ARCTIC
VOL. 39, NO. 3 (SEPTEMBER 1986) P. 232-239

Reconnaissance Survey of Benthonic Foraminifera from Baffin Island Fiord Environments[1]

CHARLES T. SCHAFER[2] and FLONA E. COLE[2]

(Received 25 June 1985; accepted in revised form 2 January 1986)

ABSTRACT. Benthonic foraminiferal assemblages in 63 grab samples collected in Baffin Island fiord basin environments (67-800 m) are dominated by arenaceous species such as *Textularia earlandi* and *Spiroplectammina biformis*. These forms reflect the influence of cold ($\lessapprox$0.0°C) arctic water conditions. Incursions of comparatively warm and saline Atlantic bottom water is marked in the deepest part of some fiord basins by the distribution of several calcareous species such as *Melonis zaandamae* and *Nonionella atlantica*. The highest living calcareous species population densities are associated primarily with fiord sills and with inner shelf environments near the mouths of fiords. Conversely, the patchy distribution and low percentages of many calcareous species found in basin sediments suggest passive transport of perhaps both living specimens and empty tests from shallow nearshore (endemic) environments or their occupation of deep basin transitional environments that mark the change from Atlantic to arctic water masses.

Key words: foraminifera, Baffin Island, fiords, arenaceous foraminifera, calcareous foraminifera

RÉSUMÉ. Des espèces arénacées telles que la *Textularia earlandi* et la *Spiroplectammina biformis* étaient prédominantes dans des établissements de foraminifères benthoniques de 63 échantillons pris par dragage à des profondeurs de 67 m à 800 m dans le bassin du fjord de l'île de Baffin. Ces formes reflètent l'influence des conditions froides ($\lessapprox$0.0°C) des eaux arctiques. Des incursions d'eau de fond atlantique comparativement plus chaude et saline encouragent la croissance de nombreuses espèces calcaires, dont *Melonis zaandamae* et *Nonionella atlantica*, au plus profond de certains bassins de fjords. De façon inverse, la distribution éparpillée et les pourcentages peu élevés de plusieurs espèces calcaires trouvées dans les sédiments de bassins signalent peut-être un déplacement passif de la part des deux spéciment vivants ainsi que des tests vides à partir de milieux peu profonds littoraux (endémiques), ou encore leur occupation de milieux transitoires dans des bassins profonds marquant le point de rencontre des masses d'eau atlantique et arctique.

Mots clés: foraminifères, île de Baffin, fjords, foraminifères arénacés, foraminifères calcaires

Traduit pour le journal par Maurice Guibord.

INTRODUCTION

Benthonic foraminifera inhabiting various shallow water and deep basin environments that occur in arctic fiords have received little attention in Canada. During the first field program of the Canadian Geological Survey's project SAFE (Sedimentology of Arctic Fiords Experiment) in 1982, an axial reconnaissance of ten fiords located along the east coast of Baffin Island was carried out by an international scientific team (see Syvitski and Schafer, 1984, and Fig. 1). Sixty-three grab samples were collected and subsequently analyzed for their foraminifera assemblages (Appendix 1). The samples were raised from fiord and inner shelf environments between latitudes 66°N and 72°N and cover a wide range of oceanographic and geological settings. Distinctive "end member" environmental conditions occur in prodelta environments near the heads of the fiords, on fiord sills, and in deep fiord basins. The foraminiferal assemblages observed in these settings constitute a diverse suite of modern analogs applicable to the interpretation of older Quaternary sequences and that complement investigations carried out in associated marginal marine environments (e.g., Anderson, 1972; Elverhøi *et al.*, 1980).

This report summarizes results on the time-averaged environmental signal reflected by total foraminiferal assemblages (living specimens plus empty tests) observed in the upper several centimetres of fiord bottom sediments. A brief statistical evaluation of the environmental associations suggested by the distribution of calcareous species is also included. These forms are of importance because they are often found as fossils in Quaternary sediments deposited on the eastern Canadian continental shelf and slope under glacial conditions. Living species were not considered separately because of their low numbers and the lack of a serial sample suite from any of the end member settings.

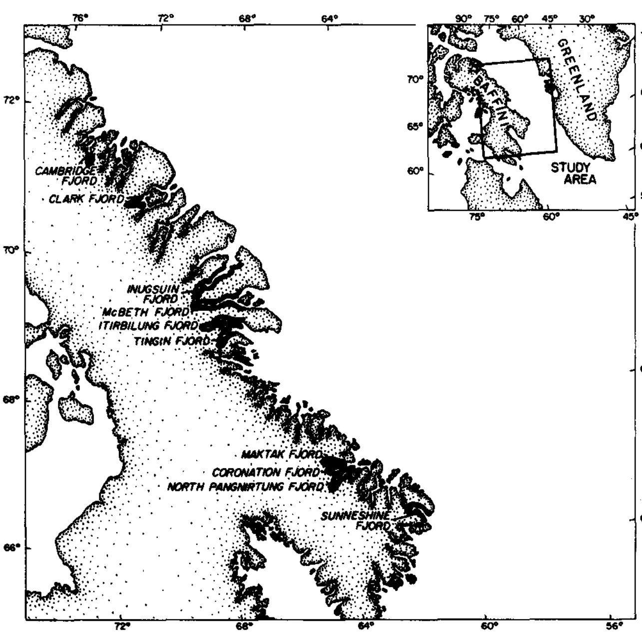

FIG. 1. Location of fiords along the east coast of Baffin Island.

METHODOLOGY

Sediments were collected using a Van Veen grab sampler usually in water depths ≥100 m (Appendix 1). A portion of the grab surface (upper 1-3 cm) was placed in a vial containing a buffered formalin solution (final pH = 8.3). In the laboratory,

[1]SAFE (Sedimentology of Arctic Fiords Experiment) contribution number 8. See Arctic 38(4):264 for further explanation.
[2]Geological Survey of Canada, Bedford Institute of Oceanography, Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2

the preserved subsample was stained with Sudan Black B (Walker *et al.*, 1974) to facilitate the recognition of living specimens (Appendix 2). The total foraminifera population was isolated and concentrated using a 63 micron sieve and heavy liquid techniques (Gibson and Walker, 1967). Specimen counting was carried out with a binocular microscope, and data on the calcareous species component of the total population are tabulated in Clattenburg *et al.* (1983) and were evaluated using Q-mode cluster and R-mode factor analysis techniques (Bonham-Carter, 1967; Nie *et al.*, 1975).

ENVIRONMENTAL SETTING

The ten fiords range in length from about 25 km to 100 km (Table 1). Drainage basin areas vary by about a factor of six from 564 km^2 in the case of Sunneshine to almost 3600 km^2 for McBeth (Gilbert and MacLean, 1983). Sills are from <100 m to >439 m deep, and some fiords (e.g., McBeth and Cambridge) have several that divide them into distinct subbasins. The depth of these subbasins ranges up to at least 800 m.

The fiords are covered by sea ice for up to ten months each year and alpine glaciers reach tidewater at the head of Coronation Fiord or through side entry valleys in several of the other systems. Water mass properties are influenced by both cold arctic water (Canada Current) and relatively warm "Atlantic" water. Bottom water temperatures and salinities at the time of the survey were in the range of 1.3°C to −1.5°C and 33.0-34.5‰ respectively. The influence of Atlantic water is evident especially in the deeper parts of basins in Tingin, Clark and Cambridge fiords, where bottom waters were above 0°C below depths of 300-500 m (Trites *et al.*, 1983).

Suspended particulate matter (SPM) concentrations in surface waters can be in excess of 5 mg l^{-1} near the edge of a tidewater glacier but are normally of the order of 1.0 mg l^{-1}, considerably lower than the values observed by Elverhøi *et al.* (1980) in water collected from a Spitzbergen fiord. Suspended sediments in the Baffin fiords have a modal grain size of about 15 μm (Asprey *et al.*, 1983). The annual input of SPM per fiord shows a general inverse relationship to the fiord-averaged percent organic carbon of surface sediment (Syvitski *et al.*, 1984).

Surface water primary production is typically 80-90 mg C M^3 D^{-1} and bacterial biomass averages about 0.65 mg C M^3 (Albright and Stroh, 1983). Most bottom sediments are more than 85% silt plus clay-size particles that have a modal total carbon and organic carbon content of about 1.3% and 0.7% respectively (Clattenburg *et al.*, 1983). Modal algal and bacterial biomass in surficial sediments is about 45 mg C M^3 and 38 mg C M^3 respectively. In Coronation, Itirbilung and McBeth fiords surface sediment organic carbon percentages increase down fiord (Syvitski *et al.*, 1984).

TABLE 1. Morphological and geological characteristics of Baffin Island fiords (data from Gilbert and MacLean, 1983)

Fiord [length in km]	Maximum depth (m)	Drainage basin area km^2	Area elevation ratio (km^2/m)	Glacier cover (%)	Sill depth (m)	Tidal prism ($m^3 \times 10^6$)	Sediment volume ($m^3 \times 10^9$) Thickness [m]
Sunneshine [36]	(215?)	(564)	(0.31)	(16)	(64)	(300)	(?) [?]
North Pangnirtung [48]	(479)	(2064)	(1.05)	(35)	(None)	(155)	(0.42) [40]
Coronation [41]	(606)	(1128)	(0.60)	(70)	(None)	(142)	(1.06) [130]
Maktak [26]	(585)	(1132)	(0.60)	(47)	(None)	(65)	(0.45) [70]
Tingin [47]	(523)	(1228)	(0.83)	(37)	(180?)	(119)	(2.10) [130]
Ititbilung [55]	(435)	(2184)	(1.28)	(32)	(249)	(89)	(3.60) [200]
McBeth [93]	(563)	(3584)	(2.05)	(26)	(249)	(196)	(7.67) [97]
Inugsuin [98]	(633)	(2192)	(1.28)	(24)	(121)	(240)	(1.83) [110]
Clark [67]	(552)	(1324)	(0.81)	(40)	(108)	(57)	(2.17) [200]
Cambridge [61]	(708)	(1992)	(1.42)	(12)	(439)	(140)	(6.55) [290]

RESULTS

(a) General Characteristics of the Total Population

Benthonic foraminifera and thecamoebian (fresh to brackish water protozoans) specimens were studied in all of the grab samples (Appendix 2). The average number of foraminifera species in the ten fiords is 54, with a remarkably low standard deviation (SD) of only 14 (Table 2). The proportion of calcareous species in the total population averages 26% and is also distributed in a comparatively uniform pattern throughout the ten fiords (SD = 7.2%). The absolute total number of foraminifera in terms of number of tests per ml of wet sediment (N/ml) averages 111 individuals (SD = 39.6) and is highest in Sunneshine Fiord. This fiord is the shallowest and the most southerly surveyed in this study. It is characterized by the highest fiord-averaged sedimentary organic carbon and by one of the lowest annual inputs of suspended sediment (Syvitski, unpubl. data).

Because of the persistence of below zero water temperatures at intermediate depths (10 m->400 m) throughout the year, the

TABLE 2. Summary of foraminiferal assemblage characteristics

Fiord [no. of samples]	Sample depth range [m] Mean depth (m)	Total species Foram.	Thec.	Dominant species Aren.	*Calc.	Calc. species %	Total N/CC.	Plank. foram (*)
Sunneshine [5]	[67-215] (143)	54	2	*R. arctica* *S. biformis*		37	177	L
North Pangnirtung [3]	[80-347] (253)	31	2	*TR. nana* *TE. earlandi*		16	60	
Coronation [6]	[90-495] (294)	44	3	*S. biformis* *TR. nana*	**C. reniforme*	32	50	U
Maktak [7]	[90-670] (440)	52	1	*S. biformis* *TR. nana*		27	75	L
Tingin [4]	[302-800] (484)	56	1	*TE. earlandi* *TR. nana*	**C. reniforme*	27	124	U
Ititbilung [4]	[167-417] (302)	52	1	*TE. earlandi* *A. glomerata*		31	137	U
McBeth [9]	[250-572] (405)	42	2	*TE. earlandi* *TR. nana/* *A. glomerata*		26	99	
Inugsuin [8]	[160-570] (385)	56	2	*S. biformis* *R. arctica*		32	124	
Clark [7]	[192-755] (486)	73	3	*TE. earlandi* *TR. nana*		21	124	U
Cambridge [10]	[366-681] (473)	79	3	*TE. earlandi* *TR. nana*		15	140	L
	Average =	54			Average =	26	111	
	SD =	14.0			SD =	7.2	39.6	

*U = upper to middle fiord occurrences.
L = middle to lower fiord occurrences.

total foraminiferal assemblage in the Baffin fiords is predominantly arenaceous (Figs. 2 and 3). *Textularia earlandi* (Phleger) is the dominant species in five of the fiords, all located north of latitude 68°N. This species is of secondary importance in North Pangnirtung. *Spiroplectammina biformis* (Parker and Jones) and *Trochammina nana* (Brady) dominate in four fiords situated south of latitude 70°N. *T. nana* is an important secondary taxon in six of the fiords. It is replaced by *S. biformis* in Sunneshine, where *Reophax arctica* (Brady) is the dominant species, and by *Adercotryma glomerata* (Brady) and *R. arctica* in Itirbilung and Inugsuin respectively.

Between one and three thecamoebian species were observed in the samples; these forms are poorly represented in Maktak, Tingin and Itirbilung fiords. The most ubiquitous taxon is *Pontigulasia compressa* (Carter) (see Clattenburg *et al.*, 1983). Planktonic foraminifera tests of the arctic species *Neogloboquadrina pachyderma* (Ehrenberg) were noted in Tingin, Itirbilung and Clark.

(b) Calcareous Species

Calcareous species are poorly represented compared to arenaceous taxa especially in the deeper parts of fiord basins. *Cassidulina reniforme* (Norvang) is the dominant member of the calcareous assemblage in Tingin and Coronation fiords (Fig. 3). Elsewhere the percentages of calcareous species are too low and regionally variable (i.e., patchy) to establish a reliable dominant taxon. Nevertheless, this report overemphasizes calcareous species data in recognition of their importance for interpreting the paleoceanographic and biostratigraphic significance of Quaternary sediments.

Calcareous specimens are especially sparse in Cambridge Fiord, where they constitute only 15% of the total population. When single occurrences are omitted from the 63 station data set, the number of calcareous species decreases from 40 to 24 and the remaining comparatively widespread forms occur at only 47 stations. The calcareous species from the associated 47 samples were classified into assemblage using Q-mode cluster analysis (unweighted pair-group method) run on a matrix of Dice coefficients of association (Bonham-Carter, 1967).

Nine sample clusters were defined at the 0.5 level of similarity. The individual groups reflect differences in the species diversity of sample assemblages. Coronation, Tingin and Itirbilung fiords support the most diverse calcareous assemblages. The Cambridge Fiord calcareous assemblages have uniformly low diversities, as do those in the upper part of McBeth Fiord west of longitude 69°W.

It is interesting to note that both Cambridge and McBeth fiords are anomalous in terms of their hinterland glaciers, which cover only 12% and 25% of their respective drainage basins compared to a grand average of 34% for the ten-fiord suite (Gilbert and MacLean, 1983). McBeth's drainage area is more than twice as large as the grand average of 1739 km^2 and that of Cambridge is 14% larger. Total sediment volumes and thicknesses in these fiords rank second and first respectively (Gilbert and MacLean, 1983), although contemporary annual inputs of suspended sediment are relatively low to average (Syvitski *et al.*, 1984). Intermediate to high total population N/ml values observed in McBeth and Cambridge are consistent with the suspended sediment results and would appear to rule out a sediment dilution effect where only a few of the ubiquitous and well-represented calcareous species have been collected in the grab sample (Table 2). Our knowledge of seasonal salinity and temperature variation in these areas is presently too sparse to test the influence of water mass properties on calcareous assemblage diversity differences between fiords. However, the comparatively large drainage basins and the amount of hinterland glacier

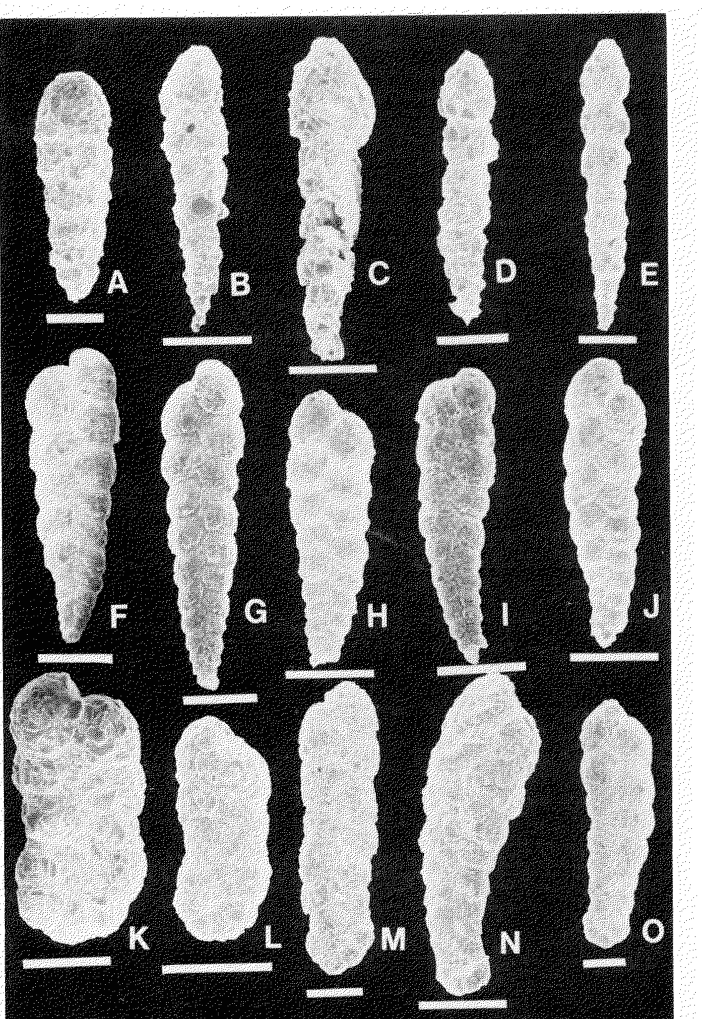

FIG. 2. Key arenaceous foraminifera species: *Reophax arctica* (A-E), *Textularia earlandi* (F-J), *Spiroplectammina biformis* (K-O). White bars are 100 μm long.

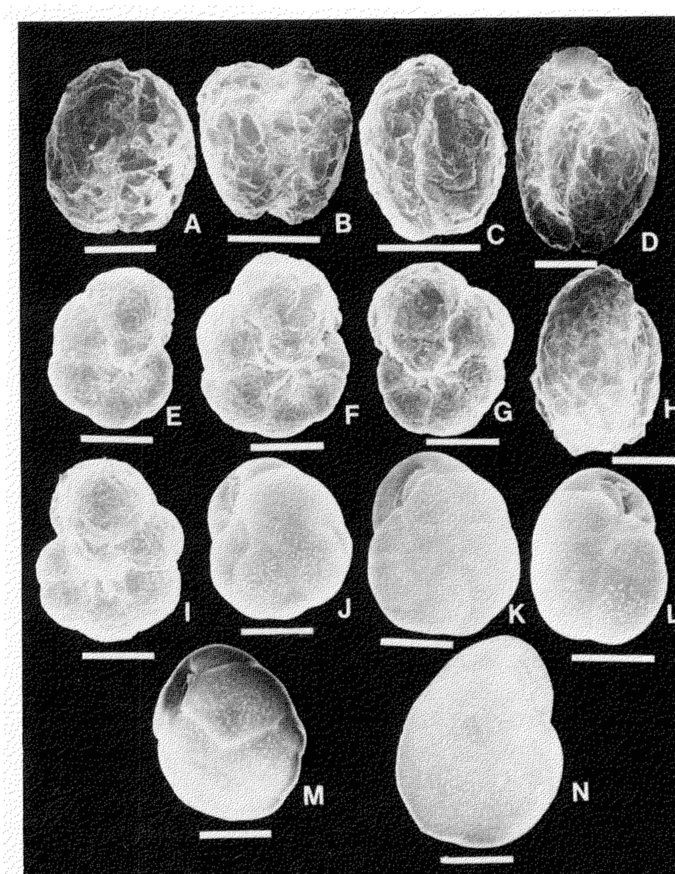

FIG. 3. Key arenaceous and calcareous species: *Adercotryma glomerata* (A-D and H), *Trochammina nana* (E-G and I), *Cassidulina reniforme* [J-N]. White bars are 100 μm long.

cover in these two fiords may influence ambient summer surface layer salinities in a way that favors the consistent annual reproduction of certain calcareous species.

In general, calcareous assemblage diversity shows both increases and decreases from the heads to the mouths of fiords. Diversity is relatively high at the head of Inugsuin, Clark and Tingin. Inugsuin and Tingin are among the group of four fiords characterized by relatively low annual inputs of suspended sediment (Syvitski *et al.*, 1984). In addition to Cambridge and McBeth fiords, diversities are also comparatively low at the head of Coronation, Sunneshine and Itirbilung, which together encompass a wide range of annual suspended sediment inputs.

In high diversity assemblages, *Cibicides lobatulus* (Walker and Jacob) and *Cassidulina reniforme* are the dominant forms (e.g., Coronation and Tingin fiords). However, the highest total percentage of *C. reniforme* occurs at MA-01, a low-diversity cluster station near the head of Maktak, while that of *C. lobatulus* occurs at a high diversity inner shelf station near the mouth of Sunneshine Fiord (SU-08). Both MA-01 and SU-08 are less than 200 m deep; however, the sediment flux to the MA-01 site may be as much as an order of magnitude higher than that at SU-08 (Syvitski, unpubl. data). These occurrences are consistent generally with the typical *C. reniforme*-ice margin, fine sediment paleoenvironmental relationship often seen in sediments of postglacial age (e.g., Vilks and Rashid, 1976) and with the well-known association of *C. lobatulus* to coarse substrate, high wave and/or bottom current turbulence continental shelf settings (e.g., Thomas and Schafer, 1982).

Fursenkoina (*Virgulina*) *fusiformis* (Williamson), *Islandiella helenae* (Feyling-Hanssen and Buzas) and *Elphidium excavatum clavata* (Cushman) are prominent secondary species in the high diversity sample clusters. Among two intermediate diversity sample clusters, *F. fusiformis* is the most ubiquitous form.

Species in the intermediate and low diversity clusters of secondary importance include *E. excavatum clavata*, *Bolivina pseudopunctata* (Höglund), *Melonis zaandamae* (van Voorthuysen), *I. helenae*, *Buccella frigida* (Cushman), *Nonionella atlantica* (Cushman) and *Pyrgo williamsoni* (Silvestri). Within the study area most of these taxa are associated with comparatively warm (≥0.0°C) Atlantic bottom water conditions. The low population density and low diversity assemblages at stations IN-08 and CL-06 are represented primarily by *E. excavatum clavata*. Both stations occur near the mouths of these fiords in water depths of 391 m and 552 m respectively. Their calcareous assemblage characteristics in relation to water depth, and to their arenaceous assemblage composition, is suggestive of passive transport of shallow water calcareous species to these offshore localities. In contrast, low diversity clusters with secondary species such as *M. zaandamae* record an Atlantic water influence in the deeper parts of some fiord basins. In general, the calcareous species *C. reniforme* shows the highest overall modal percentage abundances in all of the sample clusters.

(c) Calcareous Species-Environment Associations

Intuitive analysis of foraminifera distributions from the 44 station data set with sediment texture and oceanographic parameters indicated a number of provisional associations that need to be tested quantitatively in future surveys. The inverse relationships between calcareous and arenaceous populations, % sand and bottom water temperature, and % sand and bottom water SPM, and the direct relationships between deep basin bottom water salinity and bottom water temperature, and of % gravel and % planktonic specimens are all consistent with our present general understanding of the sedimentology, ecology and descriptive oceanography of these systems. The association of living calcareous species and high energy inner shelf or shallow fiord sill environments is reflected by the direct relationship between calcareous taxa such as *C. lobatulus, Eoeponidella pulchella* (Parker) and *Protelphidium nanum* (Vilks) with % gravel and % planktonic specimens. High values for % gravel and % planktonic specimens denote exposure to wave turbulence and proximity to open shelf marine conditions. In contrast, living arenaceous species are associated primarily with comparatively deep fine sediment environments typical of basins in the central reaches of many fiords.

The 44 station data set was analyzed statistically using R-mode factor analysis with varimax rotation (Nie *et al.*, 1975). The first five unrotated factors accounted for 62% of the total variance and define a shelf to nearshore spectrum of calcareous assemblage/environment associations that were interpreted using the rotated factor loadings (Table 3).

TABLE 3. Summary of diagnostic variables and factor loadings

Factor (variance)	Variables	Loadings
1. Sill to inner shelf (29.3%)	Gravel (%)	0.85
	Planktonic individuals (%)	0.89
	Total calcareous individuals (%)	0.78
	Total arenaceous individuals (%)	(—)0.76
	Buccella frigida (Cushman) (%)	0.91
	Cibicides lobatulus (Walker and Jacob) (%)	0.94
	Protelphidium orbiculare (Brady) (%)	0.82
	Protelphidium nanum (Vilks) (%)	0.95
	Trifarina fluens (Todd) (%)	0.87
	Astrononion gallowayi (Loeblich & Tappan) (%)	0.66
2. Nearshore, proximal freshwater source (11.2%)	Living calcareous individuals (%)	0.95
	Living arenaceous individuals (%)	(—)0.95
	Thecamoebian individuals (%)	0.38
	Cassidulina reniforme (Norvang) (%)	0.46
	Pyrgo williamsoni (Silvestri) (%)	0.64
3. Deep inner shelf to outer fiord basin (8.6%)	Bottom water salinity (%)	0.78
	Bottom water temperature (°C)	0.80
	Water depth (M)	0.78
	Bolivina pseudopunctata (Höglund) (%)	0.50
	Melonis zaandamae (van Voorthuysen) (%)	0.53
	Nonionellina labradorica (Dawson) (%)	0.56
4. Allochthonous? species (7.4%)	*Buliminella elegantissima* (d'Orbigny) (%)	0.50
	Triloculina oblonga (Montagu) (%)	0.70
	Stainforthia concava (Höglund) (%)	0.75
	Elphidium excavatum clavata (Cushman) (%)	0.62
5. Nearshore, deep water, proximal freshwater source (5.4%)	Thecamoebian individuals (%)	0.57
	Nonionella atlantica (Cushman) (%)	0.90
	Stetsonia horvathi (Green) (%)	0.99

Factor 1 is interpreted as a high foraminiferal population density-sill to inner shelf environment. This factor has high positive loading on % gravel, % planktonic specimens, % total calcareous specimens, and on important calcareous Baffin Island shelf species such as *Buccella frigida*. Its station analog (as indicated by the highest sample factor score) is SU-08, located on the inner shelf adjacent to the mouth of Sunneshine Fiord at a depth of 160 m.

Factor 2 reflects nearshore conditions with a proximal freshwater source that are indicated by the high positive loading on thecamoebians and by the high negative loading on the living arenaceous specimen percentage. An example of its station analog is CO-03, located about halfway up Coronation Fiord at a depth of 269 m.

Factor 3 describes a deep inner shelf or outer fiord basin environmental association marked particularly by high loadings on Atlantic water species such as *Melonis zaandamae* and *Nonionella atlantica*. Its analog stations MA-6A (658 m deep) and TI-06 (800 m deep) are both located in Baffin Bay shelf troughs that lie adjacent to Maktak and Tingin fiords.

Factor 4 is a ubiquitous assemblage relationship that may reflect passive transport of shallow water calcareous species to the flanks of fiord basins. Station IT-01 (167 m deep) has the highest score for this factor. It is situated near the head of Itirbilung Fiord in an area subject to sediment gravity flows originating in adjacent shallow environments (J. Syvitski, pers. comm. 1985).

Factor 5 denotes a nearshore but deep water fiord environment proximal to a fresh water source. Its lower fiord, deep water aspect is indicated by the high loading on *N. atlantica*; its station analog is CL-05 (683 m deep).

(d) Foraminiferal Paraecology

The small number of samples collected in each fiord and the patchy distribution of most calcareous species does not allow a rigorous quantitative test of species-environment relationships. However, the characteristics of the relatively conservative total population N/ml parameter suggests several tentative relationships that may be tested in future surveys. The two lowest average N/ml's per fiord occur in Coronation and North Pangnirtung, which rank first and third in terms of annual input of suspended sediment (Syvitski *et al.*, 1984). Coronation and North Pangnirtung samples are among the three shallowest suites in the ten-fiord set. However, the shallowest sample suite (143 m — Sunneshine Fiord) is related to the highest mean N/ml. Coronation and North Pangnirtung fiords are characterized further by the absence of sills, while Sunneshine has the shallowest sill (64 m). Sunneshine also differs from all the other fiords in having the smallest drainage basin area/elevation relationship, the smallest drainage basin (Gilbert and MacLean, 1983), the lowest sediment bacterial biomass and one of the lowest annual inputs of suspended sediment (Syvitski *et al.*, 1984). Its mean total sedimentary carbon concentration is equal to the grand average (0.61%) and its tidal prism is double that of Coronation and North Pangnirtung (300 vs 150 $M^3 \times 10^6$; Gilbert and MacLean, 1983). In contrast, the mean total sedimentary carbon value for Coronation Fiord is only 0.20% and that of North Pangnirtung is 0.48%, still somewhat below the grand mean of 0.68% but consistent with their comparatively high annual inputs of suspended sediment. The marine environment in Sunneshine is therefore relatively isolated but nevertheless well mixed with an adequate supply of organic carbon compared to that observed in the lowest total N/ml fiords.

These conditions, in addition to its low sedimentation rate setting, may explain why the Sunneshine environment supports a larger standing crop of benthonic foraminifera, which perhaps can maintain a proportionately higher level of annual test production. This contention is supported indirectly by the high percentage of calcareous specimens (37%) recorded for Sunneshine. Elsewhere these forms are indicative of comparatively warm bottom water conditions over a proportionately large part of the water column during the summer months (e.g., Chaleur Bay, Schafer and Cole, 1977). The relatively low bacterial biomass of surface sediments in Sunneshine Fiord could therefore reflect predation by a relatively dense population of foraminifera in conjunction with other competing species of the endemic benthos.

CONCLUSIONS

The observations made on the benthonic foraminiferal and thecamoebian assemblages in surficial sediment samples from axial locations in ten east coast Baffin Island fiords suggest that:

(1) the assemblages have a distinctive arctic character, with most being dominated by one or two arenaceous species;
(2) the abundance of arenaceous species and specimens reflects continuous cold water temperatures at intermediate depths in all fiord basins;
(3) calcareous species are sparse in the offshore areas of fiord basins and appear to prefer restricted and well-mixed shallow water conditions. In Sunneshine fiord, the comparatively high percentage of calcareous specimens suggests that during the summer season warm water may be mixed to relatively greater depth and persist for longer periods than in the deeper open systems lying to the north;
(4) the presence of comparatively warm, high salinity bottom water of Atlantic origin in the deepest parts of several fiord basins is marked by the occurrence and distribution of the calcareous species *Melonis zaandamae* and *Nonionella atlantica*;
(5) the highest living calcareous species population densities are related to fiord sill and inner shelf settings where the species *Cassidulina reniforme* and *Cibicides lobatulus* are often dominant. The dominance of *C. reniforme* over *C. lobatulus* in some shallow nearshore fiord environments may be related to its tolerance of high concentrations of suspended particulate matter;
(6) the occurrence of modern (?) planktonic foraminifera specimens near the heads of several fiords (Clark, Itirbilung, Tingin) suggests transport of surface shelf water to these distal areas by wind because at least two of these systems (Clarke and Itirbilung) have relatively small tidal prisms.

APPENDIX 1. Summary of station locations* and water depths

Station	Latitude(N)	Longitude(W)	Depth(m)
McBETH			
MC-1	69°31.9′	69°47.5′	329
MC-3	69°31.4′	69°16.0′	440
MC-4	69°34.7′	68°57.0′	530
MC-5	69°36.8′	69°35.0′	572
MC-6	69°31.7′	68°09.4′	415
MC-7	69°37.5′	68°16.0′	497
MC-8	69°44.0′	67°44.0′	290
MC-9	69°30.0′	67°51.0′	326
MC-11	69°29.5′	66°39.0′	250
INUGSUIN			
IN-1	69°40.8′	69°43.5′	160
IN-2	69°42.9′	69°54.0′	280
IN-3	69°48.8′	69°33.0′	557
IN-4	69°53.0′	69°17.3′	585
IN-5	69°58.5′	69°02.2′	503
IN-6	70°03.8′	68°41.4′	267
IN-7	70°19.1′	68°19.2′	338
IN-8	70°23.1′	68°03.6′	391
CLARK			
CL-1	70°49.6′	72°37.0′	192
CL-2	70°50.0′	72°27.0′	234
CL-3	70°52.8′	72°15.7′	256
CL-4	70°58.5′	72°07.3′	530
CL-5	71°05.5′	71°53.0′	683
CL-6	71°02.7′	71°31.0′	552
CL-7	71°02.6′	71°13.7′	685
CL-8	71°10.9′	70°49.2′	755
CAMBRIDGE			
CA-1	71°12.5′	75°00.0′	196
CA-2	71°16.6′	74°52.0′	316
CA-3	71°23.6′	74°40.0′	366
CA-4	71°26.5′	74°43.7′	476
CA-5	71°33.0′	74°45.7′	575
CA-6	71°34.9′	74°40.0′	640
CA-7	71°41.3′	74°25.2′	398
CA-8	71°46.9′	74°12.3′	681
CA-9	71°48.8′	73°31.0′	610

Station	Latitude(N)	Longitude(W)	Depth(m)
SUNNESHINE			
SU-1	66°36.9′	61°53.8′	215
SU-5	66°33.3′	61°42.6′	155
SU-6	66°30.7′	61°39.2′	117
SU-7	66°29.3′	61°31.0′	67
SU-8	66°33.1′	61°11.8′	160
CORONATION			
CO-1	67°12.5′	64°46.5′	98
CO-2	67°14.1′	64°38.0′	248
CO-3	67°14.5′	64°30.0′	269
CO-4	67°15.2′	64°18.2′	356
CO-5	67°17.8′	64°09.0′	497
MAKTAK			
MA-1	67°21.3′	64°46.5′	90
MA-2	67°19.7′	64°33.6′	257
MA-4	67°18.9′	64°17.0′	333
MA-5	67°17.5′	64°01.0′	585
MA-5A	67°16.8′	63°55.0′	575
MA-6A	67°27.4′	63°35.4′	658
MA-7	67°34.8′	63°34.6′	585
NORTH PANGNIRTUNG			
NP-1	67°03.5′	64°40.0′	80
NP-2	67°09.5′	64°25.0′	347
NP-3	67°11.6′	64°05.0′	333
TINGIN			
TI-1A	69°05.4′	68°54.0′	302
TI-2	69°07.0′	68°50.5′	347
TI-3	69°11.5′	68°23.5′	487
TI-6	68°48.9′	66°05.4′	800
ITIRBILUNG			
IT-1	69°18.5′	69°10.0′	167
IT-2	69°20.5′	68°53.0′	320
IT-3	69°16.9′	68°22.0′	417
IT-4	69°10.0′	67°45.0′	303

*Seven maps showing the locations of the grab sample stations are given in Schafer, 1983.

APPENDIX 2. Reference list for important indicator species discussed in this report

Adercotryma glomerata (Brady) = *Lituola glomerata* Brady, 1878, Ann. Mag. Nat. Hist., ser. 5, v. 1, p. 433, Pl. 20, figs. la-c.
Loeblich & Tappan, 1953, Smithson. Mis. Coll. v. 121(7), p. 26, Pl. 8, figs. 1-4.*
Astrononion gallowayi Loeblich & Tappan, 1953, Smithson. Misc. Coll. v. 121(7), p. 90, Pl. 17, figs. 407.*
Bolivina pseudopunctata Höglund, 1947, Zool. Bidrag fran Uppsala, Bd. 26, p. 273, Pl. 24, fig. 5; Pl. 32, figs. 23, 24.
Feyling-Hansen, 1964, Norges Geol. Undersokelse, NR225, p. 319, Pl. 16, fig. 7.*
Buccella frigida (Cushman) = *Pulvinulina frigida* Cushman, 1922, Contr. Canadian Biol., no. 9, p. 12 (144).
Loeblich & Tappan, 1953, Smithson. Misc. Coll. v. 121(7), p. 115, Pl. 22, figs. 2.*
Buliminella elegantissima (d'Orbigny) = *Bulimina elegantissima* d'Orbigny, 1839, Voy. dans l'Amer. merid., Foram., v. 5, pt. 5, p. 51, Pl. 7, figs. 13, 14.
Parker, Frances, 1952, Bull. Mus. Comp. Zool., v. 106(9), p. 416, Pl. 5, figs. 27, 28.*
Cassidulina reniforme Norvang = *Cassidulina crassa reniforme* Norvang, 1945, Zool. of Iceland, Foram. v. 2(2), p. 41.
Rodrigues, Hooper & Jones, 1980, J. Foram. Res., v. 10(1), p. 50; Pl. 2, figs. 2, 4, 6; Pl. 3, figs. 3, 6, 9, 11, 12; Pl. 5, figs. 10-12.*
Cibicides lobatulus (Walker & Jacob) = *Nautilus lobatulus* — Walker & Jacob, 1798, *in* Adam's Essays on the Microscope, p. 642, Pl. 14, fig. 36.
Cushman, 1931, U.S.N.M. Bull., v. 104(B), p. 118k, Pl. 21, fig. 3.*
Elphidium excavatum forma clavata Cushman = *Elphidium incertum* var. *clavatum* Cushman, 1930, U.S.N.M. Bull. 104, p. 20, Pl. 7, fig. 10a, b.
Miller, Scott & Medioli, 1982, J. Foram. Res., v. 12(2), p. 125, Pl. 1, figs. 5-8; Pl. 2, figs. 3-8; Pl. 3, figs. 3-8, Pl. 4, figs. 1-6; Pl. 5, figs. 4-14; Pl. 6, figs. 1-5.*
Eoeponidella pulchella (Parker) = *Pninanaella?pulchella*—F. Parker, 1952, Bull. Mus. Comp. Zool., v. 106(9), p. 420, Pl. 6, figs. 18-20.
Haman, 1973, Micropaleo, v. 19(1), p. 101-103.*
Fursenkoina fusiformis (Williamson) = *Bulimina pupoides* fusiformis — Williamson, 1858, Rec. Foram. Great Britain, p. 63, Pl. 5, figs. 129, 130.
Loeblich & Tappan, 1964 Treatise on Invert. Paleo., Protista 2(2) 732, 733.*
Haynesina germanica (Ehrenberg) = *Nonionina germanica* Ehrenberg, 1840, k. Preuss. Akad. Wiss. Berlin, Ber., p. 23.
Banner & Culver, 1978, J. Foram. Res. v. 8(3), p. 191, Pl. 4, figs. 1-6; Pl. 5, figs. 1-8; Pl. 6, figs. 1-7; Pl. 7, figs. 1-6; Pl. 8, figs. 1-10; Pl. 9, figs. 1-11, 15, 18.
islandiella helenae Feyling-Hanssen & Buzas, 1976, J. Foram. Res., v. 6(2), p. 155, 156.*
Melonis zaandamae (van Voorthuysen) — *Anomalinoides barleeanum* var. *zaandamae* van Voorthuysen, 1952 (new name) J. Paleo, v. 26, no. 4, p. 681.
Loeblich & Tappan, 1953, Smithson. Misc. Coll. v. 121(7), p. 87, Pl. 16, figs. 11, 12.*
Neogloboquadrina pachyderma (Ehrenberg) = *Aristospira pachyderma* Ehrenberg, 1861, K. Akad. Wiss. Verlin, Monatsber., p. 266, 277, 303.
Rögl & Bolli, 1972, DSDP Report, v. 15, #13, p. 571, Pl. 10, figs. 11-22; Pl. 16, figs. 10, 11.
Nonionella atlantica Cushman, 1947, Contr. Cushman Lab. Foram. Res., v. 23(4), p. 90, Pl. 20, figs. 4, 5.
Parker, Phleger, & Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 11, Pl. 3, figs. 30, 31.*
Nonionellina labradorica (Dawson) — *Nonionina labradorica* Dawson, 1860, Can. Nat., v. 5, p. 191, fig. 4.
Loeblich & Tappan, 1953, Smithson. Misc. Coll. v. 121(7), p. 86, Pl. 17, figs. 1, 2.*
Protelphidium nanum Vilks, 1979, *in* Vilks *et al.*, Geol. Surv. Can., Bull. 303, pp. 34, 35; Pl. 1, figs. 1-4.*
Protelphidium orbiculare (Brady) = *Nonionina orbicularis* Brady, 1881, Ann. Mag. Nat. Hist., Ser. 5, v. 8, p. 415, Pl. 21, fig. 5.
Loeblich & Tappan, 1953, Smithson. Misc. Coll. v. 121(7), p. 102, Pl. 19, figs. 1-4.
Pyrgo williamsoni (Silvestri) = *Biloculina williamsoni* Silvestri 1923, Atti Accad. Pont. Romano Nuovi Lincei, v. 76, p. 73.*
Reophax arctica Brady, 1881, K. Akad. Wiss. Wien, moth-naturw. Cl., Denkschr., Wien, Osterreich, Bd. 43, Abth. 2, p. 99, Pl. 2, fig. 2.
Loeblich & Tappan, 1953, Smithson. Misc. Coll. v. 121(7), p. 21, Pl. 1, figs. 19, 20.*
Spiroplectammina biformis (Parker & Jones) = *Textularia agglutinans biformis* Parker & Jones, 1865, Philosoph. Trans. Roy. Soc., v. 155, p. 370, Pl. 15, figs. 23, 24.*
Stainforthia concava (Höglund) = *Virgulina concavas* Höglund, 1947, Zool. Bidr. Uppsala, Bd. 26, p. 257, Pl. 23, figs. 3, 4; Pl. 32, figs. 4-7; tf. 273-275.
Loeblich & Tappan, 1964, Treatise on Invert. Paleo., Protista 2(2) C561.*
Stetsonia horvathi Green, 1958, USAF Cambridge Res. Centre, Geophys. Res. Paper No. 63, v. I, p. 79, Pl. 1, figs. 6a-b.*
Textularia earlandi Phleger, 1952, Contr. Cushman Found. Foram. Res., v. 3, p. 86, Pl. 13, figs. 22, 23.
Feyling-Hanssen, 1964, Norges Geologiske Undersokelse, NR 225, p. 238, Pl. 3, figs. 9, 10.*
Trifurina fluens (Todd) = *Angulogerina fluens* Todd, in Cushman & McCulloch, 1940, S. Calif. Univ. Publ., Allan Hancock Exped., v. 6(5), p. 288, Pl. 36, fig. 1.
Loeblich & Tappan, 1964, Treatise on Invert. Paleo., Protista 2(2) C571.*
Triloculina oblonga (Montagu) — *Vermiculum oblongum* Montagu, 1803, Test. Brit., pt. 2, p. 522, Pl. 14, fig. 9.
Feyling-Hanssen, 1964, Norges Geol. Undersokelse, NR. 225, p. 257, Pl. 6, figs. 9, 10.*
Trochammina nana (Brady) Cushman, 1920, U.S. National Museum Bulletin 104, pt. 2, p. 80, Pl. 17, fig. 1.

THECAMOEBIANS

General Reference — Medioli & Scott, 1983, Cushman Found. Foram. Res., Spec. Publ. 21.
Pontigulasia compressa (Carter) — Todd and Bronnimann (1957), p. 21, Pl. 1, fig. 5; Scott *et al.*, 1977, Canadian Journal of Earth Sciences 14, p. 1581, Pl. 1, figs. 3, 6.

*Specimens observed living (i.e., stained).

REFERENCES

ALBRIGHT, L.J., and STROH, E.M.D. 1983. Heterotrophic bacterial dynamics within waters and surficial sediments of several Canadian eastern arctic fiords. Data Report, Hydrography and Ocean Sciences, No. 12. Chapter 6. 13 p.

ANDERSON, J.B. 1972. Nearshore Glacial-Marine Deposition from Modern Sediments of The Weddell Sea. Nature Physical Science 240:189-192.

ASPREY, K.W., BISHOP, P., BLAKENEY, C., LEBLANC, W., SYVITSKI, J.P., and WINTERS, G. 1983. SAFE: 1982 suspended particulate matter data. Data Report, Hydrography and Ocean Sciences, No. 12. Chapter 5. 30 p.

BONHAM-CARTER, G.F. 1967. Fortran IV program for Q-mode cluster analysis of non-quantitative data using IBM 7090/7094 computers. Computer Contribution No. 17, State Geological Survey, Lawrence, Kansas. 13 p.

CLATTENBURG, D., COLE, F.E., KELLY, B., LEBLANC, W., BISHOP, P., RASHID, M.A., SCHAFER, C.T., and SYVITSKI, J.P.M. 1983. SAFE: 1982 bottom grab samples. Data Report, Hydrography and Ocean Sciences, No. 12. Chapter 8. 94 p.

ELVERHØI, A., LIESTOL, O., and NAGY, J. 1980. Glacial erosion, sedimentation and microfauna in the inner part of Kongsfjorden, Spitsbergen. Saertrykk av Norsk Polarinstitutt, Skrifter No. 172:33-61.

GIBSON, T.G., and WALKER, W.M. 1967. Flotation methods for obtaining foraminifera from sediment samples. Journal of Paleontology 41:1294-1297.

GILBERT, R., and MACLEAN, B. 1983. Geophysical studies based on conventional shallow and Huntec high resolution seismic surveys of fjords on Baffin Island. Data Report, Hydrography and Ocean Sciences, No. 12. Chapter 15. 90 p.

NIE, H., HULL, C.H., JENKINS, J.G., STEINBRENNER, K., and BENT, D.H. 1975. Statistical package for the social sciences. New York: McGraw Hill Inc. 675 p.

SCHAFER, C.T. 1983. Introduction. SAFE: HU-82-031 Data Report, Hydrography and Ocean Sciences No. 12:1-14.

——— and COLE, F.E. 1977. Distribution of foraminifera in Chaleur Bay, Gulf of St. Lawrence. Geological Survey of Canada, Paper 77-30. 55 p.

SYVITSKI, J.P.M., and SCHAFER, C.T. 1984. Introduction, CDRHOS28; Geological Survey of Canada, Open File Report No. 1122. Chapter 1. 25 p.

SYVITSKI, J.P.M., FARROW, G.E., TAYLOR, R., GILBERT, R., and EMORY-MOORE, M. 1984. SAFE: 1983 delta survey report. Data Report, Hydrography and Ocean Sciences No. 28. Chapter 18. 39 p.

THOMAS, F., and SCHAFER, C.T. 1982. Distribution and transport of some common foraminiferal species in the Minas Basin, eastern Canada. Journal of Foraminiferal Research 12:24-38.

TRITES, W.M., HAY, A.E., and PETRIE, W.M. 1983. Synoptic oceanography. Data Report. Hydrography and Ocean Sciences No. 12. Chapter 2. 129 p.

VILKS, G., and RASHID, M.A. 1976. Post-glacial paleo-oceanography of Emerald Basin, Scotian Shelf. Canadian Journal of Earth Sciences 9:1256-1267.

WALKER, D.A., LINTON, A.E., and SCHAFER, C.T. 1974. Sudan Black B. A superior stain to Rose Bengal for distinguishing living from non-living foraminiferal. Journal of Foraminiferal Research 4:205-215.