Limnocythere sp.

Species diversity and abundance increase in samples MF4152 and MF4329, indicating a slightly more stable environment; the co-occurrence of Pontocythere sp. A and Cytheropteron montrosiense suggest that slightly more normal marine salinities exist in this interval.

Samples MF4151 and MF4150, from 9.6 to 8.9 m below sea level, are taken from what has been interpreted as nearshore pebbly sand. Ostracode species present in these samples include Sarsicytheridea bradii, Rabilimis septentrionalis, Cytheretta teshekpukensis, Cytheromorpha macchesneyi, and Loxoconcha venepidermoidea. These are shallow-water species that live in nearshore conditions.

The remainder of the borehole, from sample MF4328 to MF4148 (8.4 to 2.8 m below sea level), contains a typical Prudhoe Bay assemblage. The interval from sample MF4325 to MF4148 (4.4 to 2.8 m below sea level) reveals a continuous decline in species diversity and abundance to the most recent sample. The assemblages are dominated by Cytheromorpha macchesneyi, Heterocyprideis sorbyana, and Rabilimis septentrionalis. The dominance by these few species and the unequal distribution of individuals among species suggests fluctuating salinities, probably on a seasonal basis as prevails today. The presence of the nonmarine cyprid sp., Limnocythere liporeticulata, and Cyprinotus sp. confirms the nearshore conditions, particularly in the uppermost samples.

The decline in species diversity and abundance trends from samples MF4325 to MF4148 (4.4 to 2.8 m below sea level) may indicate gradually decreasing water depth, with consequent seasonal instability in the physiochemical environment. The sediments in this interval consist of fine silty sand, and have been interpreted as representing the formation of Gull Island shoal.

Summary

Overlying the gravel interpreted as Pelukian beach deposits in PB-5 are sand and organic silt. Microfossils indicate a progressive increase in water depth and distance from shore in the sand and organic silt interval (samples MF4155 to MF4329). This interval is thus assigned to the Pelukian transgression. The overlying sand, silt, and clay (9.6 to 2.8 m below sea level) represents the Flandrian transgression. Microfaunas indicate that water depths increased from less than 10 m to 10-20 m and then decreased as Gull Island shoal was formed.

BOREHOLE PB-6

Sediments

Borehole PB-6 was drilled near the elbow of the West Arco Dock and cored 28.8 m of sediment (figs. 1 and 18). The basal unit (30.7 to 26.4 m below sea level) consists of interbedded sand, coarse pebbly sand,

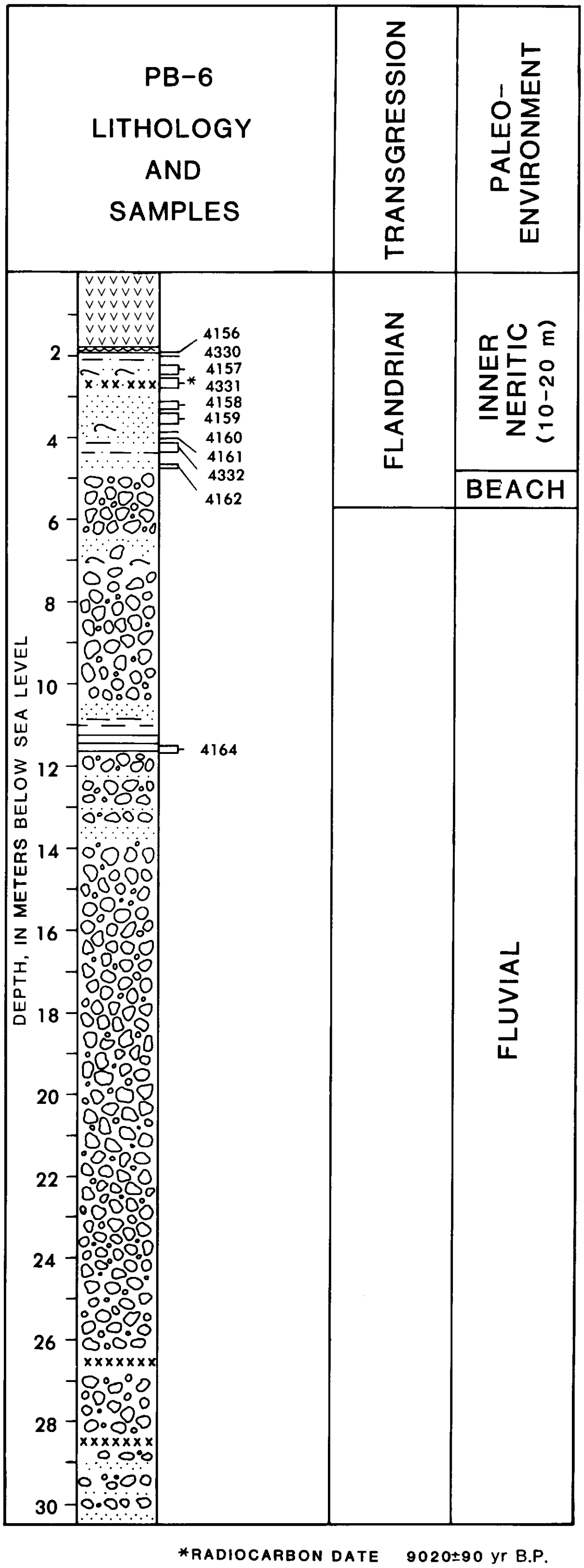


Figure 18. Lithology and paleoenvironment of transgressive sequences in borehole PB-6 (see fig. 2 for explanation).

and pebbly gravel, with abraded wood fragments and twigs lessening in abundance upsection. This unit is interpreted as alluvium of middle Pleistocene age. Overlying the alluvium is a 12.4-m-thick sequence of coarse, clean, subrounded gravel and sandy gravel with a few thin interbeds of coarse sand. The absence of organic debris or shell fragments, along with the subrounded nature of the gravel, suggest that these sediments represent glacial outwash, apparently continuous with pre-Sangamon outwash in PB-2 and PB-3. Above the outwash, from 14.0 to 10.5 m below sea level, the sediments consist of a 2.5-m-thick sequence of interbedded sand and poorly sorted sandy to silty gravel overlain by 1.0 m of plastic clay and sandy clayey silt. This sequence is interpreted as alluvium of probable Sangamon age. A 4.9-m-thick bed of pebbly gravel with interbeds of fine to medium sand representing late Wisconsin outwash overlies the clay and sandy mud. One meter of clean, well-rounded gravel grading up into medium sand with an abundance of shell fragments is thought to represent Flandrian beach to nearshore deposits. The uppermost 2.7 m of sediment (4.6 to 1.9 m below sea level) consists of interbedded fine to medium sand and silty fine sand, with minor amounts of peat. These sediments are interpreted as Flandrian delta-front deposits, and their youth is confirmed by a radiocarbon age of 9,020±90 yr. B.P. (USGS-783) obtained from a detrital peat lens at 2.7 m below sea level.

Benthic Foraminifers

Benthic foraminifers are present from 2.5 m below sea level to the sediment-water interface (samples MF4157, MF4330, and MF4156) and are absent from older sediments (figs. 19 and 20; table 10). Diversity and foraminiferal number increase upsection. Elphidium excavatum alba and E. orbiculare dominate the assemblages and suggest that deposition occurred in shallow nearshore water with conditions similar to the present Prudhoe Bay. Rare reworked Pelukian specimens are present in samples MF4156 and MF4330. Although representative of shallower conditions, the depth and faunal trends in PB-6 are nearly identical to those seen in PB-1.

Ostracodes

Ostracodes occur from 3.9 to 1.9 m below sea level in the borehole (figs. 19 and 21; table 11). Samples MF4159 to MF4330 (3.7 to 2.1 m below sea level) suggest shallow nearshore conditions, with marginal marine to normal marine salinity. A trend of increasing species diversity and abundance (fig. 19) occurs in the upper three samples (MF4157, MF4330, and MF4156).

The ostracode assemblage in the youngest sample, MF4156 (1.9 m below sea level), is assumed to represent the modern population living at this location. The sample contains seven species represented by 115 valves; Cytheromorpha macchesneyi (51 percent) and Heterocyprideis sorbyana (31 percent) dominate the assemblage. The fauna is very typical of a modern shallow-water nearshore environment of the Beaufort Sea. The

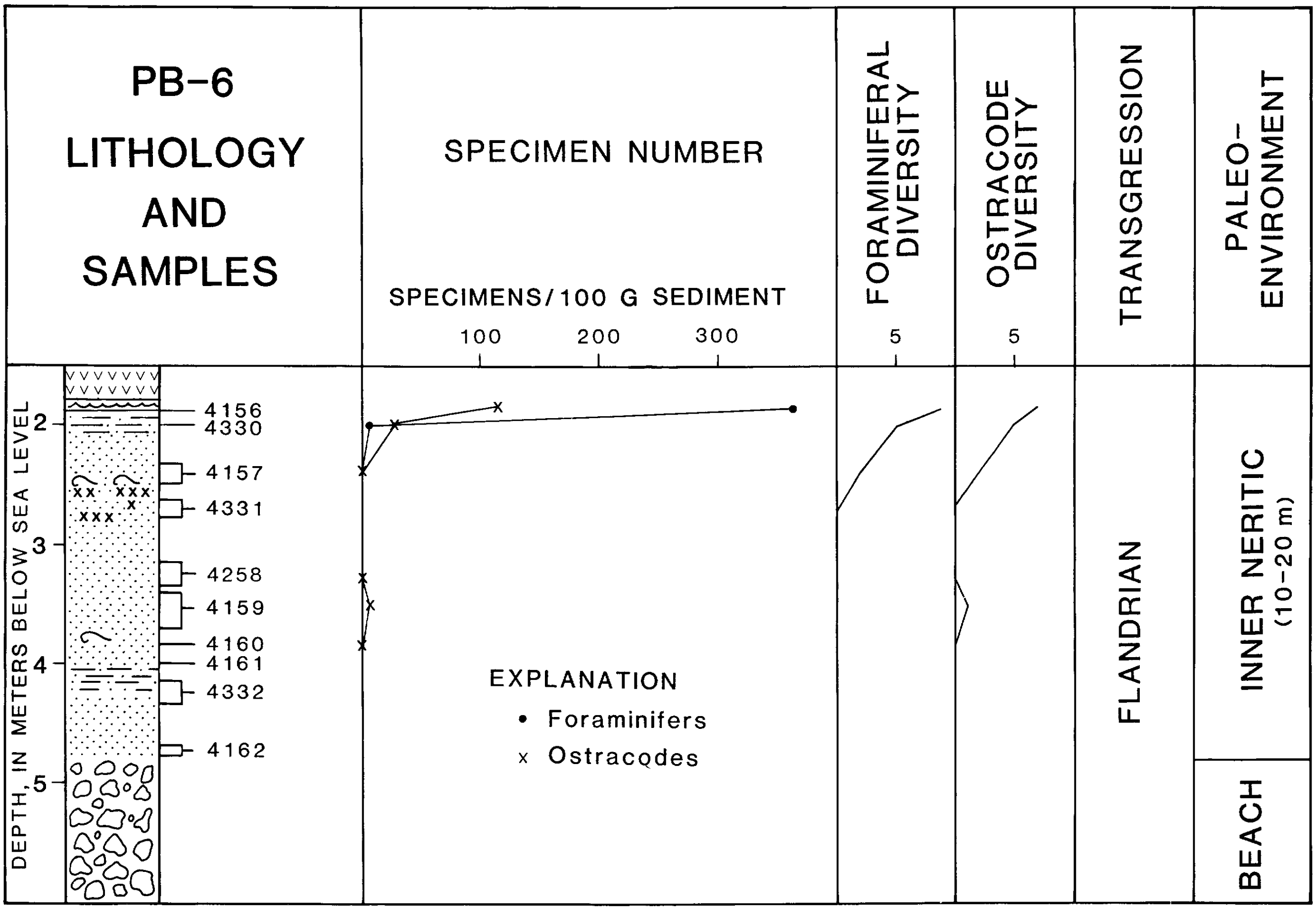


Figure 19. Benthic foraminiferal and ostracode abundance and diversity in borehole PB-6 (see figs. 2 and 3 for explanation).

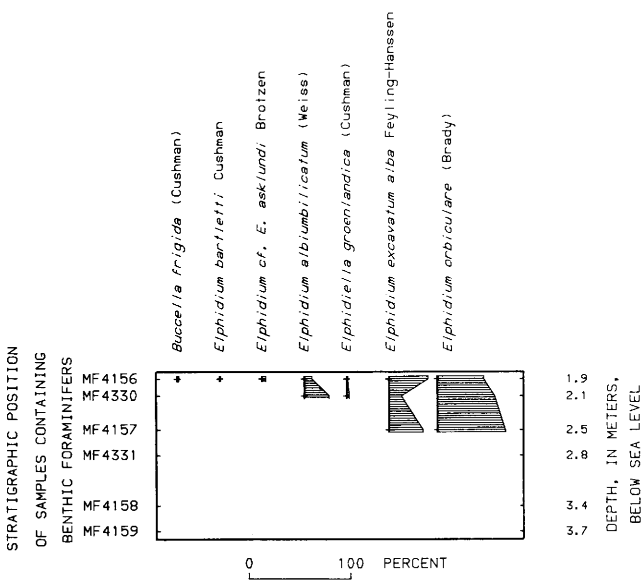


Figure 20. Distribution with depth and relative abundance of selected benthic foraminiferal species in borehole PB-6 (see fig. 4 for explanation). Species values are given in table 10.

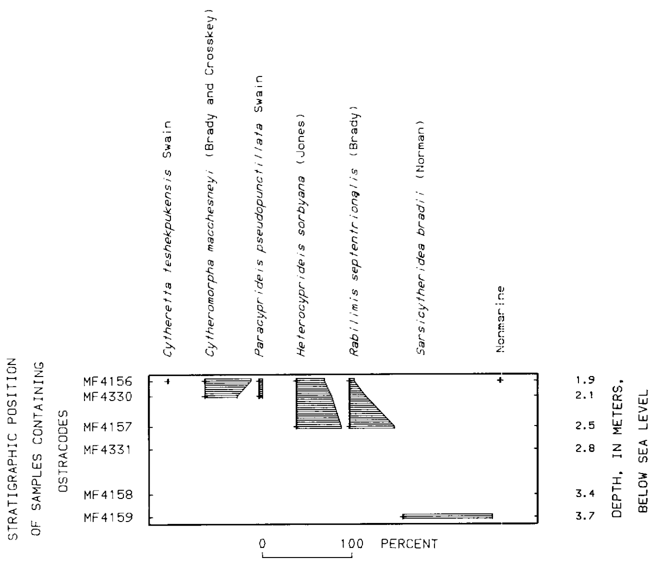


Figure 21. Distribution with depth and relative abundance of selected ostracode species in borehole PB-6 (see fig. 5 for explanation). Species values are given in table 11. Nonmarine species include Limnocythere sp.

dominance by two species and the assemblage composition suggest somewhat reduced salinities, at least on a seasonal basis. This interpretation of reduced salinity and proximity to shoreline is supported by the presence of Limnocythere sp., a nonmarine form (fig. 21).

Summary

Sediments in borehole PB-6 record several episodes of alluvial to glacial outwash deposition, followed by Flandrian beach and shallow nearshore marine sediment. Benthic foraminifers and ostracodes in the marine sediment indicate that in the Flandrian water depths increased slightly upsection and that environmental conditions became increasingly more stable, although still fluctuating on a seasonal basis.

BOREHOLE PB-7

Sediments

Borehole PB-7, located 3.3 km from the mainland shore of Steffanson Sound, penetrated 65.4 m of sediment, the greatest depth attained in the PB drilling project (figs. 1 and 22). Seven units can be recognized in this hole. The lowermost unit (68.2 to 57.8 m below sea level) consists of 4.8 m of interbedded silty sand and clayey silt, overlain by 5.6 m of coarse sandy gravel with interbeds of clayey silty sand. The common to abundant organic detritus throughout the unit suggests that it is alluvium. The second recognizable unit (57.8 to 37.3 m below sea level) is characterized by interbedded coarse sand and gravel with occasional traces of detrital wood and minor silty sandy interbeds, and is interpreted as outwash. The third unit, from 37.3 to 27.4 m below sea level, consists of 6.8 m of interbedded poorly sorted sand, coarse gravel, and sandy silt, overlain by a 3.1-m-thick fining-upward sequence of poorly sorted coarse gravel to medium sand. This unit is rich in detrital wood, and is interpreted as middle Pleistocene alluvium. From 27.4 to 13.6 m below sea level, the sediments are interbedded coarse, poorly sorted gravel, sandy gravel, and pebbly sand, representing pre-Sangamon outwash. Pebbly sand to sand from 13.6 to 11.0 m below sea level is interpreted as alluvium. A 0.3-m interval of pebbly sand with plant fragments and wood chips from 13.6 to 13.3 m yielded a radiocarbon date of 42,800 ± 1,440 yr. B.P. (USGS-249). As was the case with the radiocarbon date from PB-3, this is probably an "infinite" date, and the unit probably represents Sangamon alluvium, based on its stratigraphic position. The sixth unit, from 11.0 to 7.4 m below sea level, consists of gravelly sand to muddy sandy gravel, with a 0.4-m-thick interval of sand. This unit probably represents late Wisconsin outwash. The seventh unit (7.4 to 2.9 m below sea level) consists of 0.6 m of pebbly sand with numerous shell fragments, a few twigs, shreds of bark, and a few ventifacted pebbles, and 3.9 m of interbedded silty sand and clayey silt with clots and thin beds of detrital peat near the base. The lower sediments in this unit are interpreted

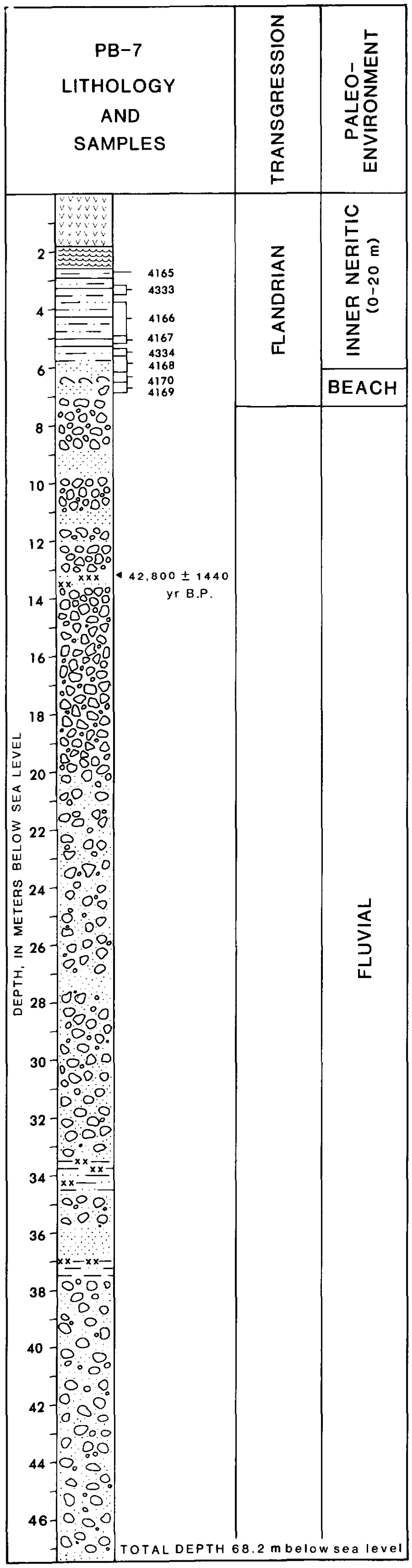


Figure 22. Lithology and paleoenvironment of transgressive sequences in borehole PB-7 (see fig. 2 for explanation).

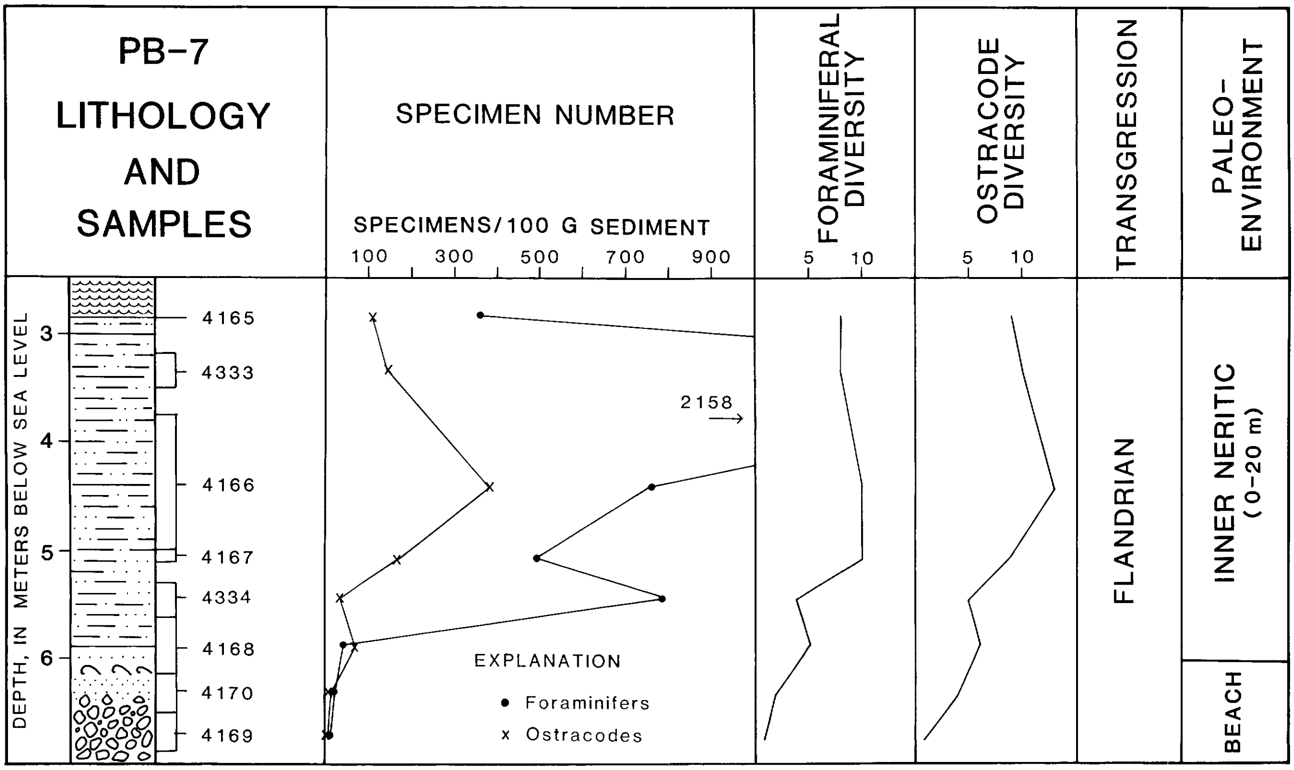


Figure 23. Benthic foraminiferal and ostracode abundance and diversity in borehole PB-7 (see figs. 2 and 3 for explanation).

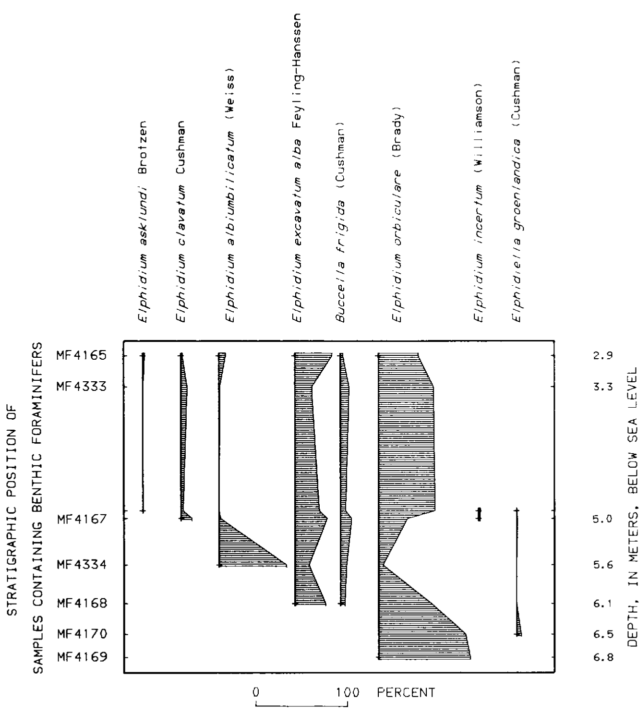


Figure 24. Distribution with depth and relative abundance of selected benthic foraminiferal species in borehole PB-7 (see fig. 4 for explanation). Species values are given in table 12.

as beach or lag deposits. The upper sediments are interpreted as a Flandrian nearshore marine deposit.

Benthic Foraminifers

Flandrian benthic foraminifers are present in samples from 6.8 m to the sediment-water interface at 2.9 m (figs. 23 and 24; table 12). The oldest fossiliferous samples (MF4169 and MF4170), just above the beach gravel, contain rare benthic foraminifers. Elphidium orbiculare dominates these samples and indicates shallow nearshore depths (10 m or less) and low salinities. The rare worn specimens of Elphidiella groenlandica occurring here have probably been reworked from older marine deposits. These assemblages are typical of the first foraminiferal assemblage to be established at the onset of the Flandrian trangression and are present in other boreholes in which this transgressive event is preserved.

The benthic foraminiferal fauna is more abundant and diverse in the overlying samples, MF4168 to MF4165. High abundances of Elphidium clavatum, E. orbiculare, and E. excavatum alba indicate a slight increase in water depth. The slightly lower abundances and lower diversity in the uppermost samples MF4165 and MF4133 may be due to shoaling associated with the development of Stump Island. The occurrences of E. albiumbilicatum indicate that water depths were not much greater than 10 m. Elphidium albiumbilicatum also indicates reduced salinities in the upper samples whereas the occurrences of quinqueloculinids in the lower part of this interval

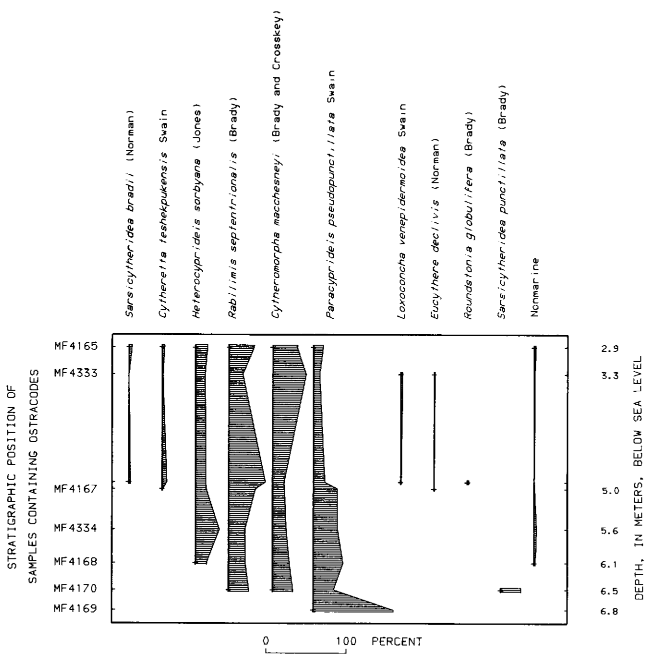


Figure 25. Distribution with depth and relative abundance of selected ostracode species in borehole PB-7 (see fig. 5 for explanation). Species values are given in table 13. Nonmarine species include Candona sp., Cytherissa lacustris, Ilyocypris sp., and Limnocythere sp.

indicate normal salinities and turbid waters. Evidence for reworked older deposits occurs sporadically throughout the core as indicated by the presence of Elphidiella groenlandica and Elphidium cf. E. asklundi.

Ostracodes

The oldest sample in the borehole that contains ostracodes is MF4169, at 6.5-6.8 m below sea level; the sample contains a single valve of Paracyprideis pseudopunctillata. More diverse and abundant assemblages occur from 6.5 m to 2.9 m and suggest shallow-water nearshore conditions, with seasonally fluctuating salinities (figs. 23 and 25; table 13). The presence of several nonmarine species (Ilyocypris sp. and Cytherissa lacustris) indicates a nonmarine input from the coast.

From 6.8 m to 3.8 m below sea level (samples MF4169 to MF4166), the trend is for gradually increasing abundance and species diversity (fig. 23). From sample MF4334 to MF4166, the change in species diversity and assemblage composition suggest that environment was more stable, possibly due to a rise in eustatic sea level. The onset of this stability in water mass condition is seen in the change from shallow nearshore marginal marine conditions at sample MF4168 to more normal marine deeper water (deeper inner neritic) conditions at sample MF4166. The presence of Pontocythere sp. A, Eucythere declivis, and particularly Roundstonia globulifera confirm the normal marine, and most probably deeper water, environment that occurs in sample MF4166.

Above 3.8 m below sea level, the ostracode assemblages show a progressive decrease in species diversity and abundance. This may be due to a gradual decrease in water depth, most likely due to shoaling related to the formation of the adjacent Stump Island.

The uppermost sample, MF4165, at 2.9 m below sea level, contains an ostracode assemblage typical of an Arctic shallow-water nearshore environment, probably with seasonal reductions in salinity. Rabilimis septentrionalis (31.2 percent) and Cytheromorpha macchesneyi (30.3 percent) dominate the sample. The presence of the nonmarine species Candona sp. and Limnocythere sp. indicate proximity to land influences (either Stump Island or more probably, the main coast).

Summary

The basal 57.2 m of sediment in borehole PB-7 consists of clayey sand to coarse gravel, representing alternating alluvium and outwash of early to late Pleistocene age. Flandrian beach deposits (7.4 to 6.8 m below sea level) and nearshore marine sediments (6.8 to 2.9 m below sea level) overlie the nonmarine sequence. Benthic foraminifers and ostracodes indicate that the water depths were inner neritic (0-20 m) throughout the marine interval. Both benthic foraminifers and ostracodes decrease in abundance and diversity during the development of Stump Island, but they return to typical inner neritic faunas in the upper part of the section.

BOREHOLE PB-8

Sediments

Borehole PB-8 is located approximately 1 km south of Reindeer Island and 11.5 km north of the West Arco Dock (fig. 1). It penetrated 25.4 m of sediment, consisting of 14.1 m of marine clay, silt, and sand overlying an 11.3-m-thick nonmarine unit of sandy, coarse to pea-size gravel with a few interbeds of clayey fine sand in its upper 2 meters (fig. 26). Except for a trace of woody fragments at 24.5 m below sea level, the gravel is barren of organic material and is interpreted as glacial outwash.

The marine sediment can be divided into three units. The basal unit (21.1 to 15.4 m below sea level) is composed of 2.8 m of sandy pebbly clay or clayey gravel with an abundance of shell fragments, overlain by 2.9 m of dark-gray to olive-black organic-rich clay interbedded with pale-yellow-brown silty clay to sandy clayey silt. Occasional pebbles and shell fragments are present in the clay and silt. The second marine unit is 2.5 m thick (15.4 to 12.9 m below sea level) and consists of 1.9 m of soft olive-black to dark-gray clay with scattered shell fragments and stringers of black organic-rich clay, overlain by 0.6 m of dark-gray silty clay with lenses of silty fine sand. The uppermost marine unit is 5.9 m thick (12.9 to 7.0 m below sea level), and consists of 1.3 m of clayey sandy silt with lenses and thin beds of silty fine sand, 1.2 m of silty sand, and 3.4 m of silty clayey sand. Shells and shell fragments occur throughout the unit, and peaty lenses are present in the uppermost 2 meters. Similarities in sediment texture, faunal characteristics, and pollen spectra suggest that these three marine units correlate with units I, II, and III in borehole PB-2 (fig. 6).

Benthic Foraminifers

Benthic foraminifers range from rare to abundant in PB-8 (figs. 27 and 28; table 14). The variation in abundance correlates with changes in the lithology and with the various transgressions. High diversities and high abundance characterize the sandy clays from MF4199 to MF4171 (13.0 to 7.0 m below sea level). These assemblages contain abundant elphidiums and other species typical of present-day conditions and indicate the Flandrian transgression. From the base of the fossiliferous section, sample MF4231 to sample MF4200 (20.4 to 13.0 m below sea level), foraminiferal assemblages have lower abundances and lower diversities and are interpreted as Pelukian. Foraminiferal assemblages in this latter group can be further divided into three faunal groups: MF4231 to MF4215 (20.4 to 15.5 m below sea level); MF4214 to MF4209 (15.4 to 14.6 m below sea level); and MF4208 to MF4200 (14.5 to 13.0 m below sea level). Reworking of sediment and specimens occurs near the base of each of the faunal groups.

A nearly complete record of the Pelukian transgression seems to be present in this borehole. Foraminiferal assemblages indicate (1) the onset of the transgression (MF4229 to MF4338); (2) the maximum sea level rise and thermal maximum of the interglacial (MF4226 to MF4337); and (3) the subsequent regression and climatic deterioration (MF4220 to MF4215). The onset of the transgression is marked by the first benthic foraminiferal faunas, which are characterized by low numbers of specimens (average 18) and low diversities (average 6). Elphidiums (E. bartletti, E. clavatum, E. orbiculare, and E. sp.) dominate the first group (20.7 to 19.0 m below sea level) and indicate shallow water depths (less than 10 m), cool temperatures, and low salinities. The presence of a few specimens of Cassidulina islandica suggests that conditions may have been deeper and closer to normal marine conditions or that sea level was rising so quickly that the shallow and deep faunas were mixed. Higher foraminiferal numbers (average 244), higher diversities (average 17), the presence of cassidulinids (principally C. islandica), and lower abundances of the elphidiums suggest that deeper water and normal marine conditions prevailed during deposition of the next group (18.9 to 17.6 m below sea level). Rare specimens of Dentalina, Lagena, and Fissurina corroborate that interpretation and, together with the dominant species, suggest a depth range of 20 to 40 m. Warmer water temperatures are indicated by the rare to few abundances of Elphidiella groenlandica.

Foraminiferal faunas suggest decreasing water depths and climatic deterioration in the highest group (17.1 to 15.5 m below sea level). The boundary between this and the underlying group is gradational, suggesting that the environmental change was

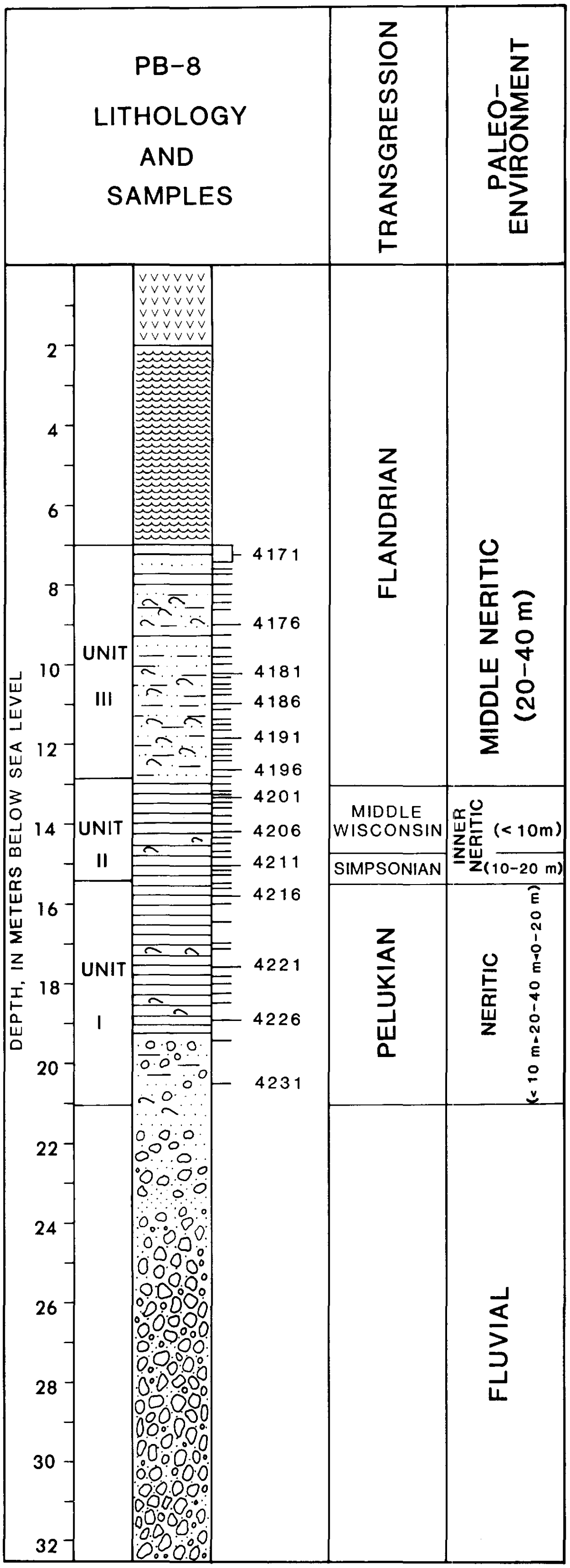


Figure 26. Lithology and paleoenvironment of transgressive sequences in borehole PB-8 (see fig. 2 for explanation).

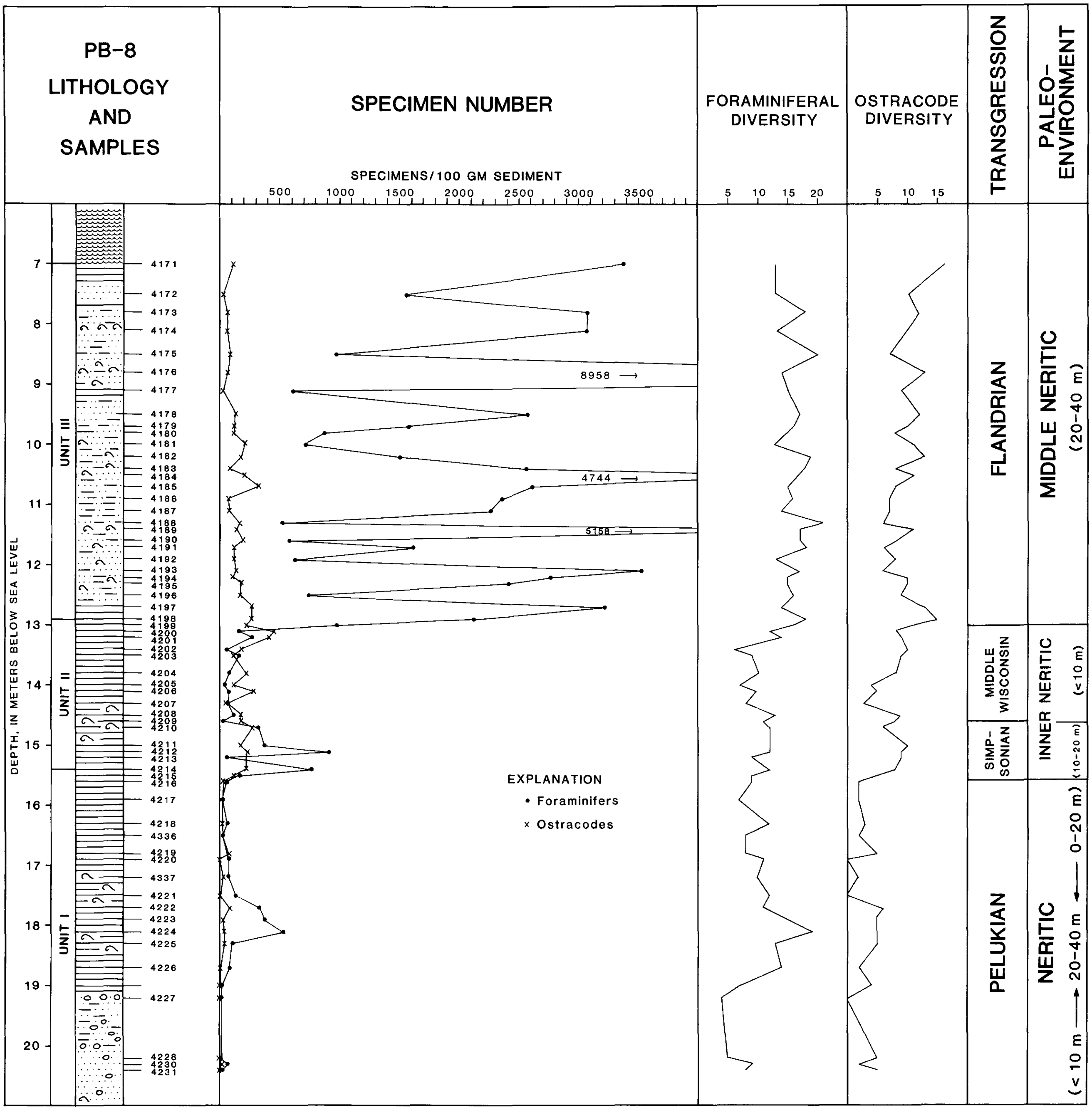


Figure 27 Benthic foraminiferal and ostracode abundance and diversity in borehole PB-8 (see figs. 2 and 3 for explanation).

gradual. Faunas in this interval have lower foraminiferal numbers (average 62) and lower diversities (average 9). There is also a decrease in the deeper water species and warm-water indicators and a corresponding increase in the number and diversity of elphidiums. Quinqueloculinids are more common in this upper group and indicate that turbid waters existed at shallower depths.

Foraminiferal assemblages in the overlying interval, MF4214 to MF4209 (15.4 to 14.6 m below sea level), contain many of the same species as the rest of the fossiliferous intervals, but the composition and environmental implications are different. Moderate foraminiferal numbers (average 411) and diversities (average 12), coupled with high abundances of elphidiums and the absence of cassidulinids, suggest inner neritic water depths probably between 10 and 20 m. Moderate numbers of Elphidiella groenlandica suggest interglacial conditions and probably warmer water temperatures. The abundance of Elphidium incertum indicates that water temperatures were cooler than during the Pelukian or Flandrian transgressions. Elphidium excavatum alba is not as common in these samples as in Flandrian assemblages; in part due to the cooler temperatures and in part to the evolutionary development of this species. The

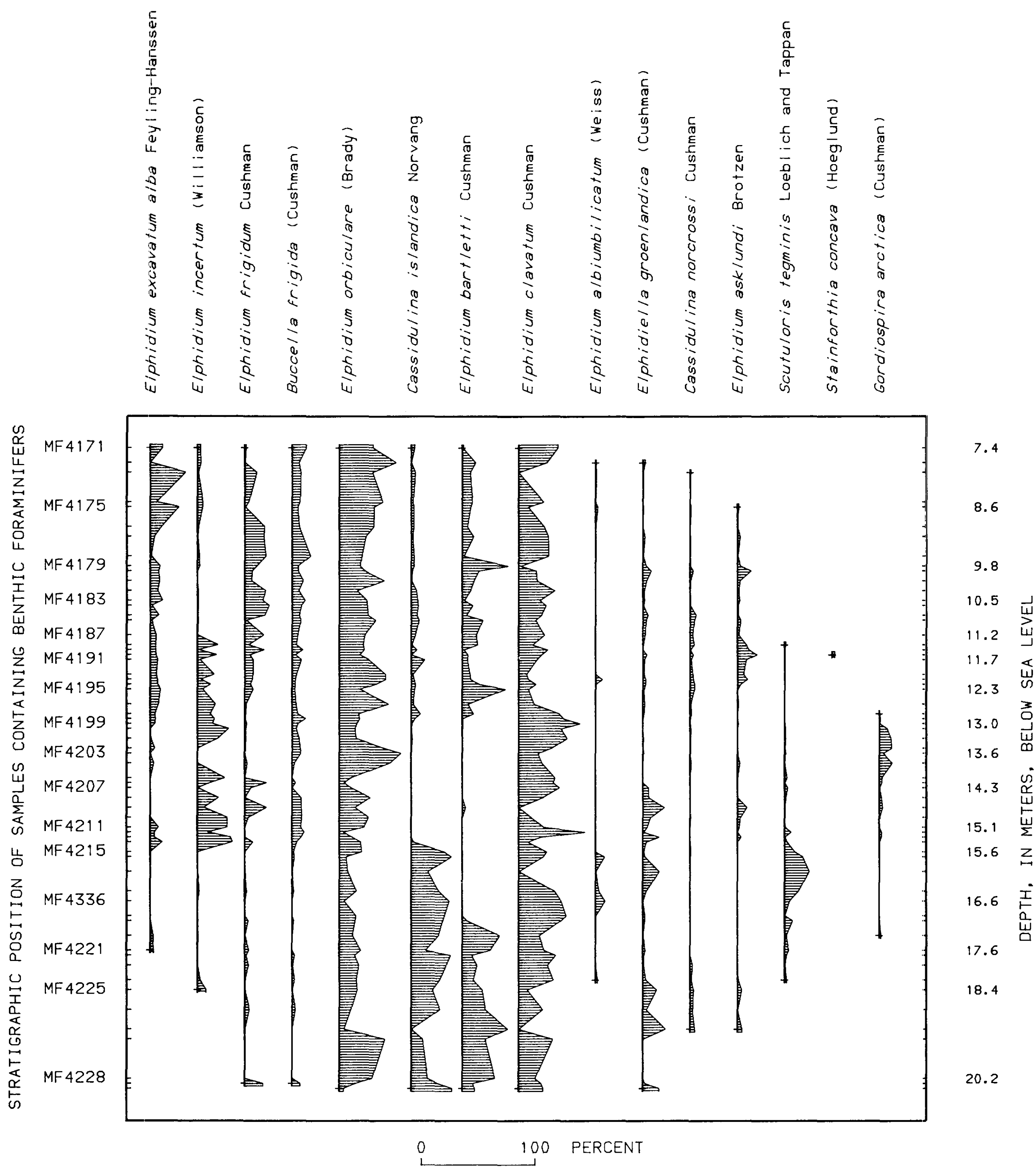


Figure 28. Distribution with depth and relative abundance of selected benthic foraminiferal species in borehole PB-8 (see fig. 4 for explanation). Species values are given in table 14.

faunal composition and environmental conditions of this assemblage suggest that deposition occurred during the Simpsonian transgression.

The lower diversity (average 10) and low abundance (average 119) of the foraminiferal assemblages from 14.5 to 13.0 m below sea level (MF4208 to MF4200) indicate inner neritic water depths (10 m or less) and cold water temperatures. Buccella frigida and middle neritic species are rare or absent whereas elphidiums (particularly E. orbiculare, E. clavatum, and E. incertum) increase in abundance. The dominance of the elphidiums also suggests that salinity was reduced and cooler water temperatures prevailed. The presence of various quinqueloculinid species in numbers greater than 10 percent indicates more turbulent waters. Gordiospira arctica occurs frequently in this interval (averages 5 percent per sample) and therefore suggests the presence of an Atlantic water mass. Faunas in this interval are questionably considered to be indicative of a middle Wisconsin transgression.

Foraminiferal assemblages in samples MF4200 to MF4171 (13.0 to 7.0 m below sea level) contain a diverse, abundant fauna similar to the Flandrian Arctic faunas. In the lower part of this interval, elphidiums, especially E. orbiculare and E. clavatum, are abundant and are associated with rare to common occurrences of Cassidulina islandica, C. norcrossi, C. teretis, and Buccella frigida. The faunal association implies middle neritic water depths (20 to 40 m). In the upper part of this interval, the cassidulinids decrease and the elphidiums and the sand component increase, suggesting a decrease in water depth or the approach of Reindeer Island. Elphidium albiumbilicatum, appearing in this upper interval, suggests decreased water depths and lower salinities. The apparent shallowing is believed to be associated with the growth of Reindeer Island.

Ostracodes

The oldest samples in PB-8 containing ostracodes (figs. 27 and 29; table 15) indicate a relatively shallow water, nearshore environment (samples MF4231 to MF4226, from 20.4 to 18.7 m below sea level). The ostracode assemblages have relatively low species diversity and low abundances. The composition of the assemblage (Paracyprideis pseudopunctillata, Rabilimis septentrionalis, Sarsicytheridea bradii, Cytheromorpha macchesneyi, and Heterocyprideis sorbyana) is typical of a modern shallow-water nearshore Arctic environment. The dominance of one or two species (over 50 percent) in these assemblages suggests that conditions of reduced salinity occurred at times. The environment implied by the species in this interval is the same as that in shallow parts of Prudhoe Bay today.

Species diversity as a whole fluctuates in samples MF4226 to MF4215 (18.8 to 15.5 m below sea level) but abundance progressively increases. Sample MF4226, at 18.7-18.8 m below sea level, contains the first appearance of Cytheropteron montrosiense, marking the onset of deeper water conditions and more normal marine salinities. Sample MF4225, at 18.3-18.4 m below sea level, contains the first appearance of Krithe glacialis and Cluthia cluthae. These two species presently live in the subfrigid marine climate in the North Atlantic, Canadian Arctic, and subfrigid Norton Sound; the appearance of these two taxa implies that oceanic conditions became warm enough for species from subfrigid climates to migrate and survive in the Arctic. "Acanthocythereis" dunelmensis and Rabilimis mirabilis appear in association with these warmer, deeper water species in sample MF4224 (18.1 m below sea level). Another Atlantic species that appears in this interval is Cytheropteron paralatissimum, occurring in samples MF4219 and MF4215. These immigrant species are believed to respond to deeper and warmer water conditions, based on their distribution in the North Atlantic. These taxa may well be following a warmer, more saline Atlantic water mass introduced below the cooler, less saline Arctic Surface water mass.

A change in assemblage occurs in samples MF4214 to MF4202 (15.4 to 13.4 m below sea level). In sample MF4214, the species diversity increases to 8 and the number doubles. Sarsicytheridea punctillata first appears commonly in sample MF4214 and is abundant in sample MF4202. At sample MF4213 (15.4 m below sea level), Cytheromorpha sp. A and Cytherura sp. D first appear, and Cytheropteron paralatissimum and Cytheropteron sp. are no longer present. These assemblage changes reflect the return to an environment similar to the shallow water and normal salinity of today.

From sample MF4201 to MF4192 (13.3 to 11.9 m below sea level), a new suite of species appears. These species are probably responding to slightly warmer and (or) possibly shallower waters. Finmarchinella curvicosta, which is circumpolar in distribution and has been reported only as a fossil in Alaska, first appears at 13.3 m below sea level (MF4201). This species indicates a frigid to subfrigid climate as it occurs above latitude 63° N. in inner to middle neritic depths (18-75 m) in the modern North Atlantic. Its presence may mark the onset of a return to modern conditions following a glacial event.

Finmarchinella finmarchica occurs from MF4195 to MF4192 (12.2 to 11.9 m below sea level). This species is Arctic and boreal-Arctic (frigid to cold temperate) and is presently known only from the North Atlantic (both fossil and living). Its presence strongly implies an Atlantic water mass. Species diversity and abundance decrease in this interval.

From 11.7 to 7.0 m below sea level (samples MF4191 to MF4171), a modern cold-water assemblage appears. The paleoenvironment is interpreted as normal marine, shallow water, fluctuating between inner and middle neritic depths. Many typical Arctic marine forms occur in this interval including Finmarchinella curvicosta, Eucythere declivis, Cytherura spp., Cytheropteron spp., Palmanella limicola, and Normanicythere leioderma. The fauna is representative of entirely normal marine salinities up to the uppermost sample, where some nonmarine species occur (Candona sp., Cypridopsis sp., and Limnocythere sp.). Water depths tend to decrease from middle neritic at sample MF4191 to inner neritic at sample MF4171. This decrease in water depth may be related to the formation of Reindeer Island. Nonmarine species in sample MF4171 may also be derived from Reindeer Island. The interval from 11.7 to 7.0 m below sea level (MF4191 to MF4171) is indicative of a frigid (Arctic) climate.

Summary

Sand and gravel in the basal part of PB-8 is interpreted as glacial outwash. The marine pebbly sand to silt and clay that overlies the outwash is interpreted as ranging in age from late Pleistocene, Sangamon to Holocene. Benthic foraminifers suggest that four transgressions are represented: Pelukian, Simpsonian, middle Wisconsin, and Flandrian. Both benthic foraminifers and ostracodes indicate that

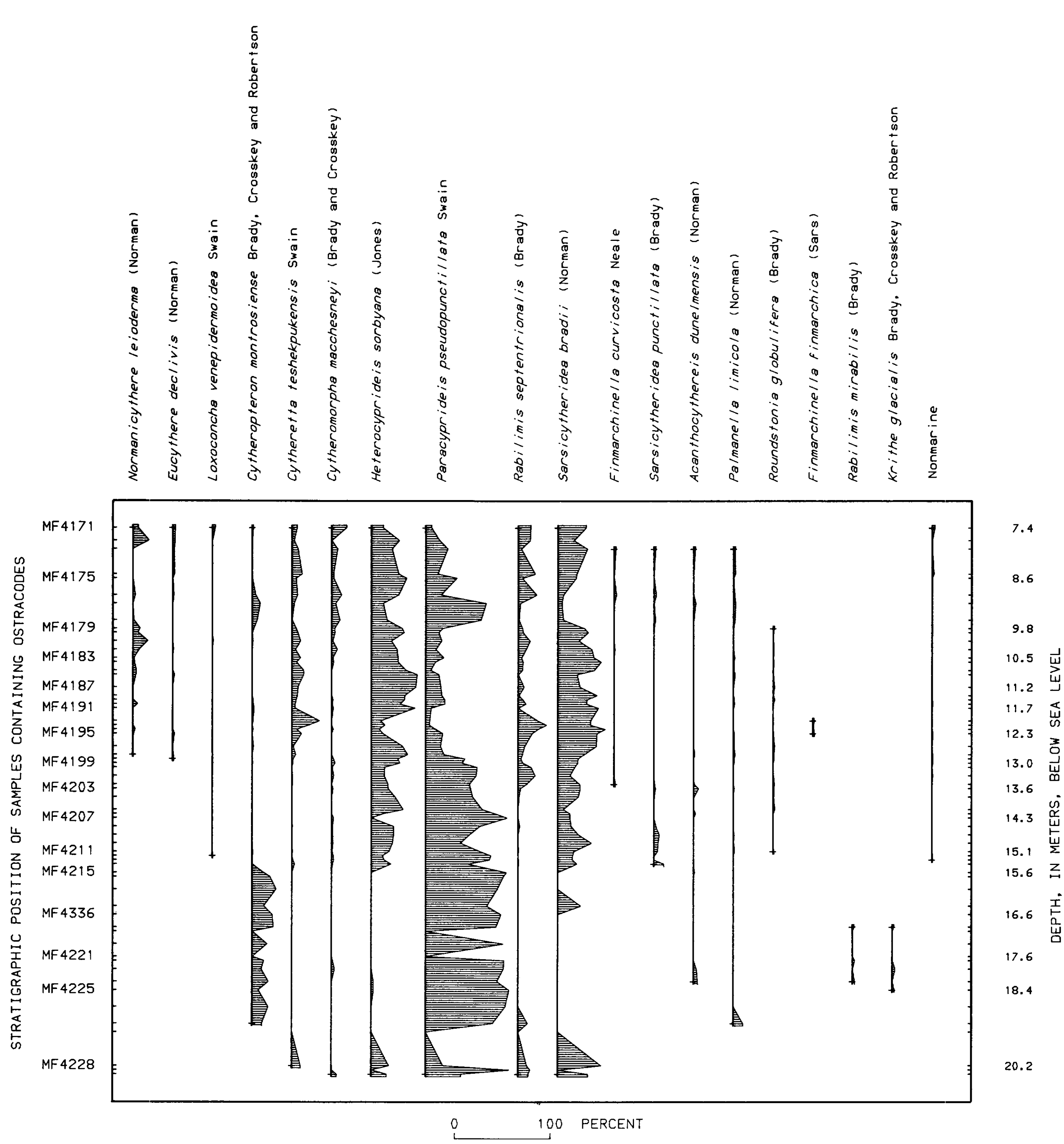


Figure 29. Distribution with depth and relative abundance of selected ostracode species in borehole PB-8 (see fig. 5 for explanation). Species values are given in table 15. Nonmarine ostracodes include Candona sp., Cypridopsis sp., and Limnocythere sp.

during the Pelukian transgression (sedimentary unit I), there was an initial phase in which the marine faunas became established and the environment was characterized by shallow water depths (less than 10 m), cool temperatures, and low salinities. The remainder of the Pelukian interval (samples MF4226 to MF4215) is characterized by faunas characteristic of middle neritic water depths (20-40 m) and warm temperatures. Ostracodes indicate marine connections with the Atlantic during this time. Benthic foraminiferal faunas suggest that there was a gradual deterioration of climatic conditions beginning in the upper part of the Pelukian interval (samples MF4220 to MF4215). Faunas in unit II suggest neritic water depths ranging from 0 to 20 m and conditions similar to modern Prudhoe Bay. Benthic foraminiferal

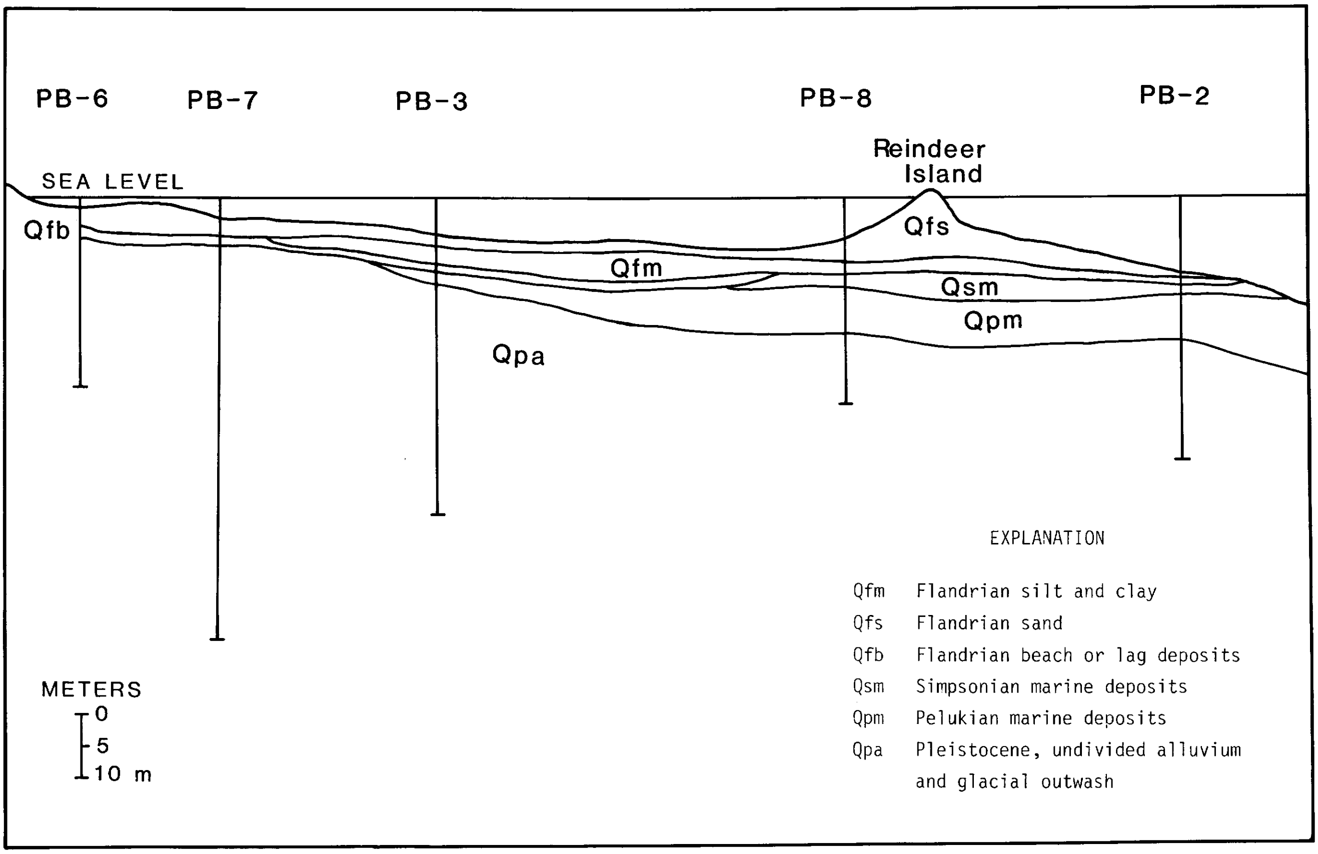


Figure 30. Cross section along a line connecting the five western boreholes, showing inferred distribution of sedimentary units.

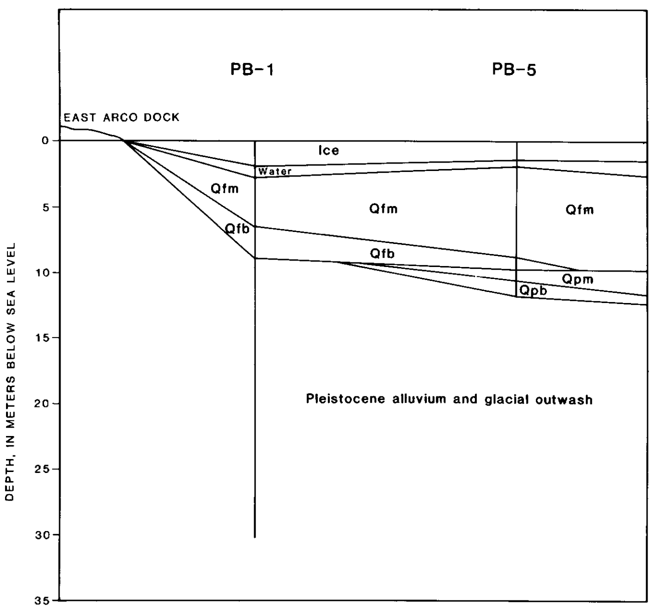


Figure 31. North-south cross section of Prudhoe Bay showing correlation and distribution of sedimentary units based on boreholes PB-1 and PB-5 (see fig. 30 for explanation of symbols).

assemblages suggest this interval may represent the Simpsonian and middle Wisconsin transgressions, and that during the latter transgression (samples MF4208 to MF4200), waters were shallower (less than 10 m) and cooler than at present. The benthic foraminiferal (13.0 m below sea level) and ostracode (13.3 m below sea level) breaks associated with the unit II-unit III boundary (12.9 m below sea level) reflect both the response time, and mixing or reworking associated with an environmental change.

Unit III was deposited during the Flandrian at middle neritic depths of 20 to 40 m. Subtle changes in the interval correspond to the shallow and cool marine waters at the beginning of the Flandrian transgression, the influx of North Atlantic taxa when the Arctic-Atlantic marine connection was reestablished, and shoaling due to the formation of Reindeer Island.

CONCLUSIONS

Three major sedimentary units, ranging in age from middle Pleistocene to Holocene, are recognized in the USGS-CRREL boreholes: alluvium, glacial outwash, and shallow to mid-shelf marine deposits (figs. 30 and 31). Alluvium and outwash account for as little as 9 percent to as much as 89 percent of the sediments in these boreholes. The glacial outwash is composed largely of coarse gravel to medium sand, with lesser amounts of silt and clay, whereas the alluvium is primarily fine pebbly sand to silty clay. The gravel and sand components vary from subangular to well-rounded, and pebble suites are similar in both units. Both the outwash and the alluvium represent primarily fluvial deposition, with the gravelly outwash representing deposits of high-energy, variable output braided streams during glacial intervals when sea level was lower, and the finer alluvium representing lower energy channel and floodplain sediments deposited during interglacials or interstadials, with higher sea level and lower gradient streams. Some thick sandy intervals may represent eolian deposits, but have been included with the fluvial deposits as their nature and extent cannot be determined from wash samples and as no core samples from those intervals are available.

Sediments tentatively identified as glacial outwash consist of sequences as much as 22 m thick composed of moderately to poorly sorted gravel. The gravel consists partly of beds up to 5 cm thick of openwork pebble gravel alternating with much thicker beds of muddy, sandy gravel, and partly of sequences 25 to 75 cm thick of pebble gravel grading upward to sand. Much of the interpretation of the gravel intervals is determined from wash samples, because very few intact core samples were obtained. In the core samples, bedding is primarily horizontal, with a few instances where bedding appeared to dip at angles of 15° to 30°.

Pebbles range from subangular to well rounded in the outwash samples. Fragments in the cores indicate that cobbles as large as 9 or 10 cm across are present. Chert constitutes 60 to 70 percent of the pebbles. Hard chert-quartz sandstone, siltstone, and vein quartz are consistently present in substantial quantities, and orthoquartzite, granite, aplite, and graywacke are minor components. Limestone is rare, and coal, shale, and metamorphic rocks are absent. Washed drill cuttings are dark gray, reflecting the predominance of black chert, but undisturbed gravel in the cores, because of the all-pervasive silt coating, ranges in color from olive gray to yellowish brown.

Sediments identified as alluvium consist of sequences as thick as 17.5 m that are composed of sand, pebbly sand, and subordinate sandy gravel. Some parts contain plant remains, including twigs, small wood chips, grass or sedge stems, and shreds of moss. The alluvium is also generally finer grained than the outwash gravel, but sorting is poor to moderate. Gravel clasts in the alluvium are generally subangular whereas the sand fraction ranges from angular to subround. Moist colors of fresh cores through the alluvium are typically light olive gray, greenish gray, or medium gray.

The presence of sand- and granule-sized particles of coal, commonly mixed with wood and plant debris in sandy sequences, is a distinctive component of the alluvium. Gravel and pebbly sand beds yield a few granules and small pebbles of brick-red baked shale, siltstone, and possibly pumice, but the majority of the sand and gravel is composed of chert, with lesser amounts of vein quartz and hard chert-quartz sandstone.

The data in hand thus far are not sufficient to resolve the detailed stratigraphy and geochronology of the alluvial and outwash sequences. The alluvial sequences presumably represent interstadial and interglacial intervals during which extramontane sediment sources were significant, and the outwash sequences seem to record an overwhelming predominance of sediment that originated in the Brooks Range and accumulated during glacial advances.

Marine sediments in the PB boreholes range in character from beach sand and sandy gravel to clay and silty clay typical of shallow to mid-shelf environments. Silt and clay predominate, reflecting the limited carrying capacity of the streams draining the coastal plain. Sand or interbedded sand and silt is usually found only in sequences that can be related to shoaling, barrier island passage, or to increasing water depths (beach to nearshore deposits). The Pelukian sediments consist of a basal pebbly sandy silt or clayey sand that grades upward into overconsolidated silty clay in PB-2, and into interbedded clay and silty clay in PB-8. Pebbles of Brooks Range provenance in the base of the Pelukian section show scratches and grooves apparently caused by ice, and represent material carried offshore by ice from beaches of gravelly outwash during the early part of the transgression. Sediment assigned to the Flaxman Member (Simpsonian transgression) is present in boreholes PB-2 and PB-8 by organic silt to silty clay. No characteristic Flaxman pebbles were present in the unit in PB-8, but they are present as a lag deposit at the top of the Flaxman Member in PB-2. Thickness of Flandrian fine-grained marine deposits in the boreholes ranges from 1.5 m in PB-2 to 7 m in PB-5.

Four benthic foraminiferal assemblages are recognized in the PB borehole series. They are directly associated with the late Pleistocene through Holocene marine transgressions: Pelukian, Simpsonian, middle Wisconsin, and Flandrian. The species composition varies with the transgressive-regressive cycles. Where the preserved record is complete, the composition of the foraminiferal assemblages varies from species that prefer low salinity, and cool, shallow waters to species that indicate the maximum water depth and maximum water temperatures, and finally to species that prefer cooler, shallower, more normal marine waters. The record, however, is rarely complete, and usually only the faunas typical of the early to middle part of the transgression are preserved.

The oldest assemblage, which probably corresponds to the Pelukian transgression, is characterized by foraminiferal assemblages that represent deeper and warmer marine conditions than presently occur in the study area. The Pelukian assemblages contain common occurrences of various cassidulinids, Elphidium orbiculare, E. incertum, and Buccella frigida. Stainforthia concava is present in the middle neritic assemblages (PB-2 and PB-8). Elphidiella groenlandica and Elphidium asklundi reflect the warmer water temperatures. Elphidium excavatum alba is rare throughout most Pelukian sediments, although moderate abundances are noted in the warmer intervals.

The next oldest faunas, those of the Simpsonian transgression, are similar to the Pelukian faunas. They indicate that temperature and depth conditions were slightly cooler and shallower than during the Pelukian, but still warmer and deeper than at present. Cassidulinids decrease in abundance whereas elphidiums increase in response to the shallower, cooler waters. Elphidiella groenlandica, Elphidium asklundi, and Elphidium excavatum alba became increasingly rare as the temperatures cooled.

Faunas developed during the middle Wisconsin transgression, characterized by low foraminiferal numbers and low diversities, indicate cool shallow waters of approximately the same depth as at present. Elphidium clavatum is a common component of this trangression.

Assemblages from the Flandrian transgression are the most variable and are represented by numerous ecologic biofacies. In general, foraminiferal numbers are high and species diversities are moderate to low. Elphidium orbiculare and E. excavatum alba are the most common species. Because the Flandrian has the most completely preserved record, faunal changes are numerous and correspond to increasing water depths associated with the onset of the transgression. Recent shallowing observed in several of the boreholes probably corresponds to migrations of barrier island chains or to the infilling by sediments.

The ostracode fauna responds to changes in the physiochemical environment much as do the benthic foraminifers. Primary controlling parameters are water temperature and salinity, which can change considerably as the marine climate or sea level change. The paleoenvironmental conditions of the Pelukian, Simpsonian, and Flandrian transgressions are distinct. However, the physiochemical environment of the middle Wisconsin transgression is similar to that of the Flandrian and cannot be differentiated by the ostracode fauna.

The Pelukian ostracode assemblage is characterized by taxa that indicate deeper, probably warmer water conditions and the introduction of several Atlantic immigrants. The species most indicative of the Pelukian are Krithe glacialis, Rabilimis mirabilis, Acanthocythereis dunelmensis, and Cytheropteron paralatissimum. Cluthia cluthae is a warm-water immigrant. Species diversity and abundance are moderate through this sea level event.

The Simpsonian ostracode assemblage consists of a shallow, nearshore facies and a deeper, offshore facies. The shallow facies contains eurythermal, euryhaline species such as Heterocyprideis sorbyana, Cytheretta teshekpukensis, Rabilimis septentrionalis, and Sarsicytheridea bradii. The deeper facies contains a mixture of endemic Beaufort Sea deeper taxa and subfrigid-frigid Atlantic Ocean and Bering Sea immigrants. The endemic species include Cytheromorpha sp. A, Pontocythere sp. A, Palmanella limicola, and Cytherura sp. D. The immigrant taxa include Finmarchinella (Barentsovia) curvicosta, Finmarchinella (Finmarchinella) finmarchica, Roundstonia globulifera, and Sarsicytheridea punctillata. The presence of taxa from subfrigid marine climates implies warmer water conditions than presently exist on the Arctic Coastal Plain. Species diversity is higher than during the Pelukian, and abundance values range from moderate to high.

The Flandrian ostracode assemblage can similarly be divided into a deeper inner neritic facies and a shallow nearshore facies. The shallow nearshore facies is characterized by eurytopic species such as Heterocyprideis sorbyana, Paracyprideis pseudopunctillata, Sarsicytheridea bradii, Cytheretta teshekpukensis, Loxoconcha venepidermoidea, and isolated occurrences of nonmarine taxa. Species diversity is lower and abundance values high. The deeper inner neritic facies contains taxa that require a more stable environment; these include Normanicythere leioderma, Cytheropteron montrosiense, Palmanella limicola, Cytheropteron spp., and Cytherura spp. Species diversity is higher in deeper water, and absolute abundance is low, with a more equitable distribution of taxa.

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Table 2. Borehole PB-1, benthic foraminifers. The distribution and abundance of benthic foraminiferal species in PB-1 is given as a percent of the total foraminiferal fauna. The foraminiferal number (number of specimens in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	Depth (meters) / Sample No.	(4.1) MF3603	(4.4) MF3604	(4.5) MF3605	(4.7) MF3606	(4.9) MF3607	(5.0) MF3608	(5.2) MF3609	(5.3) MF3610	(6.2) MF3611	(6.5) MF3612	(6.7) MF3613	(8.2) MF3614	(8.3) MF3616
Ammotium cassis (Parker)		–	–	–	–	–	–	–	–	0.6	0.5	–	–	–
Buccella frigida (Cushman)		3.2	2.9	3.2	4.4	8.6	2.2	2.8	4.2	7.1	1.5	0.6	–	–
Cassidulina islandica Norvang		0.1	–	–	–	–	–	–	–	–	–	–	–	–
Elphidiella groenlandica (Cushman)		1.0	0.2	0.2	0.3	–	–	–	–	–	–	–	–	–
Elphidium asklundi Brotzen		1.3	0.0	0.1	–	0.1	–	–	–	–	–	–	–	–
E. clavatum Cushman		2.4	–	2.0	1.7	1.6	1.4	8.0	–	0.6	0.2	1.9	–	–
E. excavatum alba Feyling-Hanssen		37.2	39.9	58.8	71.8	51.7	81.3	70.0	72.7	69.5	73.0	36.5	–	–
E. incertum (Williamson)		0.9	21.6	2.5	–	–	–	–	0.7	–	–	5.0	7.7	–
E. orbiculare (Brady)		49.9	33.3	30.9	18.7	35.4	13.6	18.4	19.6	18.2	20.4	54.7	87.2	–
E. sp.		–	0.1	0.1	–	–	–	–	–	–	–	–	–	–
Guttulina austriaca d'Orbigny		–	–	–	–	–	–	–	–	1.3	–	–	–	–
G. lactea (Walker and Jacob)		0.3	0.4	–	3.1	0.8	0.3	–	–	–	–	–	–	–
Polymorphina spp.		3.6	1.7	2.1	–	1.7	1.2	0.8	2.8	2.6	4.4	1.3	5.1	–
Foraminiferal number		3928	8980	3002	294	1473	690	250	143	154	407	159	78	0
Diversity		10	9	9	6	7	6	5	5	7	6	6	3	0

Table 3. Borehole PB-1, ostracodes. The distribution and abundance of ostracode species in PB-1 is given as a percent of the total ostracode fauna. The ostracode number (number of valves in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	Depth (meters) / Sample No.	MF3603	MF3604	MF3605	MF3606	MF3607	MF3608	MF3609	MF3610	MF3611	MF3612	MF3613	MF3614	MF3616
	Depth (meters)	(4.1)	(4.4)	(4.5)	(4.7)	(4.9)	(5.0)	(5.2)	(5.3)	(6.2)	(6.5)	(6.7)	(8.2)	(8.3)
Candona cf. C. candida (Mueller)		–	–	–	–	–	–	–	–	–	–	–	–	2.4
Cytheromorpha macchesneyi (Brady and Crosskey)		2.2	8.7	8.9	4.1	5.2	8.1	10.0	28.6	15.0	6.5	–	–	4.8
C. sp.		–	0.5	0.8	–	–	1.6	2.5	–	–	6.5	2.0	–	–
Heterocyprideis sorbyana (Jones)		73.0	86.2	80.6	65.3	65.9	74.0	80.0	71.4	25.0	18.2	94.0	–	31.0
Lozoconcha elliptica Brady		–	–	–	–	–	–	–	–	–	3.9	–	–	11.9
L. venepidermoidea Swain		–	–	–	–	–	–	–	–	2.5	9.1	–	–	–
Paracyprideis pseudopunctillata Swain		24.7	4.6	9.7	30.6	28.9	15.4	2.5	–	57.5	55.8	4.0	–	50.0
Rabilimis septentrionalis (Brady)		–	–	–	–	–	0.8	–	–	–	–	–	–	–
Sarsicytheridea bradii (Norman)		–	–	–	–	–	–	5.0	–	–	–	–	–	–
Ostracode number		89	369	124	49	135	123	40	14	40	77	50	0	42
Diversity		3	4	4	3	3	5	5	2	4	6	3	0	5

Table 4. Borehole PB-2, benthic foraminifers. The distribution and abundance of benthic foraminiferal species in PB-2 is given as a percent of the total foraminiferal fauna. The foraminiferal number (number of specimens in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	(12.5)	(12.9)	(13.7)	(14.0)	(14.3)	(15.0)	(15.6)	(15.7)	(15.9)	(16.2)	(16.8)	(17.7)	(18.6)	(19.4)	(20.1)	(20.2)	(20.7)	(20.8)
Sample No. / Depth (meters)	MF3628	MF3629	MF3631	MF3656	MF3632	MF3633	MF3634	MF3635	MF3655	MF3636	MF3637	MF3638	MF3639	MF3630	MF3640	MF3653	MF3652	MF3641
Bathysiphon spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.4	–	–
Buccella frigida (Cushman)	–	–	3.5	0.7	4.7	2.2	–	1.4	–	4.3	0.7	–	3.2	3.8	–	4.3	–	–
Cassidulina islandica Norvang	–	–	–	–	–	8.9	3.1	21.9	17.0	20.2	4.7	26.5	3.2	–	–	8.6	–	3.3
C. norcrossi Cushman	–	3.8	–	–	–	6.7	8.5	5.1	6.6	7.4	41.9	11.9	22.6	6.4	20.7	14.3	–	21.1
Cyclogyra involvens (Reuss)	1.1	–	–	–	–	–	–	–	–	–	0.7	0.9	–	–	–	–	–	–
Dentalina frobisherensis Loeblich and Tappan	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.9	2.9	–	–
D. gracilis d'Orbigny	–	–	–	–	–	2.2	–	–	–	0.8	–	1.4	6.5	1.9	–	–	–	1.6
D. sp. ?	–	–	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Elphidiella groenlandica (Cushman)	19.6	26.9	–	0.4	–	–	–	–	–	–	–	–	–	0.6	–	–	–	–
Elphidium albiumbilicatum (Weiss)	4.3	3.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. cf. E. asklundi Brotzen	–	–	–	–	–	–	–	–	–	0.4	–	–	–	3.2	–	–	–	–
E. bartletti Cushman	3.3	11.5	–	–	–	–	–	–	0.9	–	–	0.5	–	–	–	–	–	–
E. cf. E. bartletti Cushman	–	–	–	–	–	–	–	–	–	–	–	–	–	0.6	–	–	–	–
E. clavatum Cushman	1.1	–	45.8	–	50.4	48.9	73.1	43.7	41.5	40.3	9.5	12.3	6.5	25.6	13.8	35.7	–	52.0
E. excavatum alba Feyling-Hanssen	–	7.7	0.7	5.2	1.6	2.2	–	–	–	1.2	–	–	–	–	6.9	–	–	1.6
E. frigidum Cushman	–	–	–	–	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–
E. incertum (Williamson)	3.3	–	2.1	–	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–
E. orbiculare (Brady)	48.9	34.6	38.0	91.5	37.0	17.8	10.0	14.4	27.4	21.7	40.5	40.2	54.8	52.6	37.9	28.6	–	13.8
E. sp.	3.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eoeponidella strombodes Tappan	–	–	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eosyrinx curta (Cushman and Ozawa)	–	–	–	–	–	–	–	–	–	0.4	–	–	–	–	–	–	–	–
Fissurina marginata (Montagu)	–	–	–	–	–	–	–	0.9	–	0.4	–	0.5	–	–	–	–	–	–
F. orbignyana Sequenza	–	–	–	–	–	–	–	–	–	0.8	–	–	–	–	–	–	–	–
F. spp.	–	–	–	–	–	–	0.8	–	–	–	–	–	–	–	–	–	–	–
Glandulina laevigata (d'Orbigny)	–	–	–	–	–	–	0.8	0.5	0.9	–	–	–	–	–	–	–	–	–
Guttulina austriaca d'Orbigny	2.2	–	–	–	–	–	–	–	–	–	–	–	–	0.6	–	–	–	–
G. lactea (Walker and Jacob)	1.1	3.8	3.5	–	1.9	–	–	–	0.9	0.8	0.7	1.4	–	2.6	6.9	1.4	–	3.3
G. problema d'Orbigny	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–	–	–	–	–
G. sp.	–	–	–	–	0.1	2.2	–	–	–	–	–	–	–	–	–	–	–	–
Lagena gracillima (Sequenza)	–	–	–	–	–	2.2	–	0.9	–	–	–	–	–	1.3	–	–	–	0.8
Oolina lineata (Williamson)	–	–	–	–	–	2.2	–	0.5	–	–	–	0.9	–	–	–	–	–	–
O. sp.	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–
Parafissurina himatiostoma Loeblich and Tappan	–	–	–	–	–	–	–	0.9	–	–	–	–	–	–	–	–	–	–
Polymorphina suboblonga Cushman and Ozawa	2.2	–	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–
P. spp.	5.4	7.7	–	2.2	3.5	4.4	3.1	0.5	0.9	–	–	0.5	–	–	3.4	–	–	0.8
Pseudopolymorphina arctica MacBeth and Schmidt	–	–	–	–	–	–	–	0.9	–	–	–	0.5	–	–	–	–	–	–
Pyrulina sp.	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–	–	–	–	–
Quinqueloculina arctica Cushman	–	–	–	–	–	–	–	–	0.9	–	0.7	–	–	–	–	–	–	–
Q. subrotunda (Montagu)	–	–	0.7	–	–	–	–	–	–	0.4	–	–	–	–	–	–	–	–
Q. cf. Q. subrotunda (Montagu)	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–
Q. seminulum (Linne)	3.3	–	1.4	–	0.2	–	–	–	–	–	–	0.5	3.2	–	3.4	1.4	–	–
Q. cf. Q. seminulum (Linne)	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–
Q. spp.	–	–	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Q. vulgaris d'Orbigny	1.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Silicosigmoilina groenlandica (Cushman)	–	–	2.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stainforthia concava (Hoeglund)	–	–	–	–	–	–	0.8	6.0	2.8	0.8	–	0.5	–	–	–	–	–	0.8
Trichyohalus sp.	–	–	–	–	–	–	–	–	–	–	0.7	–	–	–	–	–	–	–
Triloculina trihedra Loeblich and Tappan	–	–	–	–	–	–	–	1.4	–	0.4	–	0.5	–	0.6	–	1.4	–	0.8
Foraminiferal number	92	26	142	539	2795	45	130	215	106	258	148	219	31	156	29	70	0	123
Diversity	14	8	12	5	11	11	8	16	10	15	9	18	7	12	8	10	0	11

Table 5. Borehole PB-2, ostracodes. The distribution and abundance of ostracode species in PB-2 is given as a percent of the total ostracode fauna. The ostracode number (number of valves in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	(12.5)	(12.9)	(13.7)	(14.0)	(14.3)	(15.0)	(15.6)	(15.7)	(15.9)	(16.2)	(16.8)	(17.7)	(18.6)	(19.4)	(20.1)	(20.2)	(20.7)	(20.8)
Depth (meters) / Sample No.	MF3628	MF3629	MF3631	MF3656	MF3632	MF3633	MF3634	MF3635	MF3655	MF3636	MF3637	MF3638	MF3639	MF3630	MF3640	MF3653	MF3652	MF3641
Acanthocythereis dunelmensis (Norman)	-		4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cytheromorpha macchesneyi (Brady and Crosskey)			-	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cytheropteron montrosiense Brady, Crosskey and Robertson	3.1		-	-	-	-	-	42.9	37.5	6.7	-	-	-	-	-	-	-	-
Cytheretta teshekpukensis Swain	9.4	10.0	12.5	-	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Heterocyprideis sorbyana (Jones)	12.5	30.0	25.0	14.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Krithe glacialis Brady, Crosskey and Robertson	-	-	-	-	-	66.7	100.0	9.5	12.5	60.0	-	100.0	-	-	-	33.3	75.0	100.0
Lozoconcha elliptica Brady	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. venepidermoidea Swain	-	-	-	8.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Normanicythere leioderma (Norman)	3.1	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Palmanella limicola (Norman)	-	-	8.3			-	-	-	-	-	-	-	-	-	-	-	-	-
Paracyprideis pseudopunctillata Swain	9.4	-	-	66.7	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Rabilimis mirabilis (Brady)		-	-	-	-	33.3	-	47.6	50.0	33.3	100.0	-	100.0	-	-	66.7	25.0	-
R. septentrionalis (Brady)	40.6	30.0	20.8	4.2	93.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarsicytheridea bradii (Norman)	21.9	10.0	29.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ostracode number	32	10	24	48	47	6	1	21	8	30	1	1	1	0	0	3	4	8
Diversity	7	5	6	6	3	2	1	3	3	3	1	1	1	0	0	2	2	1

Table 6. Borehole PB-3, benthic foraminifers. The distribution and abundance of benthic foraminiferal species in PB-3 is given as a percent of the total foraminiferal fauna. The foraminiferal number (number of specimens in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	Depth (meters) / Sample No.	(6.5) MF3658	(7.6) MF3659	(7.9) MF3660	(8.2) MF3661	(9.1) MF3662	(9.5) MF3670	(10.1) MF3663	(10.8) MF3671	(10.9) MF3664
Buccella frigida (Cushman)		0.5	1.0	1.0	6.6	0.7	–	1.6	7.7	–
Cyclogyra involvens (Reuss)		0.2	2.0	–	–	1.3	–	–	0.2	–
Dentalina ittai Loeblich and Tappan		0.1	–	–	–	–	–	–	–	–
Elphidiella groenlandica (Cushman)		0.2	13.0	3.1	2.8	56.3	1.4	40.3	12.7	100.0
Elphidium asklundi Brotzen		1.3	–	–	–	–	–	–	1.9	–
E. bartletti Cushman		1.0	11.0	7.2	2.8	19.9	–	44.2	14.8	–
E. clavatum Cushman		14.2	3.0	–	8.0	12.6	–	–	18.1	–
E. excavatum alba Feyling-Hanssen		17.3	3.0	16.5	10.5	–	55.1	0.8	4.6	–
E. frigidum Cushman		10.2	9.0	8.2	3.5	–	2.9	0.8	12.2	–
E. incertum (Williamson)		5.0	–	–	1.4	–	–	–	1.3	–
E. orbiculare (Brady)		44.2	47.0	47.4	54.9	6.0	30.4	4.7	19.9	–
Glandulina laevigata (d'Orbigny)		–	–	–	–	–	2.9	–	–	–
Guttulina lactea (Walker and Jacob)		0.1	–	–	–	–	–	–	0.2	–
Lagena gracillima (Sequenza)		–	–	–	–	–	–	–	0.2	–
Oolina melo d'Orbigny		0.1	–	–	–	–	–	–	–	–
Polymorphina suboblonga Cushman and Ozawa		–	1.0	–	–	–	–	–	–	–
P. spp.		4.8	9.0	15.5	7.7	2.6	5.8	7.0	3.9	–
Pyrgo williamsoni Silvestri		–	–	–	–	0.7	–	–	–	–
Quinqueloculina subrotunda (Montagu)		–	–	1.0	–	–	–	–	–	–
Q. seminulum (Linne)		0.3	1.0	–	1.7	–	–	–	2.5	–
Reophax scorpiurus Montfort		–	–	–	–	–	–	0.8	–	–
Scutuloris tegminis Loeblich and Tappan		0.1	–	–	–	–	–	–	–	–
Trochammina nana (Brady)		0.3	–	–	–	–	1.4	–	–	–
Foraminiferal number		980	100	97	286	151	69	129	2434	2
Diversity		17	11	8	10	8	7	8	14	1

Table 7. Borehole PB-3, ostracodes. The distribution and abundance of ostracode species in PB-3 is given as a percent of the total ostracode fauna. The ostracode number (number of valves in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa / Depth (meters) / Sample No.	(6.5) MF3658	(7.0) MF3669	(7.6) MF3659	(7.9) MF3660	(8.2) MF3661	(9.1) MF3662	(9.5) MF3670	(10.1) MF3663	(10.8) MF3671	(10.9) MF3664
Cytheromorpha macchesneyi (Brady and Crosskey)	10.8	–	–	–	11.5	1.7	17.5	1.6	1.8	–
C. sp.	–	–	–	–	3.8	–	12.5	–	–	–
Cytheropteron montrosiense Brady, Crosskey and Robertson	1.1	–	–	–	–	1.7	–	1.6	0.9	–
C. sp.	1.1	–	–	–	–	–	–	–	–	–
Cytheretta teshekpukensis Swain	–	12.5	–	8.3	9.6	3.3	–	–	2.7	–
Eucythere declivis (Norman)	–	–	–	–	1.9	–	–	–	–	–
Heterocyprideis sorbyana (Jones)	32.3	20.0	–	8.3	17.3	5.0	42.5	17.2	15.2	–
Palmanella limicola (Norman)	1.1	–	–	–	–	3.3	–	–	–	–
Paracyprideis pseudopunctillata Swain	10.8	20.0	–	38.9	19.2	78.3	25.0	62.5	48.2	25.0
Rabilimis septentrionalis (Brady)	15.1	47.5	–	36.1	32.7	1.7	2.5	1.6	–	25.0
Sarsicytheridea bradii (Norman)	28.0	–	–	8.3	3.8	5.0	–	15.6	31.3	50.0
Ostracode number	93	40	0	36	52	60	40	64	112	4
Diversity	8	4	0	5	8	8	5	6	6	3

Table 8. Borehole PB-5, benthic foraminifers. The distribution and abundance of benthic foraminiferal species in PB-5 is given as a percent of the total foraminiferal fauna. The foraminiferal number (number of specimens in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	Depth (meters) / Sample No.	(2.8) MF4148	(3.9) MF4149	(4.4) MF4325	(6.7) MF4326	(8.4) MF4328	(9.0) MF4150	(9.6) MF4151	(9.9) MF4329	(10.3) MF4152	(10.5) MF4153	(10.6) MF4154	(10.7) MF4155
Buccella frigida (Cushman)		–	0.5	0.2	9.3	47.9	2.3	6.3	8.6	3.2	3.8	14.3	3.8
Cassidulina islandica Norvang		–	–	–	–	–	–	–	1.4	–	–	–	3.8
C. norcrossi Cushman		–	–	–	–	–	–	6.3	–	–	–	–	–
Elphidiella groenlandica (Cushman)		–	0.2	–	2.3	6.3	14.0	6.3	–	–	–	–	3.8
Elphidium albiumbilicatum (Weiss)		–	0.5	–	–	–	–	–	1.0	–	–	14.3	–
E. asklundi Brotzen		–	–	–	–	–	–	–	–	2.1	–	4.8	–
E. cf. E. asklundi Brotzen		–	–	–	–	–	14.0	–	0.2	–	–	–	–
E. bartletti Cushman		–	–	–	–	–	2.3	6.3	1.0	4.3	3.8	4.8	–
E. clavatum Cushman		–	–	–	1.1	–	2.3	–	19.0	–	7.7	4.8	–
E. excavatum alba Feyling-Hanssen		50.0	31.4	30.2	44.4	22.9	–	–	10.2	22.3	–	9.5	19.2
E. orbiculare (Brady)		50.0	65.0	68.1	34.5	8.3	51.2	75.0	54.0	61.7	69.2	33.3	69.2
E. sp.		–	–	–	–	–	–	–	–	–	11.5	–	–
Lagena gracillima (Sequenza)		–	–	–	–	–	–	–	0.2	–	–	–	–
Polymorphina spp.		–	2.6	1.3	5.3	10.4	14.0	–	4.3	6.4	3.8	14.3	–
Quinqueloculina arctica Cushman		–	–	–	1.1	4.2	–	–	–	–	–	–	–
Q. spp.		–	–	–	0.6	–	–	–	–	–	–	–	–
Reophax sp.		–	–	0.2	1.5	–	–	–	–	–	–	–	–
Foraminiferal number		12	666	457	1892	48	43	16	420	94	26	21	52
Diversity		2	6	5	9	6	7	5	10	6	6	8	5

Table 9. Borehole PB-5, ostracodes. The distribution and abundance of ostracode species in PB-5 is given as a percent of the total ostracode fauna. The ostracode number (number of valves in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa												
Depth (meters)	(2.8)	(3.9)	(4.4)	(6.7)	(8.4)	(9.0)	(9.6)	(9.9)	(10.3)	(10.5)	(10.6)	(10.7)
Sample No.	MF4148	MF4149	MF4325	MF4326	MF4328	MF4150	MF4151	MF4329	MF4152	MF4153	MF4154	MF4155
Candona sp.	–	–	–	1.2	–	–	–	2.6	–	–	–	–
Cyprid sp.	–	–	1.4	–	–	–	–	–	–	–	–	–
Cyprinotus sp.	–	–	1.4	–	–	–	–	–	–	–	–	–
Cytheromorpha macchesneyi (Brady and Crosskey)	–	55.0	30.4	9.2	6.7	–	33.3	28.2	6.7	–	35.7	20.0
C. sp.	–	–	4.3	4.4	13.3	–	–	2.6	6.7	–	–	–
Cytheropteron montrosiense Brady, Crosskey and Robertson	–	–	–	–	–	–	–	2.6	–	–	–	–
Cytherissa lacustris (Sars)	–	–	–	–	–	–	–	7.7	–	–	–	–
Cytheretta teshekpukensis Swain	–	–	–	–	–	47.4	–	7.7	6.7	–	21.4	–
Eucythere declivis (Norman)	–	–	–	0.4	–	–	–	–	–	–	–	–
Heterocyprideis sorbyana (Jones)	16.7	35.0	13.0	31.9	13.3	–	–	7.7	13.3	–	7.1	30.0
Ilyocypris sp.	–	–	–	–	–	–	–	2.6	–	–	–	–
Limnocythere liporeticulata Delorme	–	–	1.4	–	–	–	–	–	–	–	–	–
L. sp.	–	–	–	–	–	–	–	5.1	–	–	–	–
Lozoconcha venepidermoidea Swain	–	–	–	–	–	–	33.3	2.6	–	–	–	–
Paracyprideis pseudopunctillata Swain	16.7	–	14.5	20.7	60.0	–	–	25.6	26.7	100.0	28.6	30.0
Pontocythere sp.	16.7	–	–	1.2	–	–	–	2.6	13.3	–	–	10.0
Rabilimis septentrionalis (Brady)	50.0	5.0	33.3	31.1	6.7	26.3	–	2.6	26.7	–	7.1	–
Sarsicytheridea bradii (Norman)	–	5.0	–	–	–	26.3	33.3	–	–	–	–	10.0
Ostracode number	6	20	69	251	15	19	3	39	15	1	14	10
Diversity	4	4	8	8	5	3	3	13	7	1	5	5

Table 10. Borehole PB-6, benthic foraminifers. The distribution and abundance of benthic foraminiferal species in PB-6 is given as a percent of the total foraminiferal fauna. The foraminiferal number (number of specimens in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	Depth (meters) / Sample No.	(1.9) MF4156	(2.1) MF4330	(2.5) MF4157	(2.8) MF4331	(3.4) MF4158	(3.7) MF4159
Buccella frigida (Cushman)		1.1	–	–	–	–	–
Elphidiella groenlandica (Cushman)		0.8	2.4	–	–	–	–
Elphidium albiumbilicatum (Weiss)		7.4	24.4	–	–	–	–
E. cf. E. asklundi Brotzen		3.6	–	–	–	–	–
E. bartletti Cushman		0.3	–	–	–	–	–
E. excavatum alba Feyling-Hanssen		38.5	12.2	33.3	–	–	–
E. orbiculare (Brady)		45.4	56.1	66.7	–	–	–
Polymorphina spp.		2.5	4.9	–	–	–	–
Reophax cf. R. arctica Brady		0.5	–	–	–	–	–
Foraminiferal number		366	41	3	0	0	0
Diversity		9	5	2	0	0	0

Table 11. Borehole PB-6, ostracodes. The distribution and abundance of ostracode species in PB-6 is given as a percent of the total ostracode fauna. The ostracode number (number of valves in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	Depth (meters)	(1.9)	(2.1)	(2.5)	(2.8)	(3.4)	(3.7)
	Sample No.	MF4156	MF4330	MF4157	MF4331	MF4158	MF4159
Cytheromorpha macchesneyi (Brady and Crosskey)		51.3	35.7	–	–	–	–
C. sp.		7.0	3.6	–	–	–	–
Cytheretta teshekpukensis Swain		0.9	–	–	–	–	–
Heterocyprideis sorbyana (Jones)		31.3	39.3	50.0	–	–	–
Limnocythere sp.		0.9	–	–	–	–	–
Paracyprideis pseudopunctillata Swain		3.5	3.6	–	–	–	–
Rabilimis septentrionalis (Brady)		5.2	17.9	50.0	–	–	–
Sarsicytheridea bradii (Norman)		–	–	–	–	–	100.0
Ostracode number		115	28	2	0	0	1
Diversity		7	5	2	0	0	1

Table 12. Borehole PB-7, benthic foraminifers. The distribution and abundance of benthic foraminiferal species in PB-7 is given as a percent of the total foraminiferal fauna. The foraminiferal number (number of specimens in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa	Depth (meters)	(2.9)	(3.3)	(4.9)	(5.0)	(5.6)	(6.1)	(6.5)	(6.8)
	Sample No.	MF4165	MF4333	MF4166	MF4167	MF4334	MF4168	MF4170	MF4169
Buccella frigida (Cushman)		2.7	9.5	5.5	12.2	6.6	4.4	–	–
Elphidiella groenlandica (Cushman)		–	–	0.1	0.8	–	–	5.0	–
Elphidium albiumbilicatum (Weiss)		7.1	0.8	–	1.6	73.6	–	–	–
E. asklundi Brotzen		1.6	–	0.3	–	–	–	–	–
E. clavatum Cushman		1.4	6.7	2.1	11.8	–	–	–	–
E. excavatum alba Feyling-Hanssen		40.4	18.3	26.5	35.1	15.1	33.3	–	–
E. incertum (Williamson)		–	–	1.6	1.4	–	–	–	–
E. orbiculare (Brady)		43.4	60.1	61.8	31.5	4.7	57.8	95.0	100.0
Globulina sp.		–	0.7	–	–	–	–	–	–
Polymorphina spp.		3.0	3.4	1.7	3.2	–	2.2	–	–
Quinqueloculina arctica Cushman		–	–	0.3	2.0	–	2.2	–	–
Q. seminulum (Linne)		–	0.4	–	–	–	–	–	–
Silicosigmoilina groenlandica (Cushman)		0.3	–	–	–	–	–	–	–
Trochammina nana (Brady)		–	–	0.1	0.4	–	–	–	–
Foraminiferal number		366	2158	765	499	848	45	20	7
Diversity		8	8	10	10	4	5	2	1

Table 13. Borehole PB-7, ostracodes. The distribution and abundance of ostracode species in PB-7 is given as a percent of the total ostracode fauna. The ostracode number (number of valves in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table.

Taxa — Depth (meters)	(2.9)	(3.3)	(4.9)	(5.0)	(5.6)	(6.1)	(6.5)	(6.8)
Sample No.	MF4165	MF4333	MF4166	MF4167	MF4334	MF4168	MF4170	MF4169
Candona sp.	0.9	–	–	–	–	–	–	–
Cytheromorpha macchesneyi (Brady and Crosskey)	30.3	41.4	14.0	14.5	16.7	20.5	25.0	–
C. sp.	3.7	13.8	2.0	5.2	–	6.8	–	–
Cytherissa lacustris (Sars)	–	–	0.3	–	–	–	–	–
Cytheretta teshekpukensis Swain	2.8	0.7	5.9	0.6	–	–	–	–
Eucythere declivis (Norman)	–	0.7	0.3	0.6	–	–	–	–
Heterocyprideis sorbyana (Jones)	14.7	11.7	13.0	13.3	30.0	13.7	–	–
Ilyocypris sp.	–	–	–	0.6	3.3	–	–	–
Limnocythere sp.	0.9	0.7	0.3	–	–	1.4	–	–
Loxoconcha sp.	–	–	1.0	–	–	–	–	–
L. venepidermoidea Swain	–	2.1	0.5	–	–	–	–	–
Paracyprideis pseudopunctillata Swain	11.9	7.6	14.2	30.1	30.0	37.0	25.0	100.0
Pontocythere sp.	–	4.1	–	2.3	–	–	–	–
Rabilimis septentrionalis (Brady)	31.2	17.2	45.5	32.9	20.0	20.5	25.0	–
Roundstonia globulifera (Brady)	–	–	1.0	–	–	–	–	–
Sarsicytheridea bradii (Norman)	3.7	–	2.0	–	–	–	–	–
S. punctillata (Brady)	–	–	–	–	–	–	25.0	–
Ostracode number	109	145	393	173	30	73	4	1
Diversity	9	10	13	9	5	6	4	1

Table 14. Borehole PB-8, benthic foraminifers. The distribution and abundance of benthic foraminiferal species in PB-8 is given as a percent of the total foraminiferal fauna. The foraminiferal number (number of specimens in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table

Taxa	Depth (meters)	(7.4)	(7.7)	(7.9)	(8.5)	(8.6)	(9.0)	(9.2)	(9.6)	(9.8)	(9.9)	(10.1)	(10.3)	(10.5)	(10.6)	(10.8)	(10.9)	(11.2)	(11.4)	(11.5)	(11.6)	(11.7)
	Sample No.	MF4171	MF4172	MF4173	MF4174	MF4175	MF4176	MF4177	MF4178	MF4179	MF4180	MF4181	MF4182	MF4183	MF4184	MF4185	MF4186	MF4187	MF4188	MF4189	MF4190	MF4191
Ammotium cassis (Parker)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Buccella frigida (Cushman)		12.3	6.2	7.8	6.9	5.1	6.5	9.6	16.4	5.4	5.5	10.1	5.9	11.5	8.2	6.2	7.8	5.1	3.9	9.5	3.0	8.2
B. inusitata Anderson		–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	–	–	–	–	–	–	–
B. sp.		–	–	–	–	–	–	–	–	–	–	–	0.1	–	–	–	–	–	–	–	–	–
Cassidulina islandica Norvang		2.9	–	3.6	1.6	2.4	2.1	1.3	2.5	2.6	0.9	0.4	4.8	5.7	6.1	4.9	6.8	3.6	0.6	5.0	–	11.8
C. norcrossi Cushman		–	–	0.3	–	0.8	–	0.2	0.0	0.4	2.8	0.3	–	0.2	0.2	5.2	3.6	2.2	3.7	0.2	2.8	0.8
Cyclogyra involvens (Reuss)		0.2	–	0.1	0.2	0.1	0.0	–	–	–	0.2	–	0.1	–	0.0	0.1	0.2	0.0	0.4	–	–	0.1
Dentalina ittai Loeblich and Tappan		–	–	1.1	–	–	0.0	–	0.6	–	0.5	–	–	–	–	0.6	–	–	0.4	–	–	–
D. pauperata d'Orbigny		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Elphidiella groenlandica (Cushman)		–	1.8	0.1	0.3	0.6	0.1	1.8	0.2	3.3	7.3	3.3	1.2	1.5	0.5	4.4	2.8	2.0	0.4	0.1	3.5	1.3
E. oregonense (Cushman and Grant)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4.1	–	–	–
Elphidium albiumbilicatum (Weiss)		–	0.1	0.5	–	2.0	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–
E. asklundi Brotzen		–	–	–	–	0.7	–	2.2	0.1	2.6	11.9	2.1	1.1	1.8	0.4	0.5	2.7	1.1	7.7	9.7	17.2	7.5
E. bartletti Cushman		0.7	11.6	6.9	8.9	7.3	4.4	9.8	1.2	40.4	14.4	10.2	7.1	1.7	9.0	3.4	17.9	12.2	13.5	1.4	4.9	4.4
E. clavatum Cushman		34.5	24.7	–	22.2	8.5	22.5	26.1	26.2	1.8	15.6	16.3	31.7	18.6	24.0	19.7	14.7	22.9	12.2	25.6	20.1	15.9
E. excavatum alba Feyling-Hanssen		10.8	–	31.0	5.6	25.4	9.8	3.5	0.4	8.5	7.3	8.2	6.4	10.7	1.3	7.2	1.0	5.1	4.6	4.7	4.9	6.4
E. frigidum Cushman		0.8	0.3	10.5	3.3	0.5	17.5	16.6	18.5	10.7	6.4	5.8	18.3	15.7	21.4	17.4	1.1	16.7	3.3	17.1	4.4	7.3
E. incertum (Williamson)		2.5	3.1	0.6	4.7	4.5	0.8	0.2	1.6	2.0	–	–	0.5	0.6	0.4	0.2	0.4	–	17.9	1.1	16.8	2.1
E. orbiculare (Brady)		29.8	50.0	29.2	38.4	30.6	30.2	23.3	19.6	18.2	22.7	39.7	15.6	24.2	24.6	25.3	31.9	22.4	21.0	22.0	17.9	26.1
E. sp.		–	–	–	–	1.6	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–
Fissurina spp.		–	–	0.5	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–	0.6	–	–
Glandulina sp.		–	–	–	–	–	–	–	–	–	–	–	0.1	–	–	–	–	–	–	0.0	0.2	0.1
Gordiospira arctica (Cushman)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guttulina problema d'Orbigny		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lagena costata (Williamson)		0.1	–	–	–	–	0.0	–	0.0	–	–	–	–	0.1	–	–	0.8	–	0.6	–	–	–
L. gracillima (Sequenza)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. hexagona (Williamson)		–	–	–	0.5	–	–	–	–	–	–	–	0.5	–	0.0	–	–	–	–	–	–	0.1
L. semistriata Williamson		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1
L. sp.		–	–	0.1	–	0.5	–	–	–	0.1	–	–	–	0.0	–	–	–	–	–	–	–	–
Pateoris hauverimoides (Rhumbler)		–	–	–	–	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Parafissurina lateralis carinata (Buchner)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polymorphina spp.		4.9	0.8	6.5	6.3	8.5	5.8	4.3	11.4	3.5	3.9	1.8	4.8	6.0	3.0	4.7	8.2	6.3	3.7	2.2	1.4	7.6
Pyrgo williamsoni Silvestri		–	–	–	–	–	–	0.5	–	0.1	–	–	–	0.7	0.0	–	–	–	–	–	–	–
Quinqueloculina arctica Cushman		0.2	0.3	0.4	–	0.4	–	–	–	0.3	–	–	–	–	–	–	–	–	–	–	0.2	–
Q. seminulum (Linne)		–	–	–	–	0.1	0.0	0.5	–	–	–	0.4	0.5	0.1	0.7	0.2	0.2	0.1	0.9	0.1	0.4	0.3
Q. spp.		–	–	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	0.6	–	0.2	–
Q. stalkeri Loeblich and Tappan		–	1.0	–	1.2	–	–	–	0.8	–	0.5	1.4	–	–	–	–	–	–	–	–	–	0.1
Reophax arctica Brady		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. scorpiurus Montfort		0.1	0.1	0.1	–	–	–	–	–	0.1	–	–	–	0.0	–	–	–	–	–	–	–	–
Scutuloris tegminis Loeblich and Tappan		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.6	0.1	0.2	–
Stainforthia concava (Hoeglund)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.1	–
Triloculina oblongata (Montagu)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T. trihedra Loeblich and Tappan		–	0.1	–	–	–	–	–	–	–	–	–	0.5	0.6	–	–	–	–	–	0.6	–	–
Trochammina rotaliformis Wright		–	–	0.7	–	–	–	–	0.2	–	–	–	0.1	–	–	–	–	–	0.2	–	–	–
Foraminiferal number		3384	1556	3092	3060	994	8958	602	2565	1594	872	706	1515	2533	4744	2616	2358	2258	542	5158	571	1627
Diversity		13	13	18	13	19	14	15	17	16	14	13	19	18	17	15	15	14	20	17	17	18

Taxa	Depth (meters)	(12.0)	(12.1)	(12.2)	(12.3)	(12.6)	(12.8)	(12.9)	(13.0)	(13.1)	(13.3)	(13.5)	(13.6)	(13.8)	(14.1)	(14.2)	(14.3)	(14.5)	(14.7)	(14.9)	(15.1)	(15.2)
	Sample No.	MF4192	MF4193	MF4194	MF4195	MF4196	MF4197	MF4198	MF4199	MF4200	MF4201	MF4202	MF4203	MF4204	MF4205	MF4206	MF4207	MF4208	MF4209	MF4210	MF4211	MF4212
Ammotium cassis (Parker)		–	–	–	–	–	–	0.0	–	–	–	–	–	–	–	–	–	–	–	1.5	0.3	–
Buccella frigida (Cushman)		3.8	2.7	2.5	2.7	3.6	5.1	12.0	5.1	3.7	6.3	7.1	7.8	2.1	–	3.0	–	7.8	8.1	8.6	7.7	10.6
B. inusitata Anderson		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B. sp.		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cassidulina islandica Norvang		1.3	2.3	3.5	2.8	1.6	8.0	3.0	0.4	–	0.7	–	–	–	–	–	–	–	–	–	–	–
C. norcrossi Cushman		2.2	2.7	3.9	3.8	0.5	1.1	–	–	0.6	0.3	–	–	1.0	–	–	–	–	–	0.3	–	–
Cyclogyra involvens (Reuss)		–	0.5	0.1	–	0.1	0.4	0.0	0.2	–	–	10.7	–	–	–	1.0	–	0.9	–	–	–	–
Dentalina ittai Loeblich and Tappan		–	–	–	–	–	–	–	–	0.6	–	–	–	–	–	–	–	–	–	–	–	–
D. pauperata d'Orbigny		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Elphidiella groenlandica (Cushman)		1.0	2.5	2.3	0.8	1.7	0.9	0.1	0.1	–	0.3	–	0.7	–	–	–	5.1	5.2	18.9	6.8	3.8	0.8
E. oregonense (Cushman and Grant)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Elphidium albiumbilicatum (Weiss)		–	5.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. asklundi Brotzen		5.1	8.6	2.6	–	0.8	–	0.1	0.5	–	–	–	–	2.1	–	–	–	–	8.1	2.5	1.5	–
E. bartletti Cushman		6.7	7.0	14.7	37.9	4.9	9.8	0.1	0.3	–	–	–	–	–	–	–	–	–	2.7	–	–	–
E. clavatum Cushman		6.7	8.6	15.0	8.7	13.6	35.9	39.9	54.2	37.3	42.5	28.6	17.0	20.6	32.0	30.3	35.9	20.9	–	11.1	22.5	58.5
E. excavatum alba Feyling-Hanssen		5.1	6.1	6.2	9.0	7.1	4.0	4.4	3.7	–	0.3	3.6	–	3.1	–	–	–	–	–	–	7.2	3.5
E. frigidum Cushman		7.0	6.3	4.6	7.3	1.1	0.6	0.2	1.6	0.6	0.7	–	–	2.1	–	19.2	5.1	–	18.9	3.1	–	0.3
E. incertum (Williamson)		14.6	2.7	11.1	4.7	15.7	11.1	14.8	13.0	27.3	17.8	–	–	–	24.0	11.1	–	18.3	5.4	26.2	26.1	8.9
E. orbiculare (Brady)		40.6	40.6	31.8	18.3	43.3	16.9	17.8	15.3	13.7	14.6	39.3	54.2	44.3	10.0	4.0	10.3	27.0	13.5	25.8	21.5	3.5
E. sp.		–	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fissurina spp.		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Glandulina sp.		–	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gordiospira arctica (Cushman)		–	–	–	–	–	0.0	0.8	0.3	6.8	10.1	10.7	3.3	11.3	2.0	2.0	–	1.7	2.7	–	–	1.9
Guttulina problema d'Orbigny		–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lagena costata (Williamson)		–	–	–	–	–	–	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. gracillima (Sequenza)		–	–	–	–	–	–	–	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–
L. hexagona (Williamson)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. semistriata Williamson		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. sp.		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pateoris hauverimoides (Rhumbler)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.7	–	–	–
Parafissurina lateralis carinata (Buchner)		–	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polymorphina spp.		4.4	2.3	1.2	1.5	4.3	5.4	4.8	2.9	3.7	4.2	–	5.9	10.3	24.0	15.2	5.1	12.2	16.2	12.6	7.9	3.7
Pyrgo williamsoni Silvestri		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Quinqueloculina arctica Cushman		1.6	–	0.4	2.0	0.1	0.8	–	–	–	–	–	3.3	3.1	–	12.1	20.5	2.6	–	–	–	–
Q. seminulum (Linne)		–	0.5	–	–	0.9	–	–	1.2	4.3	1.0	–	7.2	–	6.0	2.0	–	0.9	–	–	–	–
Q. spp.		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Q. stalkeri Loeblich and Tappan		–	–	–	–	0.5	–	0.9	0.9	–	–	–	–	–	–	–	15.4	0.9	–	–	–	0.8
Reophax arctica Brady		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.9	–	–	–	1.8
R. scorpiurus Montfort		–	–	0.1	–	–	–	0.0	–	0.6	–	–	–	–	–	–	–	–	–	–	–	–
Scutuloris tegminis Loeblich and Tappan		–	–	–	–	–	–	–	–	0.6	0.7	–	0.7	–	2.0	–	2.6	0.9	–	–	0.5	5.7
Stainforthia concava (Hoeglund)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Triloculina oblongata (Montagu)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.7	1.2	0.5	–
T. trihedra Loeblich and Tappan		–	–	–	–	–	–	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Trochammina rotaliformis Wright		–	–	–	–	–	–	–	0.1	–	–	–	–	–	–	–	–	–	–	0.3	0.5	–
Foraminiferal number		630	3544	2771	2404	750	3219	2131	991	161	287	28	153	97	50	99	78	115	37	325	391	902
Diversity		13	17	15	14	16	14	18	16	12	14	6	9	10	7	10	8	13	11	12	12	12

Table 14. Continued

Taxa — Depth (meters) / Sample No.	(15.3) MF4213	(15.4) MF4214	(15.6) MF4215	(15.7) MF4216	(16.0) MF4217	(16.4) MF4218	(16.6) MF4336	(16.9) MF4219	(17.0) MF4220	(17.3) MF4337	(17.6) MF4221	(17.7) MF4222	(17.9) MF4223	(18.2) MF4224	(18.4) MF4225	(18.8) MF4226	(19.2) MF4338	(19.4) MF4227	(20.2) MF4228	(20.3) MF4230	(20.4) MF4231
Ammotium cassis (Parker)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Buccella frigida (Cushman)	8.1	4.1	1.3	2.0	–	1.5	–	–	1.4	–	–	2.3	0.5	2.2	–	3.0	–	–	–	7.1	–
B. inusitata Anderson	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cassidulina islandica Norvang	–	2.0	29.1	35.3	14.3	24.2	33.3	29.1	27.4	23.6	12.6	34.7	30.8	24.9	18.3	25.3	–	10.0	14.3	23.2	35.7
C. norcrossi Cushman	–	–	0.6	–	–	–	–	–	–	–	–	–	2.1	0.9	2.8	2.0	4.0	–	–	–	–
Cyclogyra involvens (Reuss)	–	–	–	–	–	1.5	–	–	–	–	–	–	–	0.5	0.9	1.0	–	–	–	1.8	–
Dentalina ittai Loeblich and Tappan	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
D. pauperata d'Orbigny	–	–	–	–	–	–	–	–	–	–	1.4	1.7	0.5	0.9	1.8	2.0	24.0	–	–	–	–
Elphidiella groenlandica (Cushman)	14.5	2.9	0.6	2.0	14.3	3.0	–	1.8	1.4	–	2.1	0.9	0.8	2.6	11.9	3.0	20.0	–	–	1.8	14.3
E. oregonense (Cushman and Grant)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Elphidium albiumbilicatum (Weiss)	–	–	–	7.8	–	3.0	8.3	–	–	–	–	–	–	1.6	–	–	–	–	–	–	–
E. asklundi Brotzen	3.2	–	–	–	–	–	–	–	–	–	–	–	–	0.5	3.7	–	4.0	–	–	–	–
E. bartletti Cushman	–	–	–	–	–	–	–	–	4.1	32.6	24.5	8.2	12.9	9.5	17.4	20.2	40.0	20.0	28.6	8.9	10.7
E. clavatum Cushman	19.4	8.2	24.7	21.6	–	31.8	37.5	41.8	37.0	18.0	22.4	32.7	25.3	30.5	7.3	21.2	–	30.0	14.3	19.6	21.4
E. excavatum alba Feyling-Hanssen	3.2	10.6	–	–	–	–	–	–	–	2.2	2.8	–	–	–	–	–	–	–	–	–	–
E. frigidum Cushman	–	7.0	–	–	–	1.5	–	–	2.7	–	3.5	1.2	3.2	0.2	–	4.0	–	–	–	16.1	–
E. incertum (Williamson)	29.0	30.7	–	–	–	1.5	–	–	–	–	–	–	–	2.2	7.3	–	–	–	–	–	–
E. orbiculare (Brady)	11.3	18.8	19.6	5.9	7.1	15.2	4.2	14.5	13.7	11.2	18.9	13.4	17.1	14.8	15.6	10.1	4.0	40.0	28.6	14.3	3.6
E. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	14.3	–	–
Fissurina spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.9	1.0	–	–	–	–	3.6
Glandulina sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gordiospira arctica (Cushman)	1.6	–	–	–	–	–	–	–	–	1.1	–	–	–	–	–	–	–	–	–	–	–
Guttulina problema d'Orbigny	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lagena costata (Williamson)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. gracillima (Sequenza)	–	–	–	–	7.1	3.0	–	3.6	2.7	–	–	–	1.3	0.7	5.5	1.0	–	–	–	–	3.6
L. hexagona (Williamson)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. semistriata Williamson	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pateoris hauverimoides (Rhumbler)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Parafissurina lateralis carinata (Buchner)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polymorphina spp.	9.7	10.9	6.3	–	7.1	–	4.2	3.6	1.4	3.4	5.6	3.2	4.7	5.1	6.4	4.0	–	–	–	7.1	7.1
Pyrgo williamsoni Silvestri	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Quinqueloculina arctica Cushman	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Q. seminulum (Linne)	–	–	–	–	–	–	4.2	1.8	1.4	–	1.4	–	–	0.7	–	–	4.0	–	–	–	–
Q. spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Q. stalkeri Loeblich and Tappan	–	2.4	8.9	7.8	28.6	1.5	–	–	–	2.2	–	–	0.3	–	–	–	–	–	–	–	–
Reophax arctica Brady	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. scorpiurus Montfort	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scutuloris tegminis Loeblich and Tappan	–	2.2	8.9	15.7	21.4	12.1	4.2	–	6.8	1.1	3.5	1.5	0.3	1.5	–	–	–	–	–	–	–
Stainforthia concava (Hoeglund)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Triloculina oblongata (Montagu)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T. trihedra Loeblich and Tappan	–	–	–	2.0	–	–	4.2	3.6	–	4.5	1.4	0.3	0.3	0.4	–	2.0	–	–	–	–	–
Trochammina rotaliformis Wright	–	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Foraminiferal number	62	783	158	51	14	66	24	55	73	89	143	343	380	547	109	99	25	10	7	56	28
Diversity	9	12	9	9	7	12	8	8	11	10	12	11	14	19	13	14	7	4	5	9	8

Table 15. Borehole PB-8, ostracodes. The distribution and abundance of ostracode species in PB-8 is given as a percent of the total ostracode fauna. The ostracode number (number of valves in 100 grams of sediment) and the diversity (number of species per sample) is given at the bottom of the table

Taxa / Depth (meters)	(7.4)	(7.7)	(7.9)	(8.5)	(8.6)	(9.0)	(9.2)	(9.6)	(9.8)	(9.9)	(10.1)	(10.3)	(10.5)	(10.6)	(10.8)	(10.9)	(11.2)	(11.4)	(11.5)	(11.6)	(11.7)
Sample No.	MF4171	MF4172	MF4173	MF4174	MF4175	MF4176	MF4177	MF4178	MF4179	MF4180	MF4181	MF4182	MF4183	MF4184	MF4185	MF4186	MF4187	MF4188	MF4189	MF4190	MF4191
Acanthocythereis dunelmensis (Norman)	–	–	1.5	–	–	–	2.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Candona sp.	1.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cluthia aff. C. cluthae Brady, Crosskey and Robertson		–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cypridopsis aculeata (Liljeborg)	0.9		–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cytheromorpha macchesneyi (Brady and Crosskey)	15.5	–	6.2	1.8	2.1	10.2	4.1	8.5	2.9	3.4	1.0	5.8	1.1	2.0	–	–	–	–	1.4	0.5	1.6
C. sp.	1.7	–	–	–	–	2.3	–	1.4	0.7	–	1.5	0.6	–	2.0	–	–	1.2	1.1	0.7	–	–
Cytheropteron montrosiense Brady, Crosskey and Robertson	0.9	–	–	–		3.4	8.2	4.9	1.5	–	0.5	–	–	–	–	–	–	–	0.7	1.1	1.6
C. nodosoalatum Neale and Howe	–	–		–	–	–	–	–	–	–	–	–	–	1.0	–	–	–	–	–	–	–
C. paralatissimum Swain	–	–	–	–	–	–	–	0.7	–	–	–	–	–	–	0.3	–	–	–	–	–	–
C. punctatum Brady	1.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. aff. C. pyramidale Neale and Howe	–	2.1	–	–	–	–	–	–	–	–			–	–	–	–	–	–	–	–	–
C. sp.	–	–	–	–	–	–	–	0.7	–	–	–	0.6	–	–	–	–	–	–	–	0.5	–
Cytheretta teshekpukensis Swain	5.2	2.1	6.2	10.7	4.2	5.7	2.0	–	4.4	6.0	8.9	3.5	8.9	4.5	12.4	12.3	6.1	5.6	4.1	3.3	3.2
Cytherura sp.	0.9	2.1	1.5	3.6	1.1	–	–	–	–	–	0.5	–	–	–	–	–	–	–	1.4	–	–
Eucythere declivis (Norman)	2.6	2.1	1.5	1.8	–	1.1		–	–		–	0.6	–		–	1.5	–	–	–	–	–
Finmarchinella curvicosta Neale	–	–	1.5	–	–	2.3	–	–	–	–	–	0.6	–	–	–	–	–	–	–	–	–
F. finmarchica (Sars)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Heterocyprideis sorbyana (Jones)	12.1	29.2	21.5	28.6	36.8	28.4	12.2	16.2	32.4	34.2	20.8	26.7	27.8	27.9	36.3	47.7	46.3	34.8	34.5	29.9	45.6
Krithe glacialis Brady, Crosskey and Robertson	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–
Limnocythere sp.	0.9	–	–	1.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.5	–
Lozoconcha venepidermoidea Swain	2.6	–	–	–	–	–	–	–		–	0.5	–	–	–	–	–	–	–	–	–	–
Normanicythere leioderma (Norman)	5.2	16.7	–	–	–	2.3	–	0.7	7.4	5.1	15.3	6.4	1.1	1.5	3.5	3.1	–	–	–	4.9	–
Palmanella limicola (Norman)	–	–	1.5	1.8	–	1.1	2.0	1.4	–	–	–	–	1.1	0.5	0.3	1.5	–	–	0.7	1.1	–
Paracyprideis pseudopunctillata Swain	6.0	14.6	23.1	12.5	32.6	15.9	63.3	57.7	17.6	13.7	16.8	10.5	18.9	10.0	5.1	13.8	15.9	16.9	20.0	20.1	5.6
Pontocythere sp.	–	–	–	–	–	–	–	–	–	0.9	–	0.6	–	–	–	–	–	–	–	–	–
Rabilimis mirabilis (Brady)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. septentrionalis (Brady)	12.9	12.5	3.1	17.9	4.2	19.3	2.0	0.7	4.4	5.1	12.4	8.1	3.3	5.0	4.1	–	6.1	0.6	4.8	8.2	–
Roundstonia globulifera (Brady)	–	–	–	–	–	–	–	–	0.7	–	–	0.6	–	0.5	–	–	1.2	–	1.4	–	–
Sarsicytheridea bradii (Norman)	29.3	16.7	30.8	19.6	18.9	5.7	4.1	5.6	27.9	31.6	21.8	35.5	37.8	45.3	37.9	20.0	23.2	41.0	30.3	29.9	42.4
S. punctillata (Brady)	–	–	1.5	–	–	2.3	–	1.4	–	–	–	–	–	–	–	–	–	–	–	–	–
Sclerochilus sp.	–	2.1	–	–	–		–	–	–	–		–		–	–	–	–	–	–	–	–
Ostracode number	116	48	65	56	95	88	49	142	136	117	202	172	90	201	314	65	82	178	145	184	125
Diversity	16	10	12	10	7	13	9	12	10	8	11	13	8	11	8	7	7	6	11	11	6

Table 15. Continued

Taxa (Sample No.)	MF4192	MF4193	MF4194	MF4195	MF4196	MF4197	MF4198	MF4199	MF4200	MF4201	MF4202	MF4203	MF4204	MF4205	MF4206	MF4207	MF4208	MF4209	MF4210	MF4211	MF4212
Depth (meters)	(12.0)	(12.1)	(12.2)	(12.3)	(12.6)	(12.8)	(12.9)	(13.0)	(13.1)	(13.3)	(13.5)	(13.6)	(13.8)	(14.1)	(14.2)	(14.3)	(14.5)	(14.7)	(14.9)	(15.1)	(15.2)
Acanthocythereis dunelmensis (Norman)	–	–	–	–	–	1.2	–	–	0.2	–	0.6	5.3	0.4	–	2.1	–	–	–	–	–	–
Candona sp.	–	–	–	–	–	–	0.4	–	–	0.2	–	–	–	–	–	–	–	–	–	–	0.4
Cluthia aff. C. cluthae Brady, Crosskey and Robertson	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cypridopsis aculeata (Liljeborg)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. sp.	–	–	–	–	0.6	2.0	–	–	0.2	–	–	–	–	–	–	–	–	0.6	–	–	–
Cytheromorpha macchesneyi (Brady and Crosskey)	–	–	1.6	–	–	–	1.9	3.5	0.7	2.2	–	1.5	–	–	–	1.8	1.0	1.2	1.4	0.6	1.8
C. sp.	–	–	–	–	–	–	0.4	–	–	–	1.2	–	2.5	–	–	–	0.5	1.2	–	–	–
Cytheropteron montrosiense Brady, Crosskey and Robertson	0.9	–	0.8	–	1.2	–	0.4	0.4	–	–	–	–	–	–	–	–	0.5	–	–	0.6	0.4
C. nodosoalatum Neale and Howe	0.9	–	–	–	–	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–
C. paralatissimum Swain	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. punctatum Brady	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. aff. C. pyramidale Neale and Howe	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. sp.	–	–	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cytheretta teshekpukensis Swain	29.1	17.7	4.8	10.2	1.2	3.9	1.2	0.9	–	0.5	0.6	–	–	–	–	–	0.5	–	–	0.6	–
Cytherura sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.9
Eucythere declivis (Norman)	–	–	–	1.8	–	0.8	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Finmarchinella curvicosta Neale	–	–	–	–	–	–	–	–	–	–	1.2	–	–	–	–	–	–	–	–	–	–
F. finmarchica (Sars)	0.9	0.7	0.8	1.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Heterocyprideis sorbyana (Jones)	9.4	14.2	8.0	12.0	32.7	37.9	27.5	29.6	13.7	13.4	17.3	17.4	24.8	33.3	12.3	–	23.2	23.3	22.0	18.3	11.5
Krithe glacialis Brady, Crosskey and Robertson	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Limnocythere sp.	–	–	–	0.6	–	0.4	0.4	0.4	–	0.2	–	–	–	–	–	–	–	–	–	–	–
Loxoconcha venepidermoidea Swain	–	–	–	–	–	0.4	0.4	0.4	0.2	–	–	–	–	–	–	–	–	–	–	–	0.4
Normanicythere leioderma (Norman)	–	–	2.4	0.6	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Palmanella limicola (Norman)	–	–	–	0.6	0.6	1.6	0.8	0.4	–	–	–	0.8	–	–	–	–	–	0.6	0.3	1.1	–
Paracyprideis pseudopunctillata Swain	4.3	3.5	10.4	18.0	15.4	19.1	41.1	38.1	53.9	52.8	45.7	47.0	49.2	59.3	72.6	85.5	56.7	45.9	36.4	57.2	68.6
Pontocythere sp.	–	–	–	–	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rabilimis mirabilis (Brady)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. septentrionalis (Brady)	20.5	29.8	20.8	14.4	6.8	4.3	2.7	4.9	13.5	17.8	8.6	2.3	0.8	–	–	–	1.5	–	–	0.6	–
Roundstonia globulifera (Brady)	–	–	–	–	1.2	0.8	0.8	–	–	0.2	1.2	0.8	0.4	1.6	–	–	–	–	–	0.6	–
Sarsicytheridea bradii (Norman)	34.2	34.0	49.6	40.7	40.1	27.3	20.9	20.8	17.5	12.7	22.8	23.5	21.4	5.7	12.6	12.7	13.9	21.5	35.3	16.7	15.5
S. punctillata (Brady)	–	–	–	–	–	–	–	–	–	–	0.6	1.5	0.4	–	0.4	–	2.1	5.8	4.5	3.9	0.4
Sclerochilus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ostracode number	117	141	125	167	162	256	258	226	451	411	162	132	238	123	285	55	194	172	286	180	226
Diversity	8	6	10	10	9	13	15	11	8	9	10	9	8	4	5	3	9	8	6	10	9

Table 15. Continued

Taxa	MF4213	MF4214	MF4215	MF4216	MF4217	MF4218	MF4336	MF4219	MF4220	MF4337	MF4221	MF4222	MF4223	MF4224	MF4225	MF4226	MF4338	MF4227	MF4228	MF4230	MF4231
Depth (meters)	(15.3)	(15.4)	(15.6)	(15.7)	(16.0)	(16.4)	(16.6)	(16.9)	(17.0)	(17.3)	(17.6)	(17.7)	(17.9)	(18.2)	(18.4)	(18.8)	(19.2)	(19.4)	(20.2)	(20.3)	(20.4)
Acanthocythereis dunelmensis (Norman)	–	–	0.9	–	–	–	–	–	–	–	–	–	3.1	4.3	–	–	–	–	–	–	–
Candona sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cluthia aff. C. cluthae Brady, Crosskey and Robertson	–	–	–	–	–	–	–	–	–	–	–	1.1	–	–	2.1	–	–	–	–	–	–
Cypridopsis aculeata (Liljeborg)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. sp.	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cytheromorpha macchesneyi (Brady and Crosskey)	2.3	0.9	–	–	–	–	–	–	–	–	–	1.1	3.1	–	–	–	–	–	–	–	5.3
C. sp.	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cytheropteron montrosiense Brady, Crosskey and Robertson	–	–	11.8	18.8	25.0	12.0	21.1	22.2	–	16.1	–	12.2	9.4	17.0	6.4	16.7	10.0	–	–	–	–
C. nodosoalatum Neale and Howe	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. paralatissimum Swain	–	–	1.8	–	–	–	–	1.4	–	–	–	–	–	–	–	–	–	–	–	–	–
C. punctatum Brady	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. aff. C. pyramidale Neale and Howe	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. sp.	–	–	0.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cytheretta teshekpukensis Swain	0.9	2.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9.1	–	–
Cytherura sp.	0.5	–	–	–	–	–	–	–	–	–	–	1.1	–	–	–	–	–	–	–	–	–
Eucythere declivis (Norman)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Finmarchinella curvicosta Neale	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
F. finmarchica (Sars)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Heterocyprideis sorbyana (Jones)	13.1	20.4	–	–	–	–	–	–	–	–	–	–	–	2.1	2.1	–	–	–	18.2	–	15.8
Krithe glacialis Brady, Crosskey and Robertson	–	–	–	–	–	–	–	1.4	–	–	–	–	3.1	–	2.1	–	–	–	–	–	–
Limnocythere sp.	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lozoconcha venepidermoidea Swain	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Normanicythere leioderma (Norman)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Palmanella limicola (Norman)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.0	–	–	–	–
Paracyprideis pseudopunctillata Swain	66.7	44.4	84.5	81.3	75.0	64.0	78.9	73.6	–	83.9	–	82.2	81.3	74.5	87.2	83.3	70.0	–	18.2	87.5	36.8
Pontocythere sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rabilimis mirabilis (Brady)	–	–	–	–	–	–	–	1.4	–	–	–	2.2	–	2.1	–	–	–	–	–	–	–
R. septentrionalis (Brady)	0.5	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.0	–	9.1	12.5	10.5
Roundstonia globulifera (Brady)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sarsicytheridea bradii (Norman)	15.3	20.0	–	–	–	24.0	–	–	–	–	–	–	–	–	–	–	–	–	45.5	–	31.6
S. punctillata (Brady)	–	10.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sclerochilus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ostracode number	222	225	110	32	4	25	19	72	0	31	0	90	32	47	47	6	10	0	11	8	19
Diversity	9	8	5	2	2	3	2	5	0	2	0	6	5	5	5	2	4	0	5	2	5

APPENDIX I. — REGISTER OF MICROFOSSIL LOCALITIES

Borehole PB-1

Latitude: 70° 20.9' N
Longitude: 148°19.3' W
Sea-ice thickness: 1.9 m

Water depth: 0.8 m
Total depth of hole: 31. 2 m

Sample No. (MF)	PB1 field No.	Depth below sea level (meters)	Comments
3603	WS 17-18	3.8- 4.1	
3604	WS 18-19	4.1- 4.4	
3605	WS 19-19.5	4.4- 4.5	
3606	WS 19.5-20	4.5- 4.7	
3607	WS 20-20.5	4.7- 4.9	
3608	WS 20.5-21	4.9- 5.0	
3609	WS 21-21.5	5.0- 5.2	
3610	WS 21.5-22	5.2- 5.3	
3611	WS 23-25	5.6- 6.2	
3612	WS 25-27	6.2- 6.8	
3613	GS1a	6.5- 6.7	
3614	GS2	8.2	No foraminifers
3616	GS4	8.3	No ostracodes
3617	GS5	8.3	Barren
3618	GS6	8.4	Barren
3619	GS7b	9.0	Barren
3621	WS 37-39	9.9-10.5	Barren
3620	GS 11	15.6	Barren
3622	WS 92-92.5	26.7-26.8	Barren
3623	WS 94.7-100	27.5-29.1	Barren
3624	WS 100-101	29.1-29.4	Barren
3625	WS 101-102	29.4-29.7	Barren

Borehole PB-2

Latitude: 70° 30.6' N
Longitude: 148° 18.0' W
Sea-ice thickness: 2.29 m

Water depth: 9.55 m
Total depth of hole: 41. 37 m

Sample No. (MF)	PB2 field No.	Depth below sea level (meters)	Comments
3628	WS 43.8-45.8	11.9-12.5	
3629	WS 45.8-47.0	12.5-12.9	
3631	Clay bit 49.7	13.7	
3656	GS 03	14.0	
3632	GS 03e	14.3	
3633	GS 04b	15.0	
3634	GS 04e	15.5-15.6	
3635	GS 05b	15.7	
3655	GS 05C	15.9-16.2	
3636	GS 05E	16.2	
3637	Clay bit 58-60	16.2-16.8	
3638	GS 06x	17.7	
3639	Clay bit 65.8	18.6	
3630	Clay bit 68	19.4	No ostracodes
3640	Clay bit 70.75	20.1	No ostracodes
3653	08A	20.1-20.2	
3652	08E	20.5-20.7	No foraminifers
3641	Clay bit 72.9	20.8	
3642	WS 73-81	20.7-23.2	Barren
3643	WS 88-92	25.4-26.6	Barren
3644	WS 92-101	26.6-29.3	

Borehole PB-2—Continued

Latitude: 70° 30.6' N
Longitude: 148° 18.0' W
Sea-ice thickness: 2.29 m

Water depth: 9.55 m
Total depth of hole: 41.37 m

Sample No. (MF)	PB2 field No.	Depth below sea level (meters)	Comments
3645	WS 101-111	29.3-32.4	Barren
3646	WS 111-112	32.4-32.7	Barren
3647	WS 123-126	36.0-36.9	Barren
3648	WS 127-129	37.3-37.9	Barren
3649	WS 129-131	37.9-38.5	Barren
3650	WS 131-133	38.5-39.1	Barren
3651	WS 133-135	39.1-39.7	Barren

Borehole PB-3

Latitude: 70° 25.6' N
Longitude: 148° 26.6' W
Sea-ice thickness: 1.9 m

Water depth: 4.0 m
Total depth of hole: 44.1 m

Sample No. (MF)	PB3 field No.	Depth below sea level (meters)	Comments
3658	GS 01b	5.9-6.5	
3669	GS 02b	6.7-7.0	
3659	GS 02y	7.3-7.6	
3660	GS 03X	7.6-7.9	
3661	GS 03x	8.2	
3662	GS 05x	9.1	
3670	GS 05B	9.3-9.5	
3663	GS 06x	10.1	
3671	06A	10.6-10.8	
3664	WS 40-40.9	10.7-10.9	
3665	WS 39.9-43.0	10.6-11.6	Barren
3666	WS 43-44	11.6-11.8	Barren
3667	WS 44-46	11.8-12.5	Barren
3668	WS 46-52	12.5-14.3	Barren

Borehole PB-5

Latitude: 70° 23.3' N
Longitude: 148° 24.7' W
Sea-ice thickness: 1.5 m

Water depth: 0.3 m
Total depth of hole: 11.8 m

Sample No. (MF)	PB5 field No.	Depth below sea level (meters)	Comments
4148	PB5 2.75	2.8	
4149	PB5 3.90	3.9	
4325	PB5 03C	4.2-4.4	
4326	PB5 04c	6.6-6.7	
4328	PB5 05D	8.3-8.4	
4150	PB5 6A	8.9-9.0	
4151	PB5 7A	9.5-9.6	
4329	PB5 7D	9.8-9.9	
4152	PB5 8A	10.2-10.3	
4153	PB5 8C	10.4-10.5	
4154	PB5 8D	10.5-10.6	
4155	PB5 8E	10.6-10.7	

Borehole PB-6

Latitude: 70° 23' N
Longitude: 148° 30.6' W
Sea-ice thickness: 1.80 m

Water depth: 0.1 m
Total depth of hole: 30.7 m

Sample No. (MF)	PB6 field No.	Depth below sea level (meters)	Comments
4156	Shelby tube	1.9	
4330	01C	2.1	
4157	01f/g	2.4-2.5	
4331	2A	2.7-2.8	Barren
4158	3A/C	3.2-3.4	Barren
4159	3E/H	3.5-3.7	No foraminifers
4160	4A	3.9	Barren
4161	4C	4.2	Barren
4332	04E	4.3-4.4	Barren
4162	5C	4.7-4.8	Barren
4164	9B/C	11.2-11.4	Barren

Borehole PB-7

Latitude: 70° 24.2' N
Longitude: 148° 28.5' W
Sea-ice thickness: 1.8 m

Water depth: 1.1 m
Total depth of hole: 68.2 m

Sample No. (MF)	PB7 field No.	Depth below sea level (meters)	Comments
4165	Shelby tube	2.9	
4333	01D	3.2-3.3	
4166	WS 3.75-5.00	3.8-5.0	
4167	02A	4.9-5.0	
4334	02D	5.2-5.6	
4168	WS 5.60-6.12	5.6-6.1	
4170	WS 6.12-6.50	6.1-6.5	
4169	03A	6.5-6.8	

Borehole PB-8

Latitude: 70° 28,5' N
Longitude: 148° 21.6' W
Sea-ice thickness: 2.2 m

Water depth: 4.8 m
Total depth of hole: 32.4 m

Sample No. (MF)	PB8 field No.	Depth below sea level (meters)	Comments
4171	1A/B	7.0-7.4	
4172	1C/2A	7.5-7.7	
4173	2B	7.8-7.9	
4174	2C	8.1-8.5	
4175	3A	8.5-8.6	
4176	3E	8.8-9.0	
4177	4A	9.1-9.2	
4178	4E	9.5-9.6	
4179	4G	9.7-9.8	
4180	5A	9.8-9.9	
4181	5C	10.0-10.1	

Borehole PB-8—Continued

Latitude: 70° 28,5' N
Longitude: 148° 21.6' W
Sea-ice thickness: 2.2 m

Water depth: 4.8 m
Total depth of hole: 32.4 m

Sample No. (MF)	PB8 field No.	Depth below sea level (meters)	Comments
4182	5F	10.2-10.3	
4183	6A	10.4-10.5	
4184	6C	10.5-10.6	
4185	6E	10.7-10.8	
4186	6H	10.8-10.9	
4187	7A	11.1-11.2	
4188	7C	11.3-11.4	
4189	7E	11.4-11.5	
4190	7H	11.5-11.6	
4191	8A	11.6-11.7	
4192	8D	11.9-12.0	
4193	8F	12.0-12.1	
4194	8H	12.1-12.2	
4195	9A	12.2-12.3	
4196	9D	12.5-12.6	
4197	9F	12.7-12.8	
4198	9H	12.8-12.9	
4199	10A	12.9-13.0	
4200	10C	13.0-13.1	
4201	10E	13.2-13.3	
4202	10G	13.4-13.5	
4203	11A	13.5-13.6	
4204	11C	13.8	
4205	11E	14.0-14.1	
4206	12A	14.1-14.2	
4207	12C	14.3	
4208	12E	14.5	
4209	12G	14.6-14.7	
4210	12I	14.7-14.9	
4211	13A	15.0-15.1	
4212	13C	15.1-15.2	
4213	13E	15.2-15.3	
4214	13G	15.4	
4215	13I	15.5-15.6	
4216	14A	15.6-15.7	
4217	14D	15.9-16.0	
4218	15A	16.3-16.4	
4336	15C	16.5-16.6	
4219	15E	16.8-16.9	
4220	16A	16.9-17.0	No ostracodes
4337	16D	17.2-17.3	
4221	17A	17.5-17.6	No ostracodes
4222	17C	17.6-17.7	
4223	17E	17.7-17.9	
4224	18A	18.1-18.2	
4225	18C	18.3-18.4	
4226	19A	18.7-18.8	
4338	19D	19.0-19.2	
4227	19F	19.2-19.4	No ostracodes
4228	20A	20.2-20.3	
4231	20A-1	20.3-20.4	
4229	20C	20.5-20.7	Barren

APPENDIX II. — TAXONOMIC NOTES

Benthic Foraminifers

Ammotium cassis (Parker)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 33, pl. 2, figs. 12-18.

Bathysiphon sp.—This paper, pl. 1, fig. 1.—Fragments of an unidentified species of Bathysiphon.

Buccella frigida (Cushman) = Pulvinulina frigida Cushman, 1920, Canada Biol. Board, Canadian Biol., no. 9, p. 12.—This paper, pl. 1, fig. 2.

Buccella inusitata Andersen, 1952, Washington Acad. Sci., Jour., vol. 42, no. 5, p. 148, tfs. 10-11.

Buccella sp.—Small specimens which cannot be clearly assigned to a species.

Cassidulina islandica Norvang, 1945, Zoology of Iceland, vol. 2, pt. 2, p. 41, tfs. 7, 8d-f.—This paper, pl. 1, fig. 3.

Cassidulina norcrossi Cushman, 1933, Smithsonian Misc. Coll. vol. 89, no. 9, p. 7, pl. 2, figs. 7a-c.—This paper, pl. 1, fig. 4.

Cassidulina teretis Tappan, 1951, Cushman Found. Foram Res. Contr., vol. 2, pt. 1, p. 7, pl. 1, fig. 30.—This paper, pl. 1, fig. 5.

Cyclogyra involvens (Reuss)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 49, pl. 7, figs. 4, 5.—This paper, pl. 1, fig. 6.

Dentalina frobisherensis Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 55, pl. 10, figs. 1-9.—This paper, pl. 1, fig. 7.

Dentalina gracilis d'Orbigny—MacBeth and Schmidt, 1973, Jour. Paleo., vol. 47, p. 1052, pl. 1, fig. 1.—This paper, pl. 1, fig. 8.

Dentalina ittai Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 56, pl. 10, figs. 10-12.—This paper, pl. 1, fig. 9.

Dentalina pauperata d'Orbigny—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 57, pl. 9, figs. 7-9.

Dentalina sp.?—Fragments which may belong to this genus.

Elphidiella groenlandica (Cushman) = Elphidium groenlandicum Cushman, 1933, Smithsonian Misc. Coll., vol. 89, no. 9, p. 4, pl. 1, fig. 10.—This paper, pl. 1, fig. 10.

Elphidiella oregonense (Cushman and Grant)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 103-105, pl. 18, figs. 1-3.

Elphidium albiumbilicatum (Weiss) = Nonion pauciloculum albiumbilicatum Weiss, 1954, U.S. Geol. Survey Prof. Paper 254G, p. 157, pl. 32, figs. 1-2.—This paper, pl. 1, fig. 11.

Elphidium asklundi Brotzen—Feyling-Hanssen, 1971, Geol. Soc. of Denmark, Bull. 21, p. 270, pl. 10, figs. 20-21; pl. 11, figs. 1-5.—This paper, pl. 1, fig. 12.

Elphidium cf. E. asklundi Brotzen—This paper, pl. 1, fig. 13.—These are worn, poorly preserved specimens which occur commonly in Holocene assemblages.

Elphidium bartletti Cushman, 1933, Smithsonian Misc. Coll., vol. 89, no. 9, p. 4, pl. 1, fig. 9.—This paper, pl. 2, figs. 1-3.

Elphidium cf. E. bartletti Cushman—Worn or poorly preserved speciemens which are close to E. bartletti.

Elphidium clavatum Cushman, 1930, U.S. Nat. Mus. Bull. no. 104, p. 20, pl. 7, figs. 10a-b.—This paper, pl. 2, figs. 4 and 8.

Elphidium excavatum alba Feyling-Hanssen, 1972, Micropaleo., vol. 18, p. 340-341, pl. 3, figs. 1-9.—This paper, pl. 2, fig. 6.

Elphidium frigidum Cushman 1933, Smithsonian Misc. Coll., vol. 89, no. 9, p. 5, pl. 1, fig. 8.—This paper, pl. 2, figs. 5 and 9.

Elphidium incertum (Williamson)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 100-102.—This paper, pl. 2, fig. 7.

Elphidium orbiculare (Brady)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 102, pl. 19, figs. 1-4.—This paper, pl. 2, fig. 10.

Elphidium sp.—These specimens can be subdivided into two groups. The first are broken specimens or juveniles of the other Elphidium species. The second group is composed of forms which may be related to Protelphidium nanum Vilks (Vilks and others, 1979).

Eoeponidiella stromboides Tappan, 1951, Cushman Found. Foram. Res. Contr., vol. 2, pt. 1, p. 6, pl. 1, fig. 22.—The rare specimens identified as this species have probably been reworked from older sediments.

Eosyrinx curta (Cushman and Ozawa) = Pseudopolymorphina curta Cushman and Ozawa, 1930, Proc. U.S. Nat. Mus., vol. 77, art. 6, p. 105, pl. 27, fig. 31-b.—This paper, pl. 2, fig. 11.

Fissurina marginata (Montagu)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 77, pl. 14, figs. 6-9.—This paper, pl. 2, fig. 12.

Fissurina orbignyana Sequenza—Feyling-Hanssen, 1971, Geol. Soc. Denmark, Bull. 21, p. 230, pl. 6, fig. 8.

Fissurina spp.—This paper, pl. 3, fig. 1.—Fragments of unidentified species of Fissurina.

Glandulina laevigata (d'Orbigny)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 81, pl. 16, figs. 2-5.

Glandulina sp.—Specimens cannot be identified to species.

Globulina sp.—Specimens cannot be identified further.

Gordiospira arctica Cushman, 1933, Smithsonian Misc. Coll., vol. 89, no. 9, p. 3, pl. 1, figs. 5-7.—This paper, pl. 3, figs. 2 and 3.

Guttulina austriaca d'Orbigny—Feyling-Hanssen, 1971, Geol. Soc. Denmark, Bull. 21, p. 211-212, pl. 4, figs. 8, 9.

Guttulina lactea (Walker and Jacob)—Feyling-Hanssen, 1971, Geol. Soc. Denmark, Bull., vol. 21, p. 214, pl. 4, figs. 14-18.—This paper, pl. 3, fig. 4.

Guttulina problema d'Orbigny—Feyling-Hanssen, 1971, Geol. Soc. Denmark, Bull. 21, p. 215, pl. 5, figs. 1, 2.

Guttulina sp.—These specimens may be variants of one of the Guttulina species named above.

Lagena costata (Williamson) = Oolina costata (Williamson)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 68, pl. 13, figs. 4-6.—This paper, pl. 3, fig. 5.

Lagena gracillima (Sequenza)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 60, pl. 11, figs. 1-4.—This paper, pl. 3, fig. 6.

Lagena hexagona (Williamson) = Oolina hexagona (Williamson)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 69, pl. 14, figs. 1, 2.

Lagena semilineata Wright—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 65, pl. 11, figs. 14-22.

Lagena sp.—This paper, pl. 3, fig. 7.—Small specimens which cannot be identified to species.

Oolina lineata (Williamson)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 70, pl. 13, figs. 11-13.—This paper, pl. 3, fig. 8.

Oolina melo d'Orbigny—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 71-72, pl. 12, figs. 8-15.

Oolina sp.—Unidentified specimens.

Parafissurina himatiostoma Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 80, pl. 14, figs. 12-14.—This paper, pl. 3, fig. 9.

Parafissurina lateralis carinata Buchner—Feyling-Hanssen, 1971, Geol. Soc. Denmark, Bull. 21, p. 233, pl. 6, figs. 12-13.

Pateoris hauverinoides (Rhumbler)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 42, pl. 6, figs. 8-12.—This paper, pl. 3, fig. 10.

Polymorphina subolonga Cushman and Ozawa = Pseudopolymorphina suboblonga Cushman and Ozawa, 1930, U.S. Nat. Mus., vol. 77, art. 6, p. 91, pl. 23, figs. 3a-c.—This paper, pl. 3, figs. 11-13.

Polymorphina sp.—Fragments probably of P. suboblonga.

Pseudopolymorphina arctica MacBeth and Schmidt, 1979, Jour. Paleo., vol. 47, no. 6, p. 1054-1055, pl. 1, figs. 7-9.—This paper, pl. 4, fig. 1.

Pyrgo williamsoni (Silvestri)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 48, pl. 6, figs. 1-4.—This paper, pl. 4, fig. 2.

Pyrulina sp.—Specimens can be identified to genus only.

Quinqueloculina arctica Cushman, 1933, Smithsonian Misc. Coll., vol. 89, no. 9, p. 2, pl. 1, fig. 3.—This paper, pl. 4, fig. 3.

Quinqueloculina seminulum (Linne)—Feyling-Hanssen, 1971, Geol. Soc. Denmark, Bull. 21, p. 194, pl. 1, figs. 18-20.—This paper, pl. 4, fig. 4.

Quinqueloculina cf. Q. seminulum (Linne)—Specimens resemble this species but are too poorly preserved for a positive identification.

Quinqueloculina sp.—Unidentified fragments of Quinqueloculina.

Quinqueloculina stalkeri Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 40, pl. 5, figs. 5-9.

Quinqueloculina subrotunda (Montagu)—Vermiculum subrotundum Montagu, 1803, Testacea Britannica, Hollis, Romsey, England, p. 521.

Quinqueloculina cf. Q. subrotundum (Montagu)—Worn and broken specimens which probably belong to this species.

Quinqueloculina vulgaris d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, tome 7, p. 302.—This paper, pl. 4, fig. 5.

Reophax arctica Brady—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 21, pl. 1, figs. 19-20.

Reophax cf. R. arctica Brady—This paper, pl. 4, fig. 7.—Fragments which resemble this species.

Reophax scorpiurus Montfort—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 24, pl. 2, figs. 7-10.—This paper, pl. 4, fig. 6.

Reophax sp.—Fragments which can only be identified to genus.

Scutuloris tegmenis Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 41, pl. 5, fig. 10.

Silicosigmoilina groenlandica (Cushman), emend. Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 38, pl. 4, figs. 7-10.—This paper, pl. 4, fig. 8.

Stainforthia concava (Hoeglund) = Bulimina exilis Brady, Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 110, pl. 20, figs. 4-5.—This paper, pl. 4, fig. 9.

Trichyohalus sp.—These specimens could not be assigned to a known species because of poor preservation.

Triloculina oblongata (Montagu) = Vermiculum oblongum Montagu, 1803, Testacea Britannica, Hollis, Romsey, England, p. 522, pl. 14, fig. 9.

Triloculina trihedra Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 45, pl. 4, fig. 10.—This paper, pl. 4, fig. 10.

Trochammina nana (Brady)—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 50, pl. 8, fig. 5.—This paper, pl. 4, fig. 11.

Trochammina rotaliformis Wright—Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, no. 7, p. 51, pl. 8, figs. 6-9.—This paper, pl. 4, fig. 12.

Ostracodes

Acanthocythereis dunelmensis (Norman)--Robinson, 1978, A stratigraphical index of British Ostracoda, ed. R. H. Bate and E. Robinson, Seel House Press, pl. 2, figs. 2a-c.—This paper, pl. 13, figs. 2-4.

Candona cf. C. candida (Mueller)—This paper, pl. 14, fig. 6.—Assignable to Candona rectangulata Alm.

Candona sp.-This specimen is a juvenile. The various instars of an ostracode undergo marked changes in valve shape, inner margin features, and ornament. This instar is too immature and generalized to be assignable to a species.

Cluthia aff. C. cluthae (Brady, Crosskey, and Robertson)—This paper, pl. 10, fig. 6. —Assignable to Cytherura complanata (Brady, Crosskey, and Robertson).

Cyprid sp.—This paper, pl. 14, fig. 8.—Assignable to Heterocypris incongruens (Ramdohr) species complex.

Cypridopsis aculeata (Costa, 1847) = Sarscypridopsis aculeata. A new genus, Sarscypridopsis, has been erected for this species and related forms. The species is well illustrated in Wagner, 1957, p. 27, pl. 7.—This paper, pl. 14, fig. 5.

Cypridopsis sp.—Not enough material is present to assign this specimen to a species.

Cyprinotus sp.—Not enough material is present to assign this specimen to a species.

Cytheretta teshekpukensis Swain, 1963, Jour. Paleo., vol. 37, p. 831-832, pl. 95, figs. 19a,b.—This paper, pl. 14, figs. 1-2.

Cytherissa lacustris (Sars)—Robinson, 1978, A stratigraphical index of British Ostracoda, eds. R. H. Bate and E. Robinson, Seel House Press, pl. 4, figs. 5a-c.—This paper, pl. 14, fig. 4.

Cytheromorpha macchesneyi (Brady and Crosskey)—Cronin, 1981, Micropaleo., vol. 27, p. 410, pl. 9, figs. 5-8.—This paper, pl. 9, figs. 1 - 3, 6.

Cytheromorpha sp. A—This paper, pl. 9, figs. 4, 5, 7.—This form represents a new, undescribed species which has been recognized by Brouwers in many Pleistocene and Holocene samples from the North Slope and the Beaufort Sea.

Cytheropteron montrosiense Brady, Crosskey, and Robertson—Whatley and Masson, 1979, Rev. Esp. Micropaleo., vol. 11, p. 240-241, pl. 2, figs. 1-4, 6.—This paper, pl. 12, figs. 1-7.

Cytheropteron nodosoalatum Neale and Howe, 1975, Bull. Am. Paleo., vol. 65, pl. 6, figs. 8, 10; pl. 7, figs. 4, 10, 11.

Cytheropteron paralatissimum Swain, 1963, Jour. Paleo., vol. 37, p. 817, pl. 95, fig. 12.—This paper, pl. 12, fig. 8.

Cytheropteron punctatum Brady—Whatley and Masson, 1979, Rev. Esp. Micropaleo., vol. 11, p. 249-250, pl. 7, figs. 7-10, 13, 14.—This paper, pl. 11, fig. 7.

Cytheropteron aff. C. pyramidale Neale and Howe—This paper, pl. 11, figs. 1-3, 5. —Assignable to Cytheropteron nodosoalatum Neale and Howe.

Cytheropteron sp. B—This paper, pl. 11, figs. 4, 6.—This form represents a new, undescribed species which has been recognized by Brouwers only in the PB borehole samples.

Cytherura sp. A—This paper, pl. 11, fig. 8.—This form represents a new, undescribed species which has been recognized by Brouwers only in the PB borehole samples.

Cytherura sp. B—This paper, pl. 10, fig. 2.—This form represents a new, undescribed species which has been recognized by Brouwers only in the PB borehole samples.

Cytherura sp. C—This paper, pl. 10, fig. 1.—This form represents a new, undescribed species which has been recognized by Brouwers only in the PB borehole samples.

Cytherura sp. D—This paper, pl. 10, fig. 4.—This form represents a new, undescribed species which has been recognized by Brouwers only in the PB borehole samples.

Eucythere declivis (Norman)—Norman, 1865, Natural History Transactions of Northumberland and Durham, vol. 1, p. 16-17, pl. 5, figs. 9-12.

Finmarchinella (Barentsovia) curvicosta Neale, 1974, Bull. Brit. Mus. (Nat. Hist.), vol. 27, p. 90-91, pl. 1, figs. 1-3; pl. 2, figs. 3, 7-9, 13.—This paper, pl. 13, figs. 5-6.

Finmarchinella (Finmarchinella) finmarchica (Sars)—Neale, 1974, Bull. Brit. Mus. (Nat. Hist.), vol. 27, p. 84-85, pl. 1, figs. 6, 7; pl. 2, figs. 1, 5.—This paper, pl. 13, fig. 7.

Heterocyprideis sorbyana (Jones)—Robinson, 1978, A stratigraphic index of British Ostracoda, Bate, R. H., and Robinson, E., Eds., Seel House Press, pl. 2, figs. 3a-c.—This paper, pl. 6, figs. 1-4.

Ilyocypris sp. = Ilyocypris gibba Ramdohr—Wagner, 1957, Sur les Ostracodes du Quarternaire Récent des Pays-Bas et leur utilisations dans l'étude Geologique des Depots Holocenes, Mouton and Co., p. 32, pl. 10.—This paper, pl. 14, fig. 3.

Krithe glacialis Brady, Crosskey, and Robertson—Robinson, 1978, A stratigraphic index of British Ostracoda, Bate, R. H., and Robinson, E., Eds., Seel House Press, pl. 6, figs. 8a,b.—This paper, pl. 7, figs. 3, 5.

Limnocythere liporeticulata Delorme, 1968, Can. J. Zool., pl. 5, figs. 76-80.—This paper, pl. 14, fig. 7.

Limnocythere sp.-This specimen is poorly preserved and not assignable to a described species.

Loxoconcha elliptica Brady, 1868, Trans. Linnean Soc. London, p. 435, pl. 27, figs. 38, 39, 45-48.—This paper, pl. 7, fig. 1.

Loxoconcha sp.-This specimen is poorly preserved and not assignable to a described species.

Loxoconcha venepidermoidea Swain, 1963, Jour. Paleo., vol. 37, p. 819-820, pl. 95, fig. 20; pl. 97, fig. 5; pl. 98, figs. 3a,b.—This paper, pl. 7, figs. 2, 4.

Normanicythere leioderma (Norman)—Robinson, 1978, A stratigraphic index of British Ostracoda, Bate, R. H., and Robinson, E., Eds., Seel House Press, pl. 2, figs. 7a-c. — This paper, pl. 5, figs. 6-8.

Palmanella limicola (Norman)—Swain, 1963, Jour. Paleo., vol. 37, p. 830-831, pl. 99, figs. 3a-d.—This paper, pl. 13, fig. 8.

Paracyprideis pseudopunctillata Swain, 1963, Jour. Paleo., vol. 37, p. 812-813, pl. 95, figs. 9, 13; pl. 96, fig. 12; pl. 97, figs. 14, 17; pl. 98, figs. 4a-e.—This paper, pl. 8, figs. 1-5.

Pontocythere sp. A—This paper, pl. 10, fig. 8.—This form represents a new, undescribed species which has been recognized by Brouwers in many Pleistocene and Holocene samples from the North Slope and the Beaufort Sea.

Rabilimis mirabilis (Brady)—Robinson, 1978, A stratigraphic index of British Ostracoda, Bate, R. H., and Robinson, E., Eds., Seel House Press, pl. 2, figs. 6a-c; pl. 6, figs. 9a-b.—This paper, pl. 13, fig. 1.

Rabilimis septentrionalis (Brady) = Pseudocythereis simpsonensis Swain, 1963, Jour. Paleo., vol. 37, pl. 97, figs. 4, 12, 20; pl. 98, figs. 12a-d.—This paper, pl. 5, figs. 1-8.

Roundstonia globulifera (Brady)—Robinson, 1978, A stratigraphical index of British Ostracoda, Bate, R. H., and Robinson, E., Eds., Seel House Press, pl. 6, figs. 7a,b.— This paper, pl. 10, fig. 5.

Sarsicytheridea bradii (Norman) Athersuch, 1982, in Fossil and Recent Ostracodes, Bate, R. H., Robinson, E., and Sheppard, L. M., Eds., Ellis Harwood Ltd., p. 241, pl. 8, figs. 1-4.—This paper, pl. 8, figs. 7, 8.—Athersuch (1982) designated a new genus (Sarsicytheridea) for Quaternary Arctic taxa formerly considered to be Eucytheridea. The original concept of Eucytheridea was not based on a distinct group of taxa, but rather on a mistaken concept of zoological nomenclature.

Sarsicytheridea punctillata (Brady) Athersuch, 1982, in Fossil and Recent Ostracodes, Bates, R. H., Robinson, E., and Sheppard, L. M., Eds., Ellis Harwood Ltd., p. 241-242, pl. 6, figs. 7-11.—This paper, pl. 7, figs. 6-8.

Sclerochilus sp.—This paper, pl. 10, fig. 5.-Not enough material is present to assign this specimen to a species.

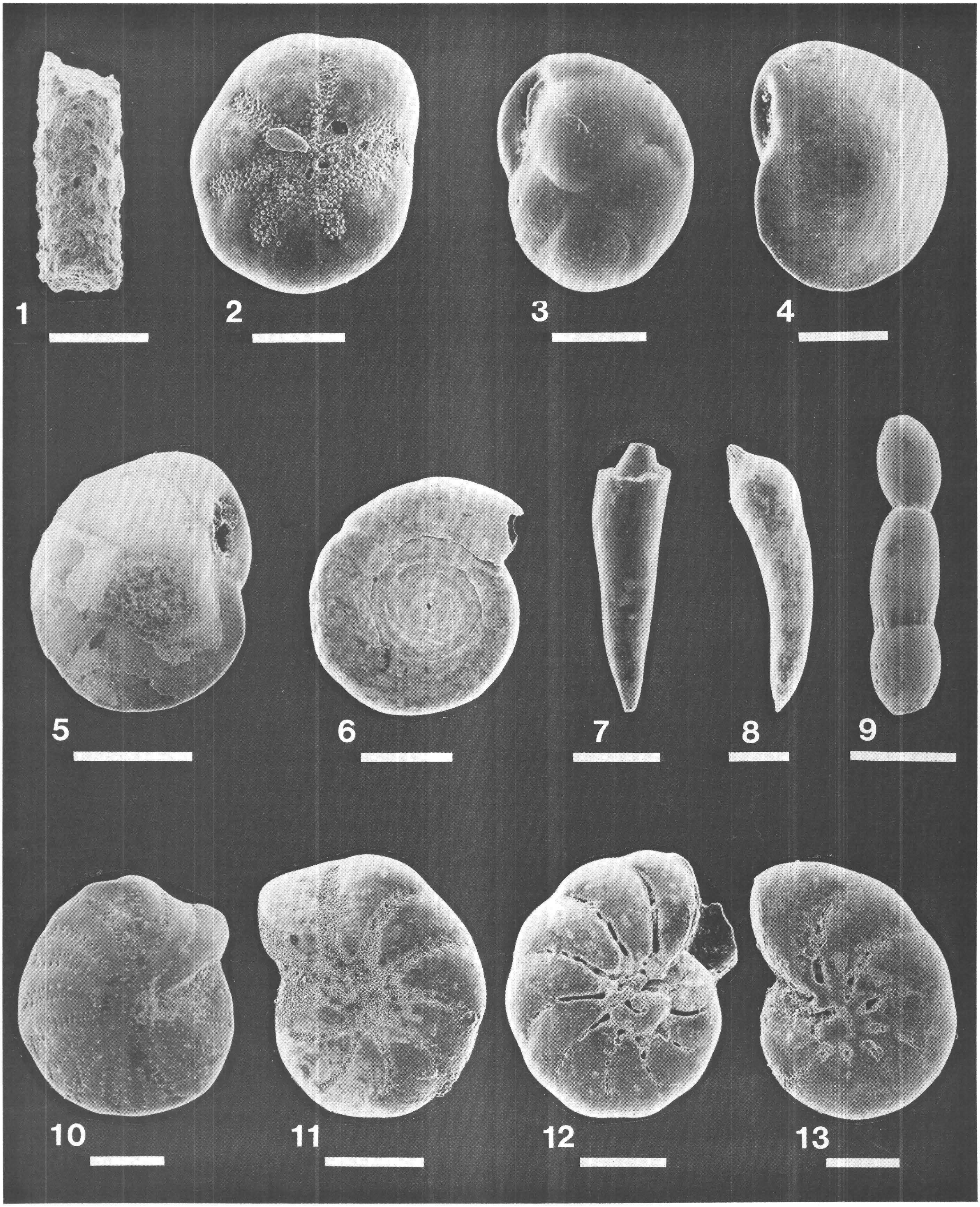
INDEX

PLATES 1-14

[Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey photographic Library, Federal Center, Denver, Colorado 80225]

PLATE 1

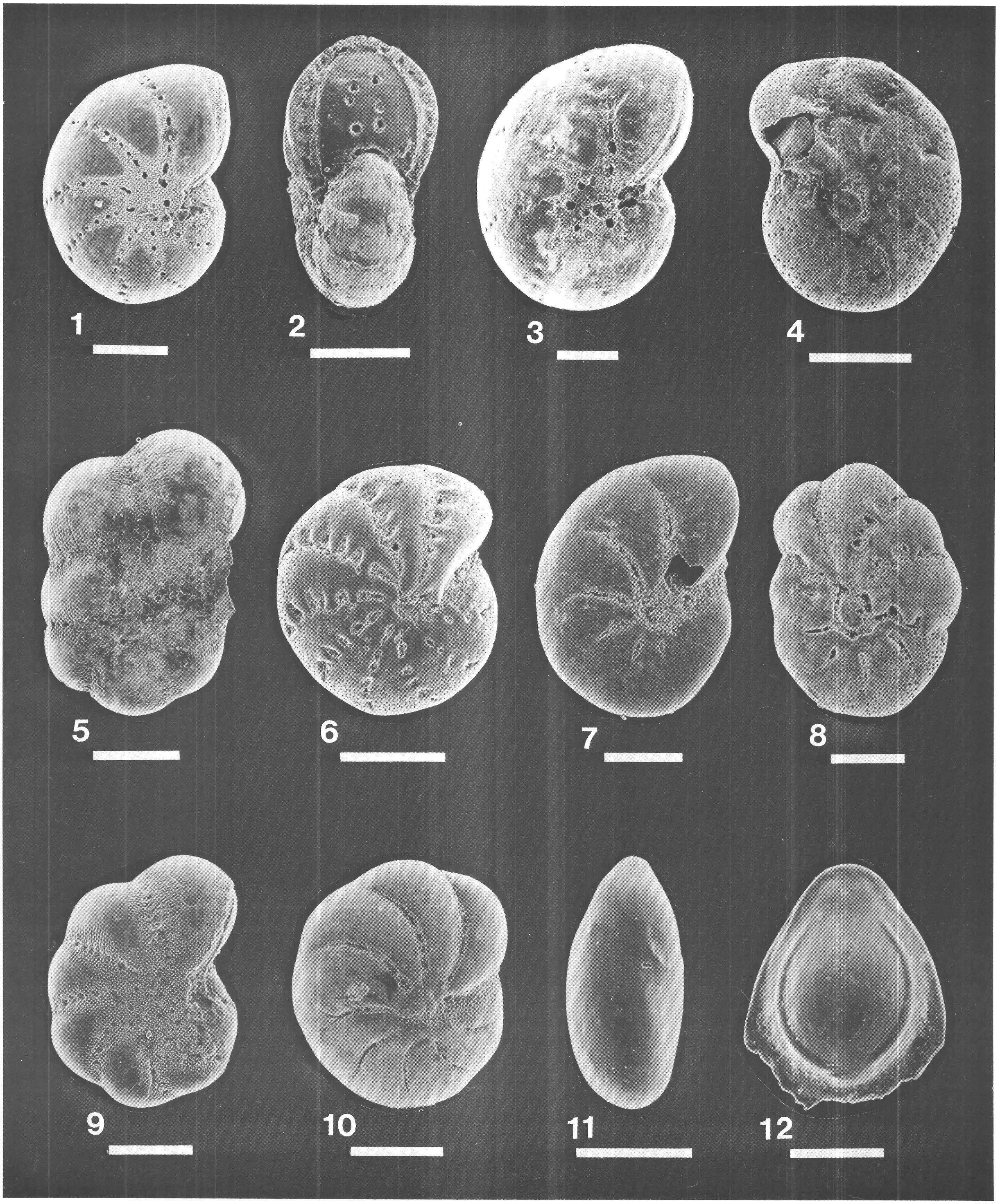
1. Bathysiphon sp.
   Locality MF3658 (PB-3). Bar equals 400 µm.
2. Buccella frigida (Cushman)
   Locality MF4152 (PB-5). Bar equals 100 µm.
3. Cassidulina islandica Norvang
   Locality MF3633 (PB-2). Bar equals 100 µm.
4. Cassidulina norcrossi Cushman
   Locality MF3633 (PB-2). Bar equals 100 µm.
5. Cassidulina teretis Tappan
   Locality MF4173 (PB-8). Bar equals 200 µm.
6. Cyclogyra involvens (Reuss)
   Locality MF3628 (PB-2). Bar equals 1 mm.
7. Dentalina frobisherensis Loeblich and Tappan
   Locality MF3640 (PB-2). Bar equals 400 µm.
8. Dentalina gracilis d'Orbigny
   Locality MF3630 (PB-2). Bar equals 400 µm.
9. Dentalina ittai Loeblich and Tappan
   Locality MF4173 (PB-8). Bar equals 200 µm.
10. Elphidiella groenlandica (Cushman)
    Locality MF4193 (PB-8). Bar equals 400 µm.
11. Elphidium albiumbilicatum (Weiss)
    Locality MF4156 (PB-6). Bar equals 200 µm.
12. Elphidium asklundi Brotzen
    Locality MF4152 (PB-5). Bar equals 200 µm.
13. Elphidium cf. E. asklundi Brotzen
    Locality MF4156 (PB-6). Bar equals 100 µm.



BATHYSIPHON, BUCCELLA, CASSIDULINA, CYCLOGYRA, DENTALINA, ELPHIDIELLA, AND *ELPHIDIUM*

PLATE 2

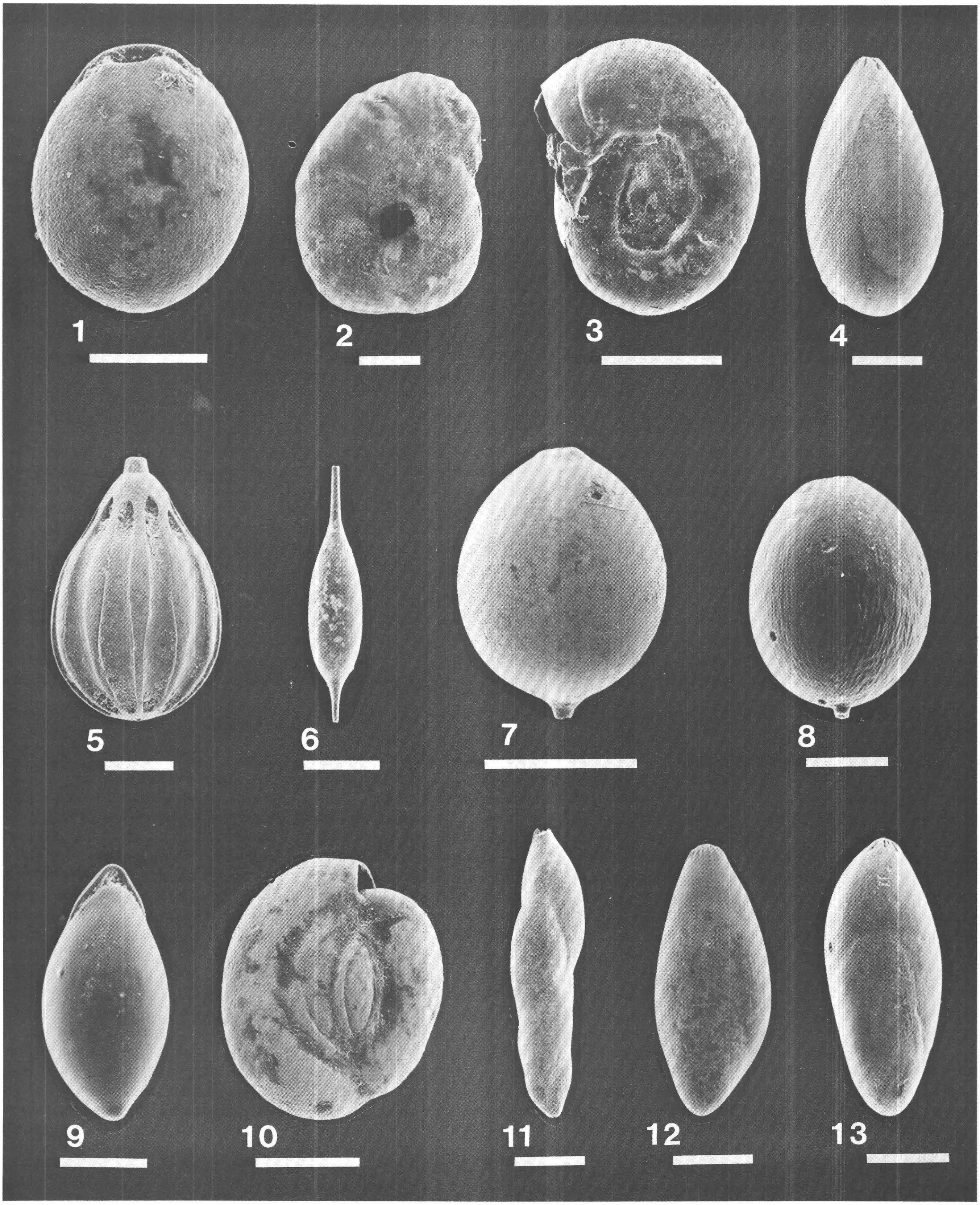
1. Elphidium bartletti Cushman
   Locality MF3628 (PB-2). Bar equals 200 μm.
2. Elphidium bartletti Cushman
   Peripheral view, showing areal apertures. Locality MF4173 (PB-8). Bar equals 200 μm.
3. Elphidium bartletti Cushman
   Poorly preserved specimen showing the dissolution of the test wall. Locality MF4151 (PB-5). Bar equals 100 μm.
4. Elphidium clavatum Cushman
   Weathered specimen in which retral processes have been enlarged so that specimen resembles E. excavatum alba. Locality MF4153 (PB-5). Bar equals 100 μm.
5. Elphidium frigidum Cushman
   An aberrant form of this species which is frequently seen the Arctic borehole samples. Locality MF4171 (PB-8). Bar equals 200 μm.
6. Elphidium excavatum alba Feyling-Hanssen
   Locality MF4156 (PB-6). Bar equals 200 μm.
7. Elphidium incertum (Williamson)
   Locality MF4171 (PB-8). Bar equals 100 μm.
8. Elphidium clavatum Cushman
   Locality MF4193 (PB-8). Bar equals 100 μm.
9. Elphidium frigidum Cushman
   Locality MF3658 (PB-3). Bar equals 200 μm.
10. Elphidium orbiculare (Brady)
    Locality MF4193 (PB-8). Bar equals 200 μm.
11. Eosyrinx curta (Cushman and Ozawa)
    Locality MF3636 (PB-2). Bar equals 200 μm.
12. Fissurina marginata (Montagu)
    Locality MF3635 (PB-2). Bar equals 100 μm.



ELPHIDIUM, EOSYRINX, AND *FISSURINA*

PLATE 3

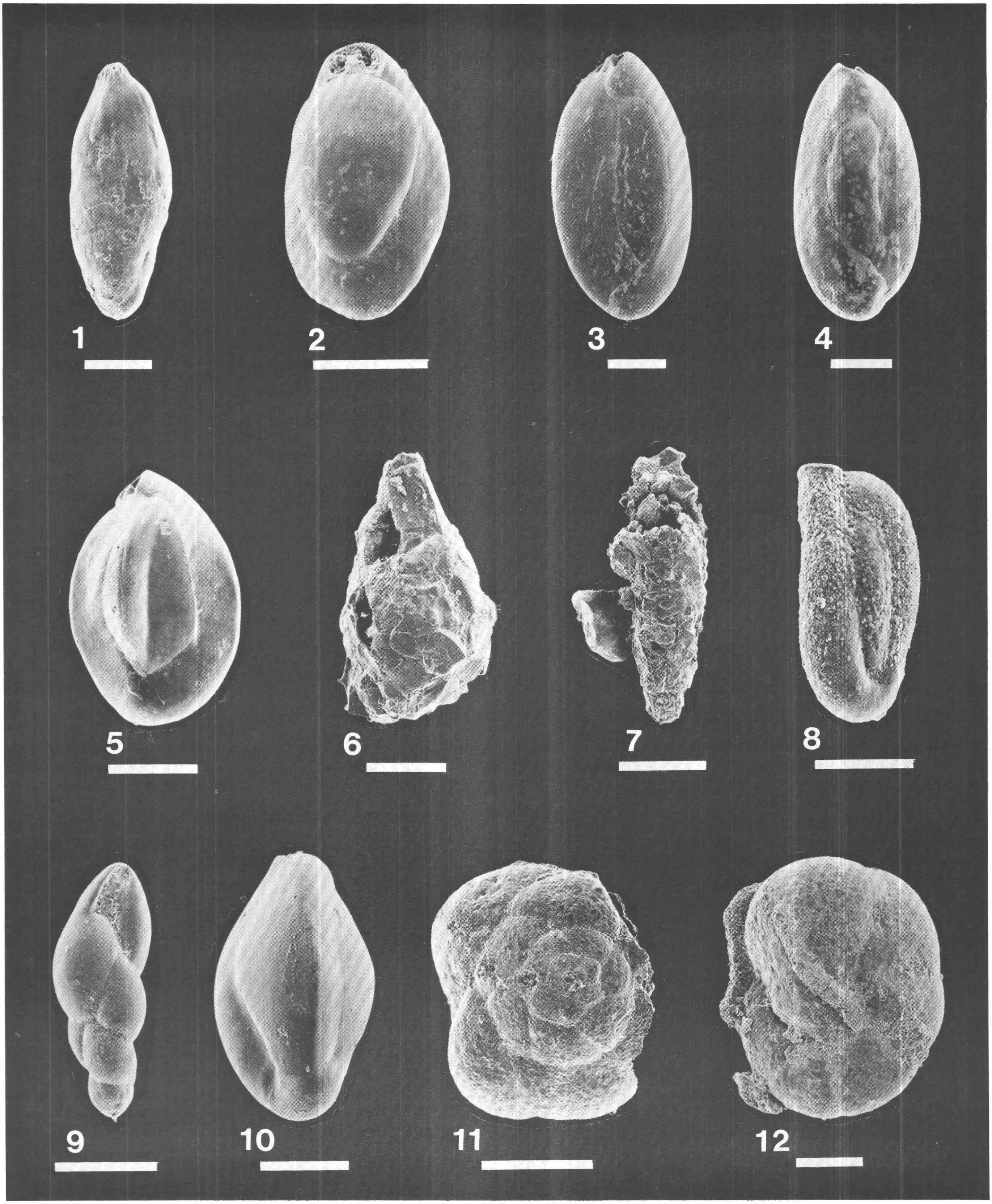
1. Fissurina spp.
   Locality MF4173 (PB-8). Bar equals 100 μm.
2. Gordiospira arctica Cushman
   Locality MF4193 (PB-8). Bar equals 100 μm.
3. Gordiospira arctica Cushman
   Locality MF4171 (PB-8). Bar equals 200 μm.
4. Guttulina lactea (Walker and Joacob)
   Locality MF3603 (PB-1). Bar equals 100 μm.
5. Lagena costata (Willaimson)
   Locality MF4171 (PB-8). Bar equals 100 μm.
6. Lagena gracillima (Sequenza)
   Locality MF3630 (PB-2). Bar equals 200 μm.
7. Lagena sp.
   Locality MF4171 (PB-8). Bar equals 200 μm.
8. Oolina lineata (Williamson)
   Locality MF3633 (PB-2). Bar equals 100 μm.
9. Parafissurina himatiostoma Loeblich and Tappan
   Locality MF3635 (PB-2). Bar equals 100 μm.
10. Pateoris hauverinoides (Rhumbler)
    Locality MF4177 (PB-8). Bar equals 200 μm.
11. Polymorphina suboblonga Cushman and Ozawa
    Locality MF4171 (PB-8). Bar equals 200 μm.
12. Polymorphina suboblonga Cushman and Ozawa
    Locality MF4171 (PB-8). Bar equals 200 μm.
13. Polymorphina suboblonga Cushman and Ozawa
    Locality MF4149 (PB-5). Bar equals 200 μm.



FISSURINA, GORDIOSPIRA, GUTTULINA, LAGENA, OOLINA, PARAFISSURINA, PATEROIS, AND *POLYMORPHINA*

PLATE 4

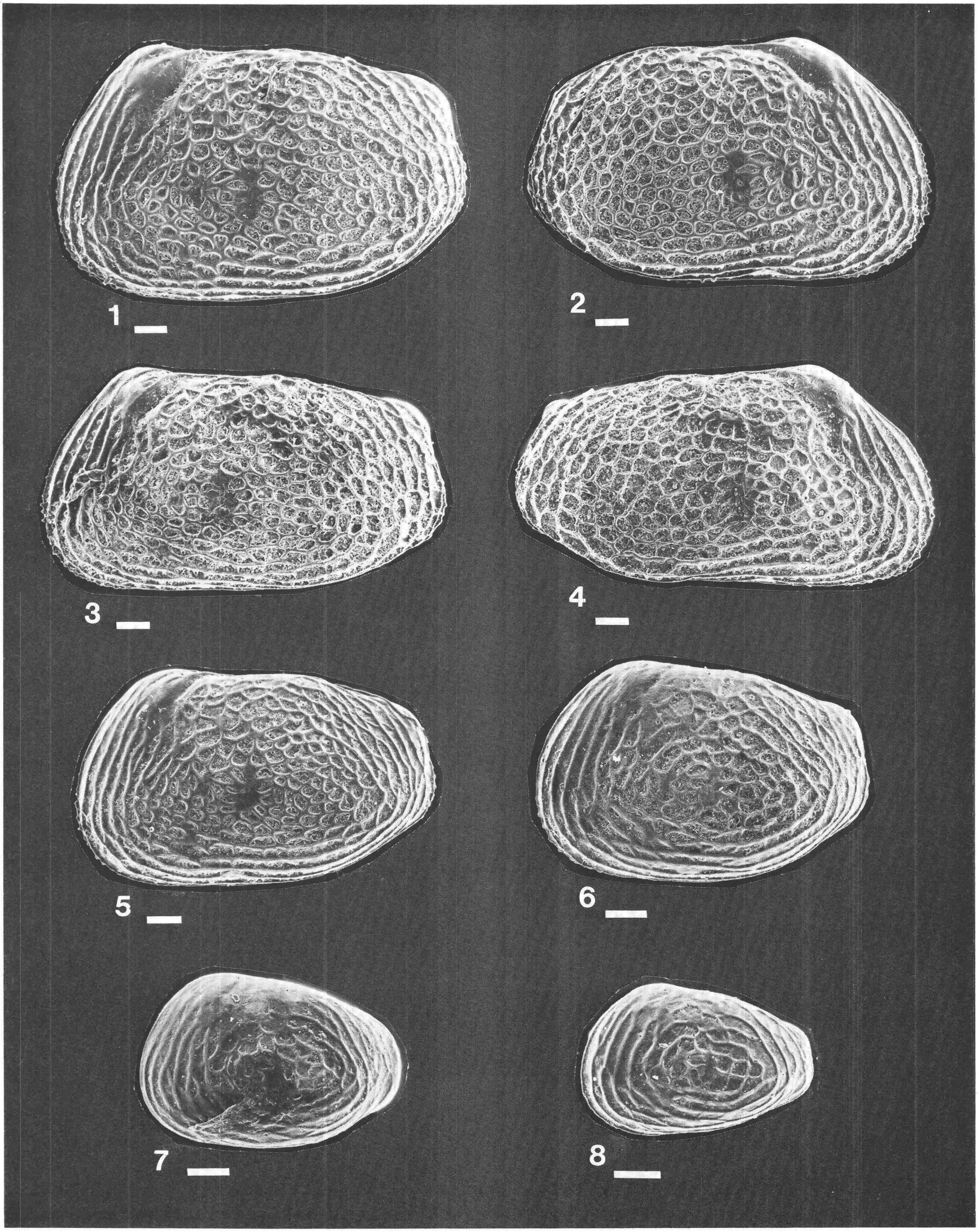
1. Pseudopolymorphina arctica MacBeth and Schmidt
   Locality MF3604 (PB-1). Bar equals 200 μm.
2. Pyrgo williamsoni (Silvestri)
   Locality MF4177 (PB-8). Bar equals 200 μm.
3. Quinqueloculina arctica Cushman
   Locality MF4172 (PB-8). Bar equals 200 μm.
4. Quinqueloculina seminulum (Linne)
   Locality MF3628 (PB-2). Bar equals 200 μm.
5. Quinqueloculina vulgaris d'Orbigny
   Locality MF3628 (PB-2). Bar equals 200 μm.
6. Reophax scorpiurus Montfort
   Locality MF4173 (PB-8). Bar equals 200 μm.
7. Reophax cf. R. arctica Brady
   Locality MF4156 (PB-6). Bar equals 400 μm.
8. Silicosigmoilina groenlandica (Cushman)
   Locality MF3631 (PB-2). Bar equals 100 μm.
9. Stainforthia concava (Hoeglund)
   Locality MF3634 (PB-2). Bar equals 200 μm.
10. Triloculina trihedra Loeblich and Tappan
    Locality MF4172 (PB-8). Bar equals 100 μm.
11. Trochammina nana (Brady)
    Locality MF4166 (PB-7). Bar equals 200 μm.
12. Trochammina rotaliformis Wright
    Locality MF4173 (PB-8). Bar equals 100 μm.



PSEUDOPOLYMORPHINA, PYRGO, QUINQUELOCULINA, REOPHAX, SILICOSIGMOILINA, STAINFORTHIA, TRILOCULINA, AND *TROCHAMMINA*

PLATE 5

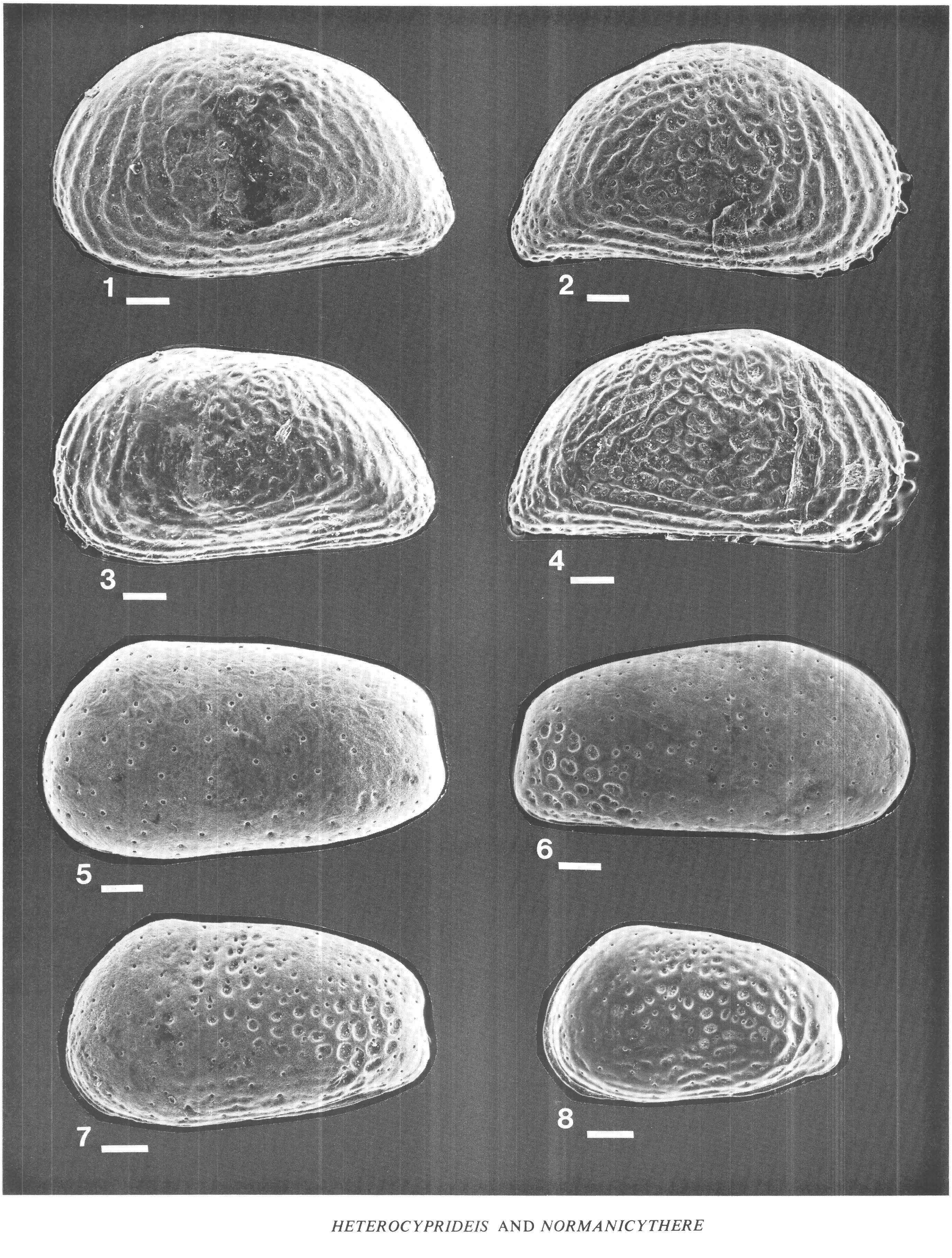
1. <u>Rabilimis septentrionalis</u> (Brady)
   Female left valve, exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.
2. <u>Rabilimis septentrionalis</u> (Brady)
   Female right valve, exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.
3. <u>Rabilimis septentrionalis</u> (Brady)
   Male left valve, exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.
4. <u>Rabilimis septentrionalis</u> (Brady)
   Male right valve, exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.
5. <u>Rabilimis septentrionalis</u> (Brady)
   Juvenile left valve (A-1 instar stage), exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.
6. <u>Rabilimis septentrionalis</u> (Brady)
   Juvenile left valve (A-2 instar stage), exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.
7. <u>Rabilimis septentrionalis</u> (Brady)
   Juvenile left valve (A-3 instar stage), exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.
8. <u>Rabilimis septentrionalis</u> (Brady)
   Juvenile left valve (A-4 instar stage), exterior lateral view, locality MF4166 (PB-7). Bar equals 100 µm.



RABILIMIS

PLATE 6

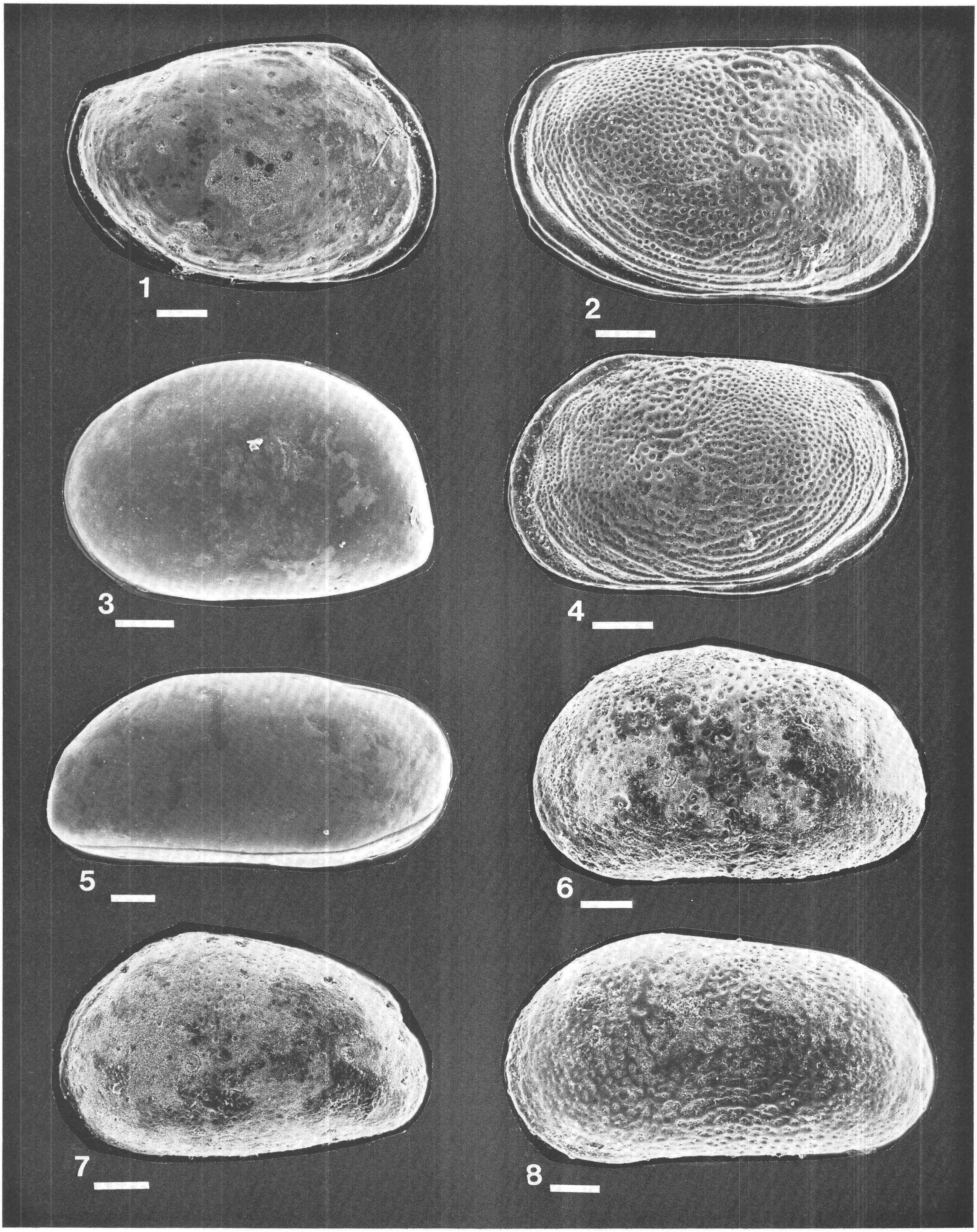
1. Heterocyprideis sorbyana (Jones)
   Female left valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
2. Heterocyprideis sorbyana (Jones)
   Female right valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
3. Heterocyprideis sorbyana (Jones)
   Male left valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
4. Heterocyprideis sorbyana (Jones)
   Male right valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
5. Normanicythere leioderma (Norman)
   Female left valve, exterior lateral view, locality MF4172 (PB-8). Bar equals 100 µm.
6. Normanicythere leioderma (Norman)
   Male right valve, exterior lateral view, locality MF4172 (PB-8). Bar equals 100 µm.
7. Normanicythere leioderma (Norman)
   Juvenile left valve (A-1 instar stage), exterior lateral view, locality MF4172 (PB-8). Bar equals 100 µm.
8. Normanicythere leioderma (Norman)
   Juvenile left valve (A-2 instar stage), exterior lateral view, locality MF4172 (PB-8). Bar equals 100 µm.



HETEROCYPRIDEIS AND *NORMANICYTHERE*

PLATE 7

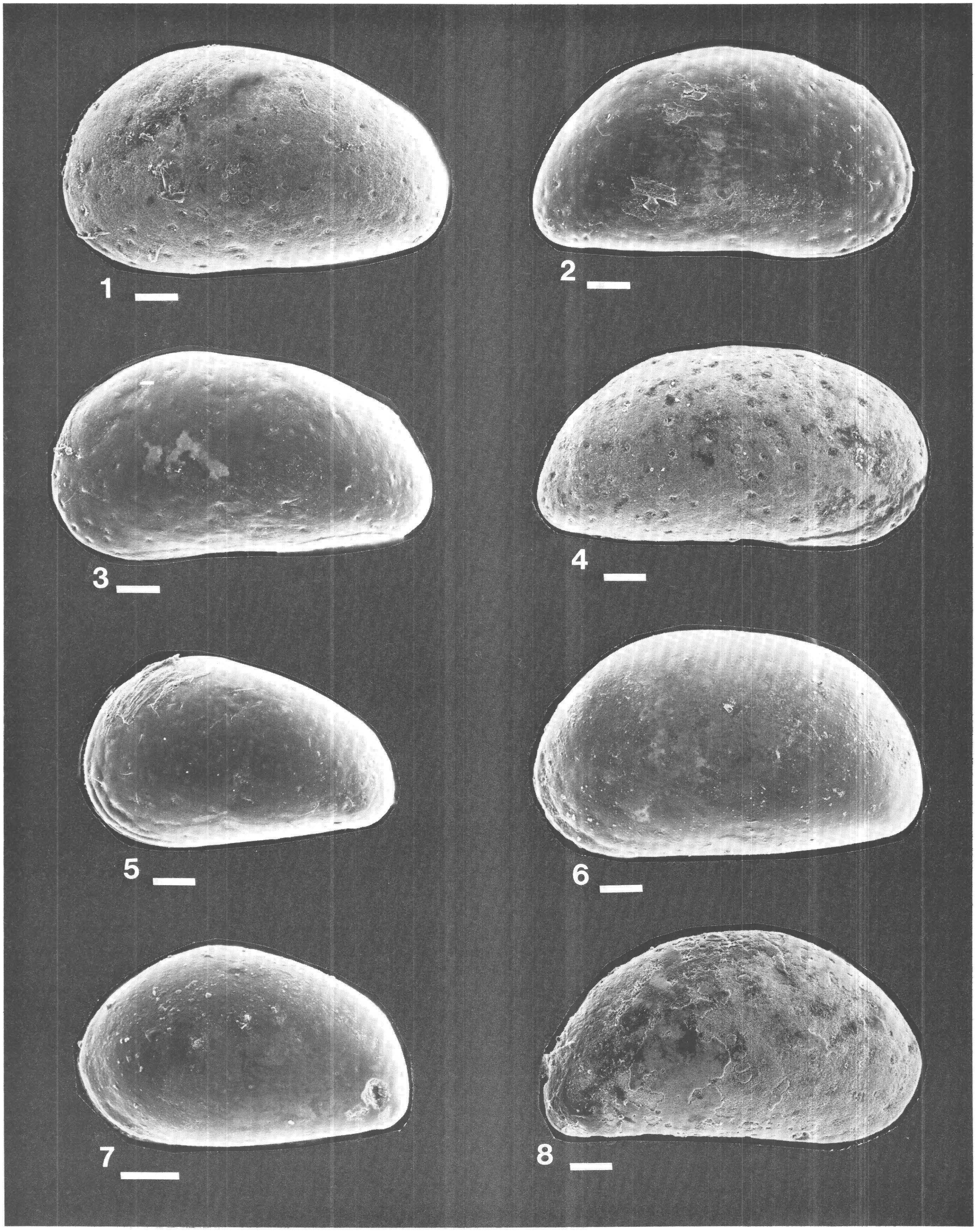
1. Loxoconcha elliptica Brady
   Female right valve, exterior lateral view, locality MF3612 (PB-1). Bar equals 100 µm.
2. Loxoconcha venepidermoidea Swain
   Female right valve, exterior lateral view, locality MF3612 (PB-1). Bar equals 100 µm.
3. Krithe glacialis Brady, Crosskey, and Robertson
   Female left valve, exterior lateral view, locality MF3655 (PB-2). Bar equals 100 µm.
4. Loxoconcha venepidermoidea Swain
   Female left valve, exterior lateral view, locality MF3612 (PB-1). Bar equals 100 µm.
5. Krithe glacialis Brady, Crosskey, and Robertson
   Male right valve, exterior lateral view, locality MF3655 (PB-2). Bar equals 100 µm.
6. Sarsicytheridea punctillata (Brady)
   Female left valve, exterior lateral view, locality MF4209 (PB-8). Bar equals 100 µm.
7. Sarsicytheridea punctillata (Brady)
   Juvenile left valve (A-1 instar stage), exterior lateral view, locality MF4209 (PB-8). Bar equals 100 µm.
8. Sarsicytheridea punctillata (Brady)
   Male left valve, exterior lateral view, locality MF 4209 (PB-8). Bar equals 100 µm.



LOXOCONCHA, *KRITHE*, AND *SARSICYTHERIDEA*

PLATE 8

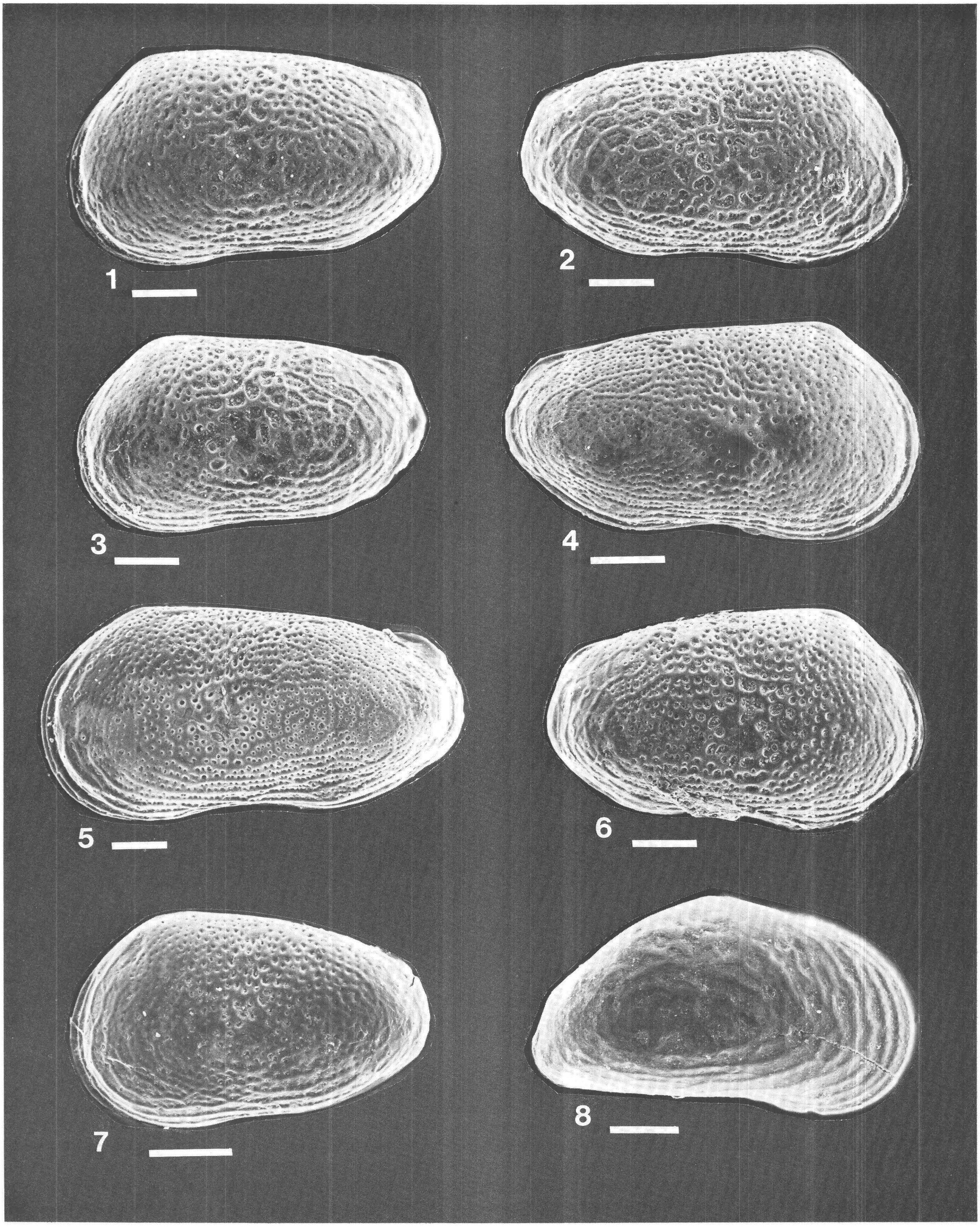
1. Paracyprideis pseudopunctillata Swain
   Female left valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
2. Paracyprideis pseudopunctillata Swain
   Female right valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
3. Paracyprideis pseudopunctillata Swain
   Male left valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
4. Paracyprideis pseudopunctillata Swain
   Male right valve, exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
5. Paracyprideis pseudopunctillata Swain
   Juvenile left valve (A-1 instar stage), exterior lateral view, locality MF3603 (PB-1). Bar equals 100 µm.
6. Sarsicytheridea bradii (Norman)
   Female left valve, exterior lateral view, locality MF4173 (PB-8). Bar equals 100 µm.
7. Sarsicytheridea bradii (Norman)
   Juvenile left valve (A-1 instar stage), exterior lateral view, locality MF4173 (PB-8). Bar equals 100 µm.
8. Sarsicytheridea bradii (Norman)
   Female right valve, exterior lateral view, locality MF4173 (PB-8). Bar equals 100 µm.



PARACYPRIDEIS AND *SARSICYTHERIDEA*

PLATE 9

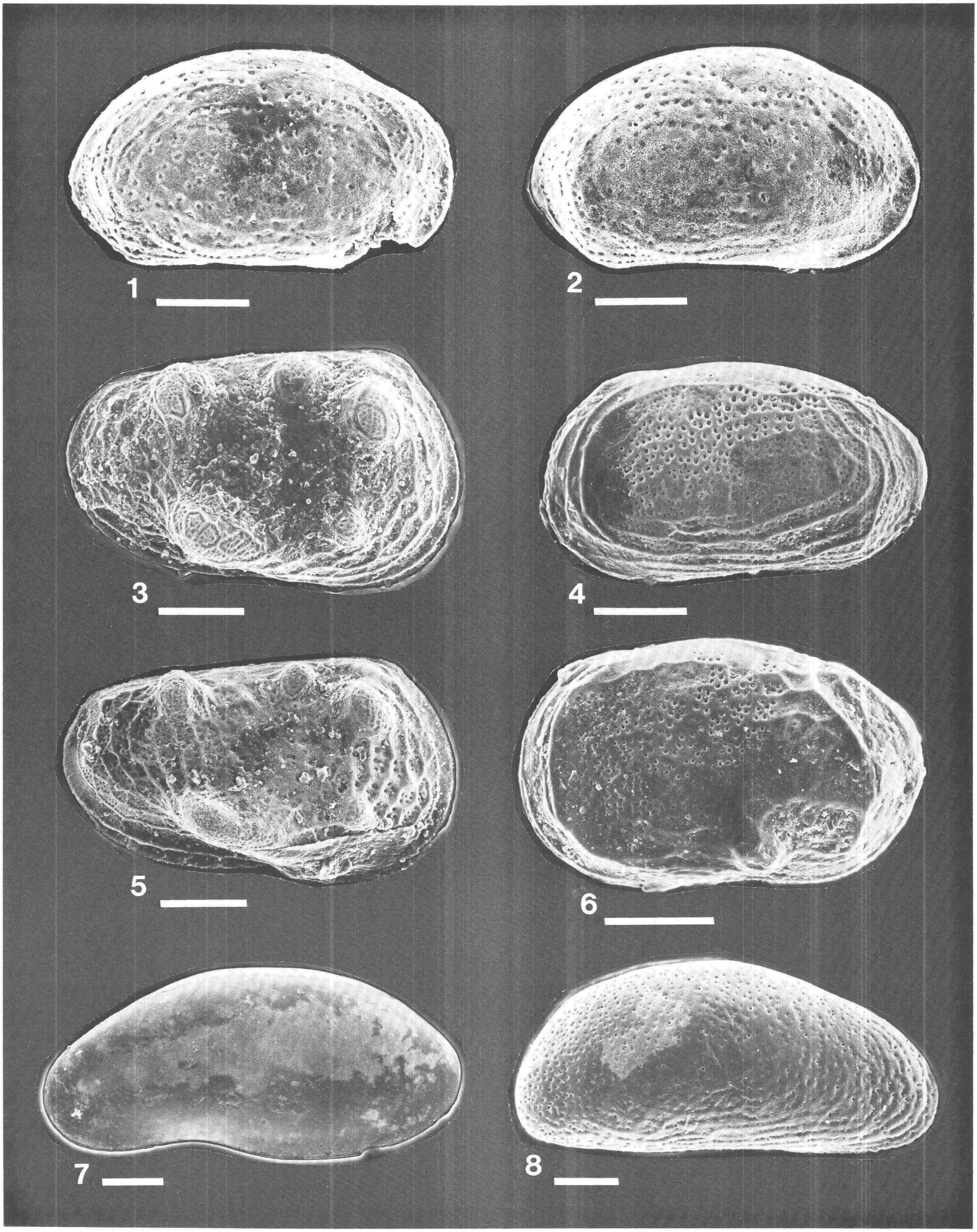
1. Cytheromorpha macchesneyi (Brady and Crosskey)
   Female left valve, exterior lateral view, locality MF3604 (PB-1). Bar equals 100 μm.
2. Cytheromorpha macchesneyi (Brady and Crosskey)
   Female right valve, exterior lateral view, locality MF3604 (PB-1). Bar equals 100 μm.
3. Cytheromorpha macchesneyi (Brady and Crosskey)
   ?Male valve, exterior lateral view, locality MF3604 (PB-1). Bar equals 100 μm.
4. Cytheromorpha sp. A
   Female right valve, exterior lateral view, locality MF4333 (PB-7). Bar equals 100 μm.
5. Cytheromorpha sp. A
   Male left valve, exterior lateral view, locality MF4333 (PB-7). Bar equals 100 μm.
6. Cytheromorpha macchesneyi (Brady and Crosskey)
   Female right valve, exterior lateral view, locality MF3604 (PB-1). Bar equals 100 μm.
7. Cytheromorpha sp. A
   Juvenile left valve (A-1 instar stage), exterior lateral view, locality MF4333 (PB-7). Bar equals 100 μm.
8. Eucythere declivis (Norman)
   Right valve, exterior lateral view, locality MF4176 (PB-8). Bar equals 100 μm.



CYTHEROMORPHA AND *EUCYTHERE*

PLATE 10

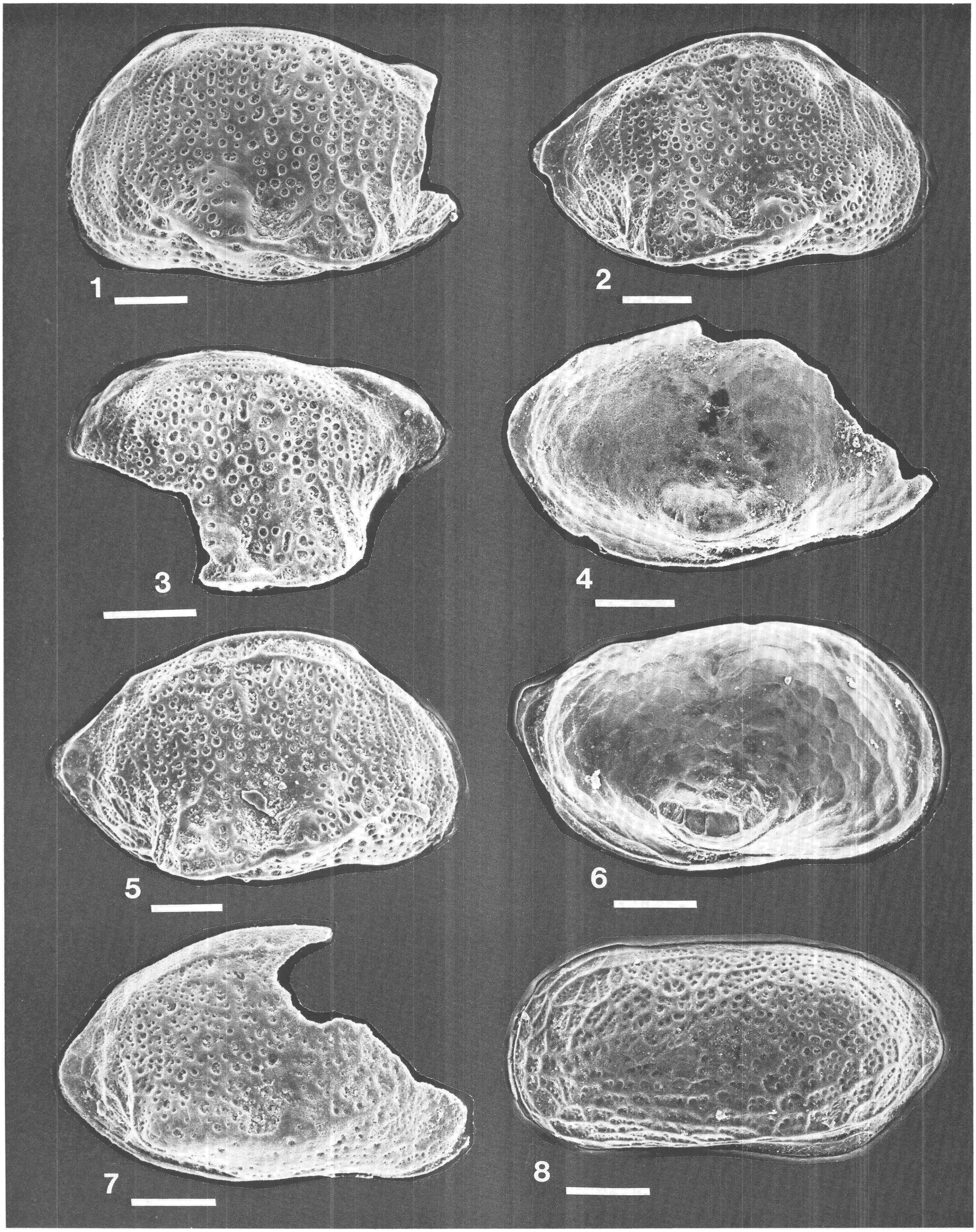
1. Cytherura sp. C
   Left valve, exterior lateral view, locality MF4173 (PB-8). Bar equals 100 µm.
2. Cytherura sp. B
   Right valve, exterior lateral view, locality MF4174 (PB-8). Bar equals 100 µm.
3. Roundstonia globulifera (Brady)
   Female right valve, exterior lateral view, locality MF4182 (PB-8). Bar equals 100 µm.
4. Cytherura sp. D
   Left valve, exterior lateral view, locality MF4213 (PB-8). Bar equals 100 µm.
5. Roundstonia globulifera (Brady)
   Male right valve, exterior larteral view, locality MF4182 (PB-8). Bar equals 100 µm.
6. Cluthia aff. C. cluthae (Brady, Crosskey, and Robertson)
   Left valve, exterior lateral view, locality MF4222 (PB-8). Bar equals 100 µm.
7. Sclerochilus sp.
   Right valve, exterior lateral view, locality MF4172 (PB-8). Bar equals 100 µm.
8. Pontocythere sp. A
   Right valve, exterior lateral view, locality MF4148 (PB-5). Bar equals 100 µm.



CYTHERURA, ROUNDSTONIA, CLUTHIA, SCLEROCHILUS, AND *PONTOCYTHERE*

PLATE 11

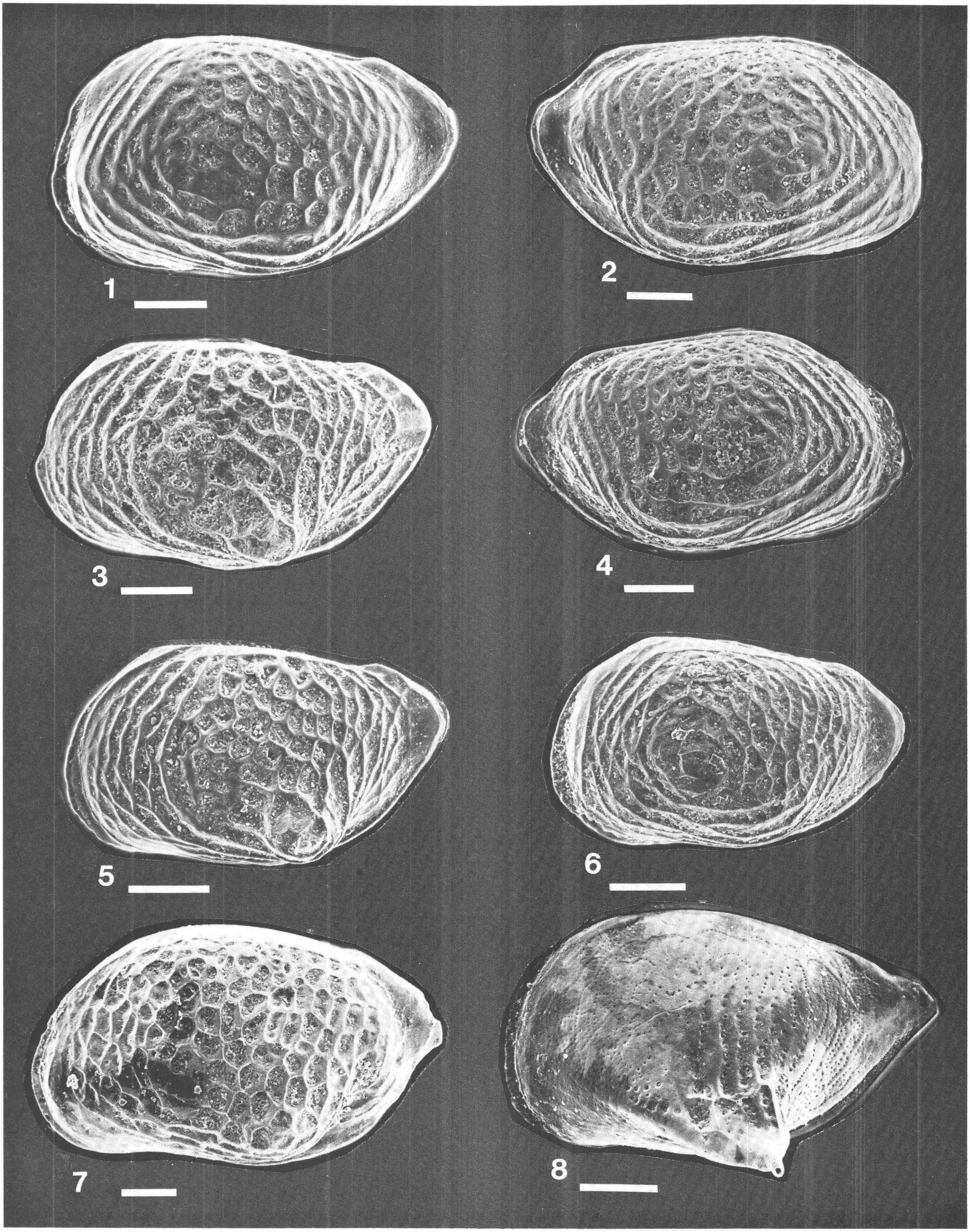
1. Cytheropteron aff. C. pyramidale Neale and Howe
   Left valve, exterior lateral view, locality MF4192 (PB-8). Bar equals 100 μm.
2. Cytheropteron aff. C. pyramidale Neale and Howe
   Right valve, exterior lateral view, locality MF4184 (PB-8). Bar equals 100 μm.
3. Cytheropteron aff. C. pyramidale Neale and Howe
   Right valve, exterior lateral view, locality MF4172 (PB-8). Bar equals 100 μm.
4. Cytheropteron sp. B
   Left valve, exterior lateral view, locality MF4178 (PB-8). Bar equals 100 μm.
5. Cytheropteron aff. C. pyramidale Neale and Howe
   Right valve, exterior lateral view, locality MF4184 (PB-8). Bar equals 100 μm.
6. Cytheropteron sp. B
   Right valve, exterior lateral view, locality MF4171 (PB-8). Bar equals 100 μm.
7. Cytheropteron punctatum Brady
   Right valve, exterior lateral view, locality MF4171 (PB-8). Bar equals 100 μm.
8. Cytherura sp. A
   Left valve, exterior lateral view, locality MF4171 (PB-8). Bar equals 100 μm.



CYTHEROPTERON AND *CYTHERURA*

PLATE 12

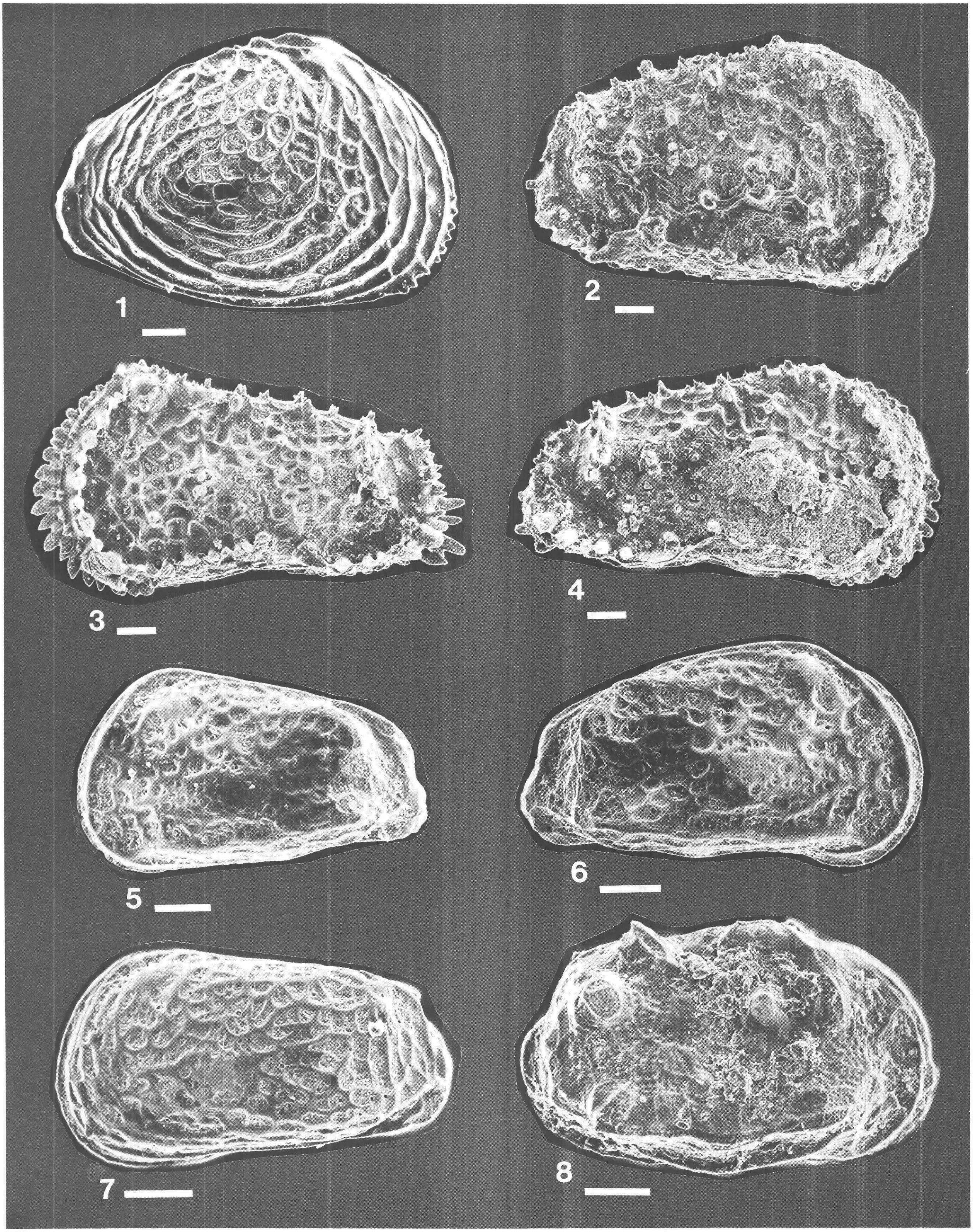
1. Cytheropteron montrosiense Brady, Crosskey, and Robertson
   Left valve, exterior lateral view, locality MF3635 (PB-2). Bar equals 100 µm.
2. Cytheropteron montrosiense Brady, Crosskey, and Robertson
   Right valve, exterior lateral view, locality MF4208 (PB-8). Bar equals 100 µm.
3. Cytheropteron montrosiense Brady, Crosskey, and Robertson
   Left valve, exterior lateral view, locality MF4192 (PB-8). Bar equals 100 µm.
4. Cytheropteron montrosiense Brady, Crosskey, and Robertson
   Right valve, exterior lateral view, locality MF4216 (PB-8). Bar equals 100 µm.
5. Cytheropteron montrosiense Brady, Crosskey, and Robertson
   Left valve, exterior lateral view, locality MF3635 (PB-2). Bar equals 100 µm.
6. Cytheropteron montrosiense Brady, Crosskey, and Robertson
   Juvenile left valve, exterior lateral view, locality MF4216 (PB-8). Bar equals 100 µm.
7. Cytheropteron montrosiense Brady, Crosskey, and Robertson
   Left valve, exterior lateral view, locality MF4191 (PB-8). Bar equals 100 µm.
8. Cytheropteron paralatissimum Swain
   Left valve, exterior lateral view, locality MF4215 (PB-8). Bar equals 100 µm.



CYTHEROPTERON

PLATE 13

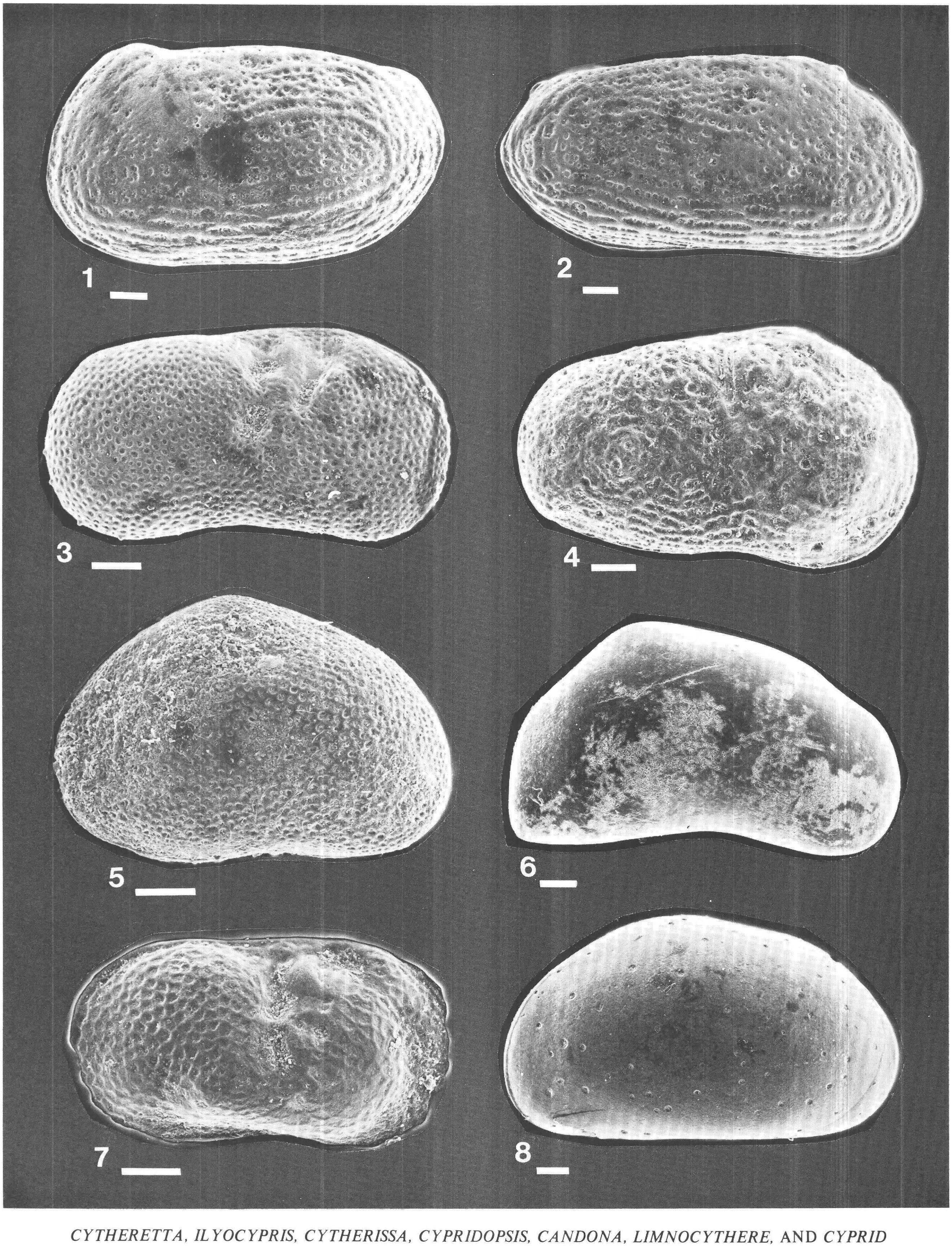
1. Rabilimis mirabilis (Brady)
   Right valve, exterior lateral view, locality MF3633 (PB-2). Bar equals 100 µm.
2. Acanthocythereis dunelmensis (Norman)
   Female right valve, exterior lateral view, locality MF4206 (PB-8). Bar equals 100 µm.
3. Acanthocythereis dunelmensis (Norman)
   Male left valve, exterior lateral view, locality MF4206 (PB-8). Bar equals 100 µm.
4. Acanthocythereis dunelmensis (Norman)
   Male right valve, exterior lateral view, locality MF4203 (PB-8). Bar equals 100 µm.
5. Finmarchinella (Barentsovia) curvicosta Neale
   Juvenile right valve, exterior lateral view, locality MF4176 (PB-8). Bar equals 100 µm.
6. Finmarchinella (Barentsovia) curvicosta Neale
   Juvenile left valve, exterior lateral view, locality MF4192 (PB-8). Bar equals 100 µm.
7. Finmarchinella (Finmarchinella) finmarchica (Sars)
   Female left valve, exterior lateral view, locality MF4192 (PB-8). Bar equals 100 µm.
8. Palmanella limicola (Norman)
   Right valve, exterior lateral view, locality MF4177 (PB-8). Bar equals 100 µm.



RABILIMIS, ACANTHOCYTHEREIS, FINMARCHINELLA, AND *PALMENELLA*

PLATE 14

1. Cytheretta teshekpukensis Swain
   Female left valve, exterior lateral view, locality MF4150 (PB-5). Bar equals 100 µm.
2. Cytheretta teshekpukensis Swain
   Male right valve, exterior lateral view, locality MF4150 (PB-5). Bar equals 100 µm.
3. Ilyocypris sp.
   Right valve, exterior lateral view, locality MF4167 (PB-7). Bar equals 100 µm.
4. Cytherissa lacustris (Sars)
   Right valve, exterior lateral view, locality MF4329 (PB-5). Bar equals 100 µm.
5. Cypridopsis aculeata (Liljeborg)
   Left valve, exterior lateral view, locality MF4171 (PB-8). Bar equals 100 µm.
6. Candona cf. C. candida (Mueller)
   Right valve, exterior lateral view, locality MF4171 (PB-8). Bar equals 100 µm.
7. Limnocythere liporeticulata Delorme
   Right valve, exterior lateral view, locality MF4325 (PB-5). Bar equals 100 µm.
8. Cyprid sp.
   Left valve, exterior lateral view, locality MF4325 (PB-5). Bar equals 100 µm.



CYTHERETTA, ILYOCYPRIS, CYTHERISSA, CYPRIDOPSIS, CANDONA, LIMNOCYTHERE, AND *CYPRID*

GPO 687-049/45011