LATE PLEISTOCENE-HOLOCENE PALEOCEANOGRAPHY
OF THE NORTHEAST NEWFOUNDLAND SHELF;
BENTHONIC FORAMINIFERAL EVIDENCE

by

Kevin G.MacNeil

A Thesis submitted to the Department of Geology,
Dalhousie University, in partial fulfillment of the
requirement for the Honours Bachelor of Science degree

March,1986

DALHOUSIE UNIVERSITY
Department of Geology
Halifax, N.S. Canada B3H 3J5 Telephone (902) 424-2358 Telex: 019-21863

DALHOUSIE UNIVERSITY, DEPARTMENT OF GEOLOGY

B.Sc. HONOURS THESIS

Author: Kevin G. MacNeil

Title: Late Pleistocene-Holocene Paleoceanography of the Northeast Newfoundland Shelf; Benthonic Foraminiferal Evidence.

Signature of author

Date: 10/04/86

Distribution License

DalSpace requires agreement to this non-exclusive distribution license before your item can appear on DalSpace.

NON-EXCLUSIVE DISTRIBUTION LICENSE

You (the author(s) or copyright owner) grant to Dalhousie University the non-exclusive right to reproduce and distribute your submission worldwide in any medium.

You agree that Dalhousie University may, without changing the content, reformat the submission for the purpose of preservation.

You also agree that Dalhousie University may keep more than one copy of this submission for purposes of security, back-up and preservation.

You agree that the submission is your original work, and that you have the right to grant the rights contained in this license. You also agree that your submission does not, to the best of your knowledge, infringe upon anyone's copyright.

If the submission contains material for which you do not hold copyright, you agree that you have obtained the unrestricted permission of the copyright owner to grant Dalhousie University the rights required by this license, and that such third-party owned material is clearly identified and acknowledged within the text or content of the submission.

If the submission is based upon work that has been sponsored or supported by an agency or organization other than Dalhousie University, you assert that you have fulfilled any right of review or other obligations required by such contract or agreement.

Dalhousie University will clearly identify your name(s) as the author(s) or owner(s) of the submission, and will not make any alteration to the content of the files that you have submitted.

If you have questions regarding this license please contact the repository manager at dalspace@dal.ca.

Grant the distribution license by signing and dating below.

Name of signatory	Date

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

Page

ABSTRACT: A micropaleontological study based on benthonic foraminifera was made of seventy-one samples from core 80-030-26(Gravity and Piston) taken at a water depth of 267 m in outer Notre Dame Bay, northeast Newfoundland Shelf. The data obtained were compared with the pollen data from the gravity core and piston core top. These results were correlated with those from previous work on the northeast Newfoundland Shelf.

Late Pleistocene paleoceanography until 10, 000 years BP was characterised by an Elphidium excavatum f. clavata-Cassidulina reniforme "warm" ice margin fauna, interrupted in early postglacial time by an important local meltwater input event. Substantial bottom water cooling occurred at the base of the Holocene as indicated by abundance of agglutinated forms, followed by a gradual warming indicated by the abundance of warmer water calcareous fauna from 5000-7000 years BP. There has been a marked cooling in the last 2500 years represented by the presence of an exclusively agglutinated assemblage at the core surface.

Bottom water temperatures on the inner northeast Newfoundland Shelf are colder now than at any time since the last deglaciation. Temperature gradients on the eastern Canadian continental margin have been increasing in the last 2500 years, possibly representing a cold pre-glacial phase providing conditions for the onset of a glacial stage.

ACKNOWLEDGEMENTS

I extend special thanks to my supervisor, Dr.D.B.Scott, for his time, effort and guidance throughout the progress of this study. I appreciate the efforts of Chloe Younger in assistance with core sampling and processing procedures, and of Bhan Deonarine at the Bedford Institute of Oceanography for the SEM preparations and photography. Thanks are also due to F.S.Medioli, P.Mudie, K.MacKinnon and V.Baki for their interest and advice, as well as J.MacPherson (Memorial University) for providing pollen data and interpretations, and the captain and crew of the C.S.S. Dawson for their efforts in core collection.

INTRODUCTION: One of the most useful microfossil types used for paleoceanographic study is a variety of unicellular marine organisms known as foraminifera. These testate rhizopods range in size from a few hundredths of a mm. to a few cm. (Brown, 1970), and secrete a test which is calcareous, porcellaneous or agglutinated (made up of foreign clastic fragments cemented organically).

Foraminifera are divided into two main groups based on position in the water column; the planktonic forms which live suspended at or near the water surface, and the benthonic forms which live on or directly above the bottom sediments. Distribution is controlled by restriction to a certain range of environmental conditions such as temperature, salinity, turbidity, and in the case of benthonic foraminifera, sediment type. Planktonic forms are distributed globally but largely confined to the open ocean and restricted by salinity, nutrient availability and temperature (which is largely a function of latitude). The distribution of individual benthonic species, however, is generally more restricted due to a greater complexity of environmental variables, although they occupy all marine niches.

The restriction in distribution of many benthonic species is the main reason for their usefulness as accurate environmental indicators. In areas of adequate conditions and sedimentation rate, foraminiferal abundances can be maintained and a high proportion of shells preserved by sediment cover provided that deposition is continuous. In this manner, a record of bottom water conditions through time can be preserved in the depositional sequence, and by the observation of foraminiferal fauna changes down a sediment core, reconstruction of the regional paleoceanography is possible.

The Notre Dame Channel basin on the Newfoundland Shelf is a sediment trap in which the high sedimentation rate results in an expanded late glacial-postglacial record (Fig. 1). The purpose of this work on Notre Dame Bay core 80-030-26(G and P) is to interpret the data obtained in comparison with data from core 78-023-20 from Notre Dame Channel (Scott et. al., 1984) and core 83-033-07 farther offshore (Miller et. al., 1985) to produce a Late Pleistocene-Holocene paleoceanographic reconstruction for the northeast Newfoundland Shelf.

PREVIOUS WORK: Detailed seismic and sedimentological study on the Newfoundland Shelf was done by Dale and Haworth (1979). Oceanographic studies dealing with the Labrador Current have been carried out by Sutcliffe et. al. (1976) and Lazier (1982). Determinations of the present outer Labrador Current fauna were made by Vilks (1981), Mudie et. al. (1984) and of the inner Labrador Current fauna by Vilks et. al. (1984).

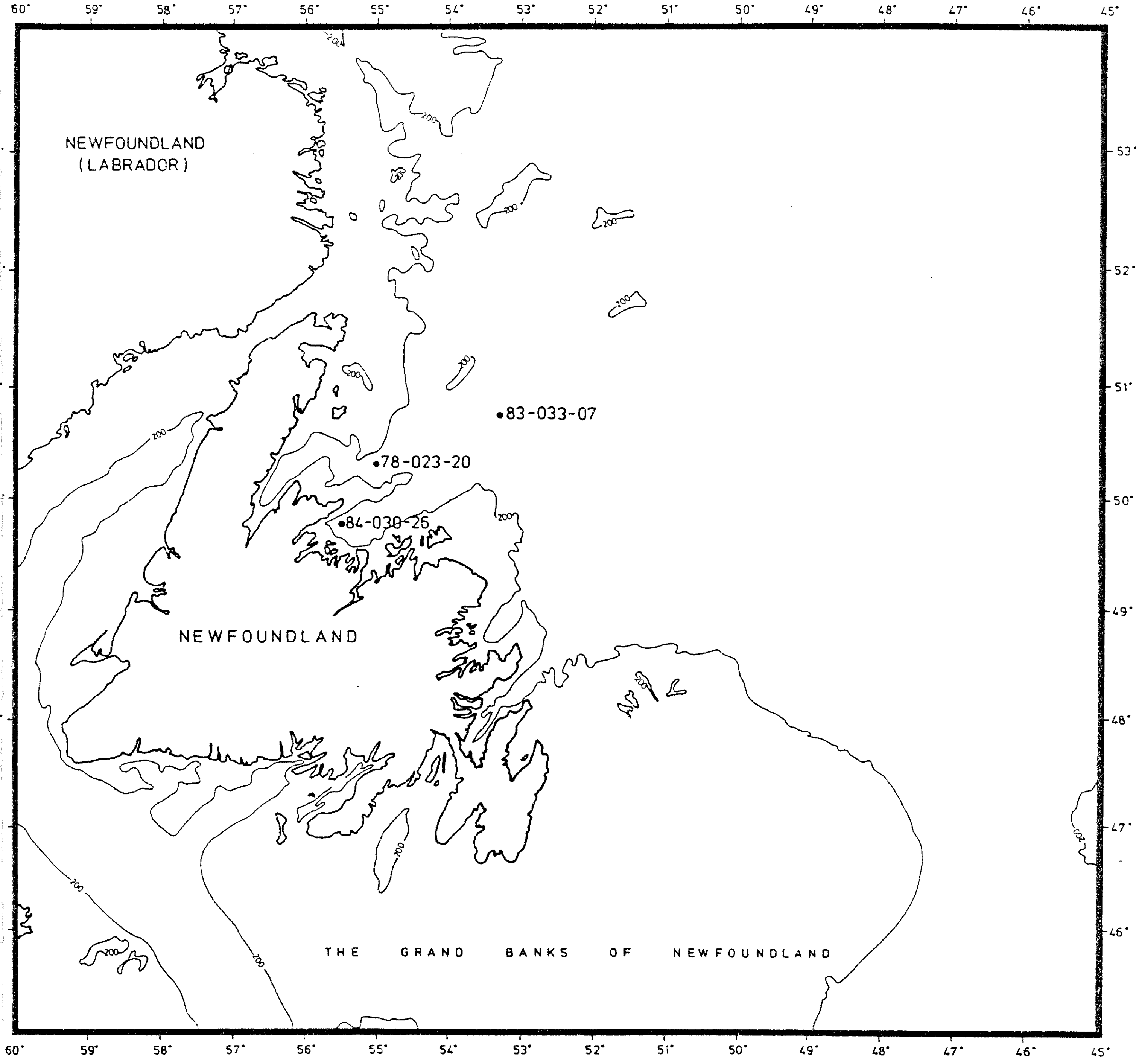


Figure 1: Regional map of the Newfoundland Shelf indicating the three comparison core sites and general physiography. Note that core number 84-030-26 should read 80-030-26. Contours are in meters.

Important paleoceanographic studies on the northeast Newfoundland shelf were done on cores 78-023-20(G and P), (Scott _et. al._, 1984) taken in Notre Dame Channel and cores 83-033-07(G and P), (Miller _et. al._, 1985) collected just offshore of this location. These were an important source of information on regional paleoceanographic trends.

PHYSIOGRAPHY: The surficially uneven Newfoundland Shelf seafloor is characterised by central shelf basins of 200-400 meters water depth as well as outer shelf banks (Fig. 1). These glacially overdeepened basins are presently areas of relatively rapid deposition, while the shelf banks are covered with a veneer of coarse sands and gravels sorted postglacially by wave and tidal action (Scott _et. al._, 1984). High resolution seismic data indicate that the northeast Newfoundland shelf sediments are mainly glaciogenic and result from essentially uniform deposition, without the truncations typical of some other eastern Canadian continental shelf basins. The glacial till at the base of these sediments overlies bedrock throughout most of the northeast Newfoundland Shelf (Dale and Haworth, 1979).

OCEANOGRAPHY: The oceanography of the Newfoundland Shelf is dominated by the southward flowing Labrador Current (Fig. 2) which is separated at an approximate depth of 300 meters into the cold inner (0-3°C) and a warmer (2-4°C) outer Labrador Current

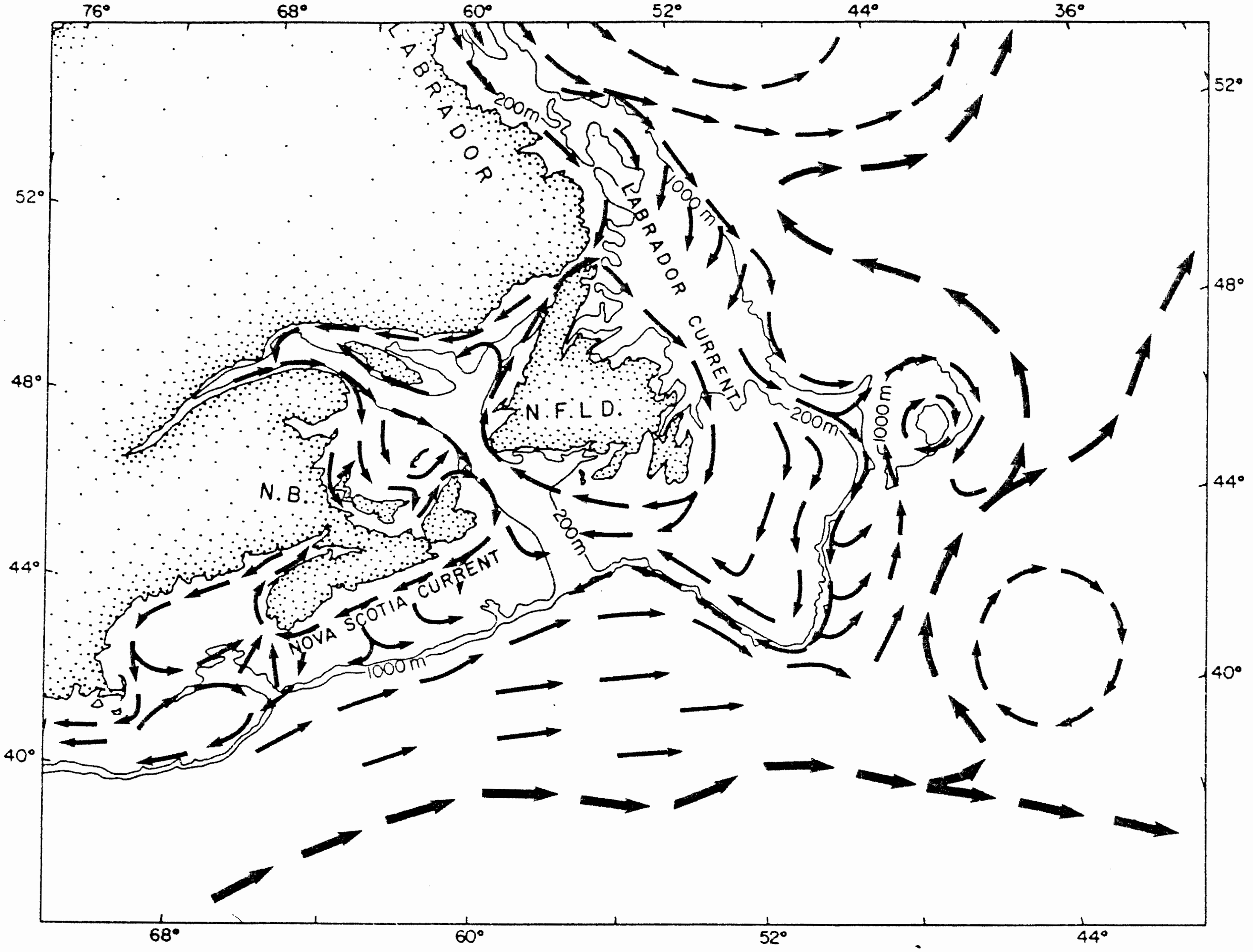


Figure 2: Modern surface oceanographic current patterns at present on the southeastern Canadian continental margin (after Scott et. al., 1984).

(Scott *et. al.*, 1984). The arctic Canada Current water from northern Baffin Bay mixes with the warmer West Greenland Current and a small but important cold Hudson Bay component in southern Baffin Bay to create the Labrador Current (Vilks, 1981). The subsurface core of this current flows along the outer Newfoundland Shelf at water depth of 600-800 m and is composed mainly of West Greenland Current water (Lazier, 1982) which is manifested on the shelf as the outer Labrador Current. The shallower inner Labrador Current is comprised of cold, lower salinity waters originating in northern Baffin Bay and Hudson Bay (Scott *et al*, 1984). There is a shallow shelf water variability in salinity primarily due to seasonal precipitation and fluvial runoff variations, and also a high seasonal surface temperature change due to substantial winter cooling (Scott *et al*, 1984).

METHODS: The site for the core studied was selected on the basis of high resolution seismic profiling, and cores 80-030-26(G and P) were subsequently collected by the Bedford Institute of Oceanography vessel *C.S.S. Dawson* at the northwest end of outer Notre Dame Bay, Newfoundland; Latitude 49.74^{o} North, Longitude 55.48^{o} West.

The cores were described with respect to sedimentology and color using Munsell soil color charts (see appendix for core description). With the aid of X-rays taken at B.I.O., sampling intervals were chosen based on sedimentological boundaries. A total of seventy-one 10 c c samples were taken at approximately 10 centimeter intervals as sedimentology permitted, eight from the 59 cm. gravity core and sixty-three from the 557 cm. piston core. These samples were wet-seived through 0.5 mm.(no.35 mesh) and 0.063 mm.(no.230 mesh) stainless steel seives, retaining the greater than 63 micron fraction. A large proportion of these were decanted to remove high numbers of diatoms, and the decants were observed to ensure that no foraminifera had been removed. All of the gravity core samples and fifty-eight of the piston core samples were oven-dried, and subsequently the foraminifera were separated from the sandy sediments by heavy liquid floatation using Carbon Tetrachloride (specific gravity 1.58) with paper filters. The five wet samples were stored in a mixture of denatured alcohol and distilled water. Depending on total numbers of specimens, most floated samples were split into quarters (some into halves or eighths) using an "otto" microsplitter. This was done to reduce numbers to reasonable counting units. The samples were counted for foraminifera using a Zeiss binocular microscope at 40X magnification, and for each sample total numbers and also numbers and percentages of total for each species were calculated and tabulated.

A key slide was compiled as a representation of the thirty-seven benthonic foraminiferal species encountered, and scanning electron micrographs of thirteen key species were taken at B.I.O. using a Cambridge Stereoscan 180

S.E.M. with Polaroid 55N/P film.

RESULTS: Core 80-030-26 displays a sedimentary sequence from silty clays at the top into laminated clays at the bottom, underlain by a poorly sorted gravelly unit(which was initially interpreted as glacial till), and represents a complete late glacial-postglacial depositional record (see appendix for core description).

Foraminifera: The base of core 80-030-26P is a poorly sorted gravelly deposit from 5.57 to 5.42msb which contains a co-dominant Cassidulina reniforme-Epistominella takayanagii fauna (Fig. 3, Table II) which is not observed in abundance anywhere else on the eastern Canadian continental shelf. Directly above this deposit at 5.4msb is a C. reniforme dominated assemblage with minor Fursenkoina fusiformis. There is an abrupt change to a totally barren zone from 5.4 to 5.22msb which indicates high sedimentation rate. Co-dominance of C. reniforme and Elphidium excavatum f.clavatum occurs from 5.22 to 4.9msb, followed by alternating dominant trends of C. reniforme from 4.9 to 4.65msb, E. excavatum with minor Spiroplectammina biformis from 4.65 to 4.35msb, C. reniforme from 4.35 to 4.25msb and finally E. excavatum along with minor Nonionellina labradorica in the 4.25 to 4.05msb interval. The fauna from 4.05 to 2.85msb is characterised by co-dominant C. reniforme-E. excavatum, and to a lesser extent F. fusiformis, with minor Islandiella teretis and agglutinated

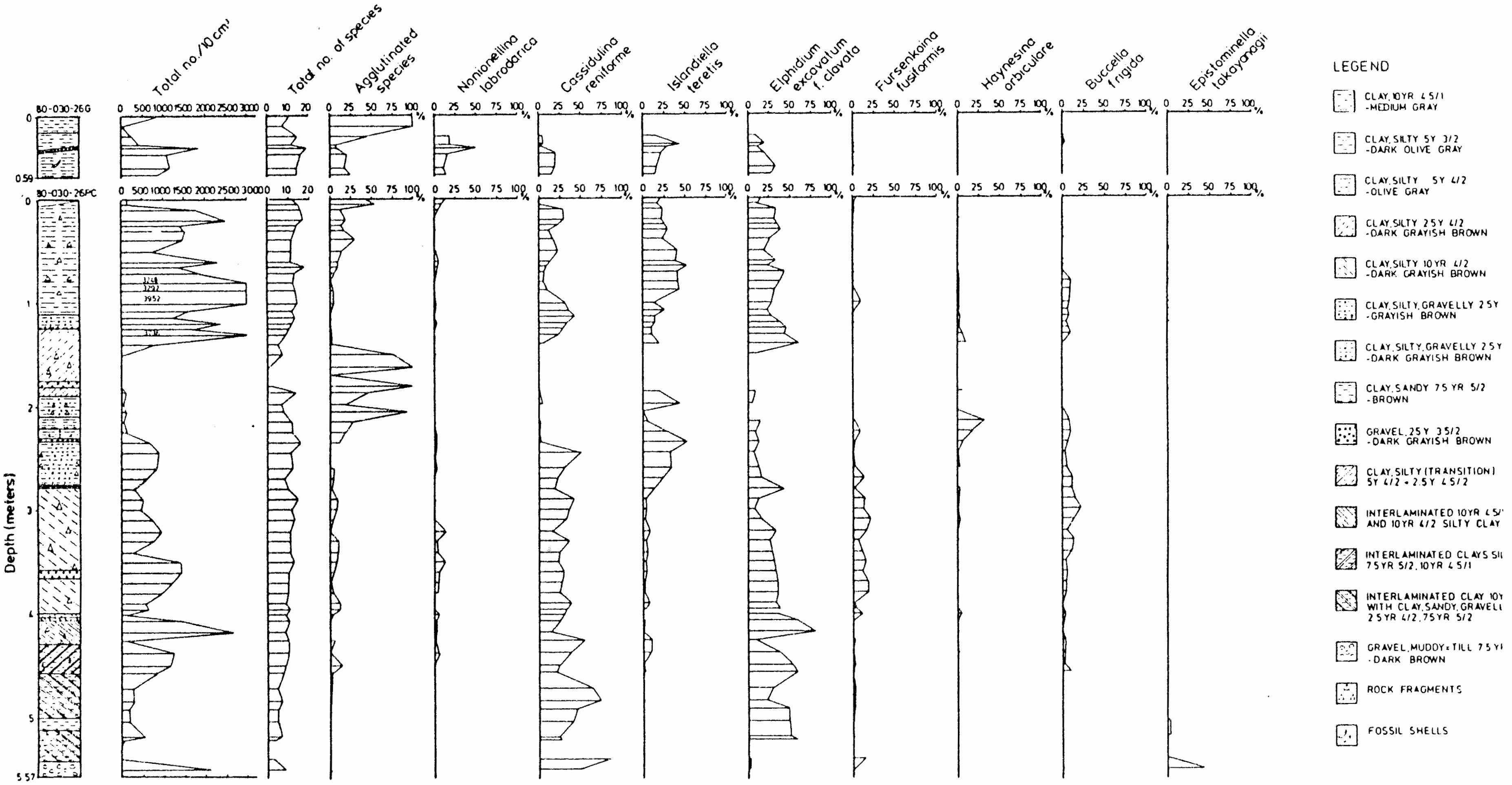


Figure 3: Foraminiferal abundances and percentage occurences of key species in core 80-030-26G(gravity core) and P(piston core), northwest end of outer Notre Dame Bay. Dots on columns represent percentages less than 1%.

Depth in Core (cm.)	0	10	20	28	31	37	50	57	0	5	10	20	25	30	39	50	60	65	71	80	88	101	108	114	120	125	131	140	150	162	170	180	186	198	205	215
Number of Species	11	7	15	11	19	16	14	14	11	15	16	17	14	13	11	11	11	18	13	12	13	14	12	13	12	10	9	5	7	1	0	2	14	7	8	12
No. of Individuals/10cc	1029	36	257	414	1847	1087	1162	871	110	131	1773	2494	1399	1528	1462	722	2306	1348	1872	3248	3292	3952	1560	1201	2390	1680	3736	808	30	3	0	3	136	22	98	48
Adercotryma glomerata	34	50	22	5	2	12	9	10	21	19	4	x		x					x										7							
Ammotium cassis	x	3								x			x																							
Brizaline pseudopunctata							x				x	x			x	x	x	x	x		x	x	x		x	x							1			
Buccella frigida			x	3	1		x					x		x	x		1	x	x	10	9	8	7	8	4	6	10	2					x		1	8
Cassidulina reniforme			5	6	3	21	19	16	5	5	28	30	24	11	18	23	14	9	7	5	10	34	37	43	34	30	23	5					1	5		2
Cibicides lobatulus					x									x				x		x	x								7							6
Cribrostomoides crassimargo	2	3	x		x	x	1	1	5	5	x	x	x	x			x	x	x			x												9		
Cyclogyra involvens	x																																			
Eggerella advena	1		x			x	x			x		x																					x	5	63	4
Elphidium bartletti												x						x																		
E. excavatum f. clavatum			9	21	11	20	33	28	16	11	33	31	36	41	26	19	33	23	43	38	32	29	23	29	39	47	45	62	7				10	5		15
Eoeponidella pulchella			x																																	
Epistominella takayanagii					x						x	x	x			x		x		x		x	x	x	x								2			
Fursenkoina fusiformis				x	x	2	2	x	4	2	2	x	x		x	x		x	x	x	2	9	3	x	x	x										2
Globobulimina auriculata					x	x		x																												
G. pacifica					x								x																							
Gyroidina soldanii																																				
Haynesina orbiculare												x						x	x	2	1	2	2	4	2	2	7	10					7		1	33
Islandiella teretis			14	44	28	22	17	15	22	17	23	22	27	29	24	42	38	54	41	42	44	14	26	14	14	10	12	20					19	45	1	6
Lagena spp.											x																									
Miliolina spp.																																				
Nonion barleeanum																																				
Nonionellina labradorica			19	19	51	17	11	15	14	9	6	x	x	x	x	2	5	4	3	1	x	1	x	x	4	1	x		3							
Quinqueloculina seminulum																					x	x	x	x	1		x		7				12	27	2	
Recurvoides turbinatus	1	8																																		
Reophax arctica	10		5		x	x	1	1	2	5	x	13	6	12	23	10	5	5	x					x					7				2			
R. fusiformis									x		x																									
R. nodulosa																																	13			
R. scotti	1									x		1	2	7	3	2	x	1																		
Saccammina difflugiformis		8	2		x	x		x			x						x																			
Spiroplectammina biformis	30	19	8	x	x	1	2	3	11	16	x	x	x	1	x	x		x	x	x	x	x	x	x		x	x					33	15		6	10
Textularia torquata	20	8	7	x	x	3	3	9	x	5	2	1	2	2	4	x	2	x	1	x	x	x			x	x	x						13		11	8
Trifarina fluens			5	x	x	x				4	x							x						x	x											
Triloculina trihedra																																				
Trochammina lobata																																			14	2
T. nana																													63	100		67		5		2
T. ochracea	x				x	x		x		2				x							x	x						x					1			
Planktonics			2	x	x	x	x	x					x	x				x	x	x			x	x												

Table I: Percentage occurences of foraminiferal species in core 80-030-26G and P, Notre Dame Bay. X = less than 1%; 26G, 0-57 cm; 26P, 0-215 cm.

Depth in Core (cm.)	225	235	245	260	270	280	290	300	310	321	330	341	350	360	370	380	390	396	401	407	416	426	436	450	457	472	484	492.5	504	516.5	522	528.5	535	540	550
Number of Species	12	16	11	12	8	10	15	11	13	11	11	11	13	10	10	10	9	11	9	11	6	10	10	9	8	5	7	5	5	7	3	0	0	3	9
No. of Individuals/10cc	103	682	879	840	620	306	515	456	755	979	764	257	1413	1420	1204	980	593	643	65	1456	2060	146	1267	1190	872	264	304	183	200	573	48	0	0	31	2134
Adercotryma glomerata																																			
Ammotium cassis																																			
Brizalina pseudopunctata																																			
Buccella frigida	10	7	3	5	12	12	14	22	13	6	13	11	4	7	5	5	1	x	4	3	x	4	3	2	10										1
Cassidulina reniforme	x	4	52	30	23	19	43	37	33	17	37	25	24	31	29	25	39	34	32	27	15	55	38	25	21	64	73	46	42	24	29			64	45
Cibicides lobatulus							x																												
Cribrostomoides crassimargo																			2																
Cyclogyra involvens		x																		x								2							x
Eggerella advena	x																																		
Elphidium bartletti																																			
E. excavatum f. clavatum	8	13	6	13	17	44	12	9	17	34	26	29	32	34	37	37	33	39	36	58	82	10	39	54	59	30	23	50	49	50	58			3	x
Eoeponidella pulchella																																			
Epistominella takayanagii																													3	4					43
Fursenkoina fusiformis	9	3	2	3	14	2	14	13	22	16	6	12	15	11	19	19	2	5	11	2		3	x	2	x	3	1	1	x	x				13	2
Globobulimina auriculata									x																										
G. pacifica		x																																	
Gyroidina soldanii																																			
Haynesina orbiculare	17	6	x	3		3	2	2	4	2	x	x	x	x				x	5	x	x		x												
Islandiella teretis	27	53	32	33	24	14	4	7	3	8	4	6	4	5	1	2	9	4		2	x	11	10	x	3		x			x					
Lagena spp.																																			
Miliolina spp.																																			1
Nonion barleeanum			x																																
Nonionellina labradorica	2	2	x	3	x		1		1	15	3	5	13	6	6	5		1	7	3	2	2	6	x											
Quinqueloculina seminulum	10	2	x	2	5	3	2	3	x	x	x	2	x	x	x	1	3	2		3	x	9	1	x			x			2					
Recurvoides turbinatus																																			
Reophax arctica							x						x																						
R. fusiformis																																			
R. nodulosa																																			
R. scotti		x					x																												
Saccammina difflugiformis							x	x																											
Spiroplectammina biformis	3	6		3	5	1	4	6	3	x	7	8	6	4	1	4	12	12	1	x		5	x	15	2	2	x	x							
Textularia torquata	8	2		x		x		x	x	x	x	x	x				x					x													
Trifarina fluens			x																																
Triloculina trihedra																													7	19	13				
Trochammina lobata	6																																		1
T. nana		x																																	
T. ochracea		x		2			2		x		3	2	x	1	x	x		x							x										
Planktonics		x	2	x		x	x	x	x	x			x		x	x	x	2	2	x	x		1	x	4	2	1								1

Table II: Percentage occurences of foraminiferal species in core 80-030-26P, Notre Dame Bay. X = less than 1%; 26P, 225-550 cm.

species (also N. labradorica from 3.8 to 3.1msb).

From 2.85 to 2.4msb, the fauna changes to one co-dominated by C. reniforme, E. excavatum and I. teretis with minor F. fusiformis and reduced levels of E. excavatum from 2.6 to 2.4msb. This is followed by a change in dominance to I. teretis from 2.4 to 2.25msb with a corresponding drop in C. reniforme numbers while other species remain essentially the same. Important at the end of this interval is the reduction of I. teretis with the emergence of minor Haynesina orbiculare (a shallow estuarine indicator) and the agglutinated species S. biformis, Textularia torquata and Trochammina lobata indicative of a change to colder, less saline water (Fig. 3, Table I). H. orbiculare is abundant from 2.25 to 2.1msb where it is co-dominant with the agglutinated species as above with the addition of Eggerella advena, (deeper estuarine indicator, Scott et. al., 1980).

From 2.1 to 2.0msb the fauna is dominated by E. advena with minor I. teretis and is marked by the disappearance of H. orbiculare, possibly indicating a gradual change to a slightly more saline deep estuarine environment. Dominance of I. teretis is observed from 2.0 to 1.9msb with diminishing E. advena and the appearance of minor E. excavatum, C. reniforme and Trochammina nana. Agglutinated species dominate the 1.9 to 1.5msb interval characterised by very low species and individual abundances. At 1.86msb, I. teretis is co-dominant with the agglutinated species Reophax nodulosa, S. biformis and T. torquata. T. nana is co-dominant with S. biformis at 1.8msb where only three individuals are present, and at 1.7msb the sediments are barren of foraminifera. At 1.62msb only T. nana is represented as three individuals, and is also dominant at 1.5msb with other species beginning to increase in abundance. A return of E. excavatum dominance occurs at the 1.5 to 1.25msb interval and is marked by the subsequent return of minor C. reniforme, I. teretis and H. orbiculare. There is co-dominance from 1.25 to 0.1msb of E. excavatum, C. reniforme and I. teretis (also Reophax arctica from 0.6 to 0.1msb) with very reduced C. reniforme from 0.9 to 0.6msb. The top of the piston core from 0.1msb to surface has a codominant agglutinated Adercotryma glomerata-S. biformis fauna with increasing N. labradorica.

The gravity core bottom fauna is characterised by the piston core top species with overall codominance but reduced S. biformis and a reappearance of C. reniforme. Above this fauna from 0.35 to 0.2msb is a codominant N. labradorica-I. teretis one, with all other species diminished and a resurgence of A. glomerata late in the interval.

The top of the gravity core from 0.2msb to surface contains an exclusively agglutinated assemblage co-dominated by A. glomerata, S. biformis and T. torquata.

A section equivalent to somewhat more than the length of the gravity core (59cm.) is missing from the piston core top as evidenced by the lack of abundant *N. labradorica* which is prominent through the lower part of the gravity core and increasing slightly at the base (Fig. 3).

DISCUSSION: Glacier front deposits in Spitsbergen dominated by *C. reniforme* were described by Elverhoi *et. al.* (1980), with those deposits closest to the glacier front being poorly sorted with a high average grainsize. This is similar to the poorly sorted till-like sediments at the bottom of core 80-030-26P, the site of a codominant *C. reniforme*-*E. takayanagii* assemblage. *E. takayanagii* has been previously observed in significant abundances only in Pleistocene glacial sediments from D.S.D.P. site 613 at 2200 meters depth off the New Jersey coast (Scott, in press) to which there is no known modern analogue. The barren zone directly above this and also the one at 1.7msb are probably due to excessively high sedimentation rates for foraminiferal abundance. The *E. excavatum*-*C. reniforme* fauna from 5.22 to 2.85msb with the warmer water indicator *N. labradorica* present at many intervals represents the "warm" ice margin Pleistocene fauna described by Scott *et. al.* (1984) and as "Unit 5" by Miller *et. al.*(1985).

Above this assemblage the co-dominance of *I. teretis* with *C. reniforme* indicates a slight rise in salinity, possibly due to a reduction in meltwater input. The rapid faunal changes characterising the interval from 2.4 to

1.9msb are interpreted as a major change in sedimentation rate and salinity due to dynamic fluctuations in glacial meltwater runoff to inshore shelf areas proximal to the glacial ice front in early postglacial times. The bottom of this interval exhibits an abrupt change to estuarine conditions represented by the E. advena-H. orbiculare faunas which indicate high influx of low salinity meltwater due to rapid proximal glacial ablation, resulting locally in a meltwater dominated basin. This effect is dissipated offshore with increasing distance from the meltwater source due to more efficient mixing and higher salinity of the open shelf waters. The resulting high sedimentation rates in part explain the low foraminiferal abundances. The presence of the shallow estuarine indicator H. orbiculare at depth is evidence for deep mixing of meltwater with the higher salinity basin water. The low diversity zone from 1.9 to 1.5msb dominated by agglutinated species represents a colder water mass probably characterised by abrupt changes in environmental conditions and sedimentation rate.

In the next interval the short return of the E. excavatum-C. reniforme fauna with codominant I. teretis is interpreted as a higher salinity "warm" ice margin fauna marking a very late Pleistocene cooling with slowing of meltwater input. Pollen are abundant in the gravity core and top of the piston core down to a depth of 70 cm., where pollen counts along with C. reniforme numbers are drastically reduced. This corresponds to a very early

Holocene horizon dating at approximately 9000-10,000 years BP (MacPherson, 1982). This horizon is seen in core 78-023-20P at a depth of 2 meters, indicating a substantially higher sedimentation rate in outer Notre Dame Channel than within Notre Dame Bay itself. This points to shelf area sediment movement rather than terrestrial runoff as the main sediment source for the entire Notre Dame Channel basin during the Holocene. The 70 cm. horizon also correlates approximately with the final disappearance of glacier ice from southeast Newfoundland between 10,000 and 9700 years BP (MacPherson, 1982).

The presence in abundance of the agglutinated form Reophax arctica from 0.6 to 0.1msb in the piston core indicates the presence of conditions similar to those of the present-day inner Labrador Current, corresponding to that described as early Holocene in core 78-023-20P by Scott et. al. (1984). The assemblage of A. glomerata, S. biformis and N. labradorica at the piston core top and gravity core base is similar to the early-mid Holocene "colder" outer Labrador Current fauna described by Scott et. al. (1984) and as a "Unit 4" fauna by Miller et. al. (1985), however the high agglutinated component represents either a lower salinity or colder bottom water mass at this time. The gravity core N. labradorica-I. teretis assemblage corresponds to the regional mid-Holocene outer Labrador Current warming event (Scott et. al. 1984) but with a high agglutinated component as in the fauna below it. The exclusively agglutinated assemblage at the gravity core top correlates well with the late Holocene inner Labrador Current fauna of Scott _et. al._ (1984) representative of substantial bottom water cooling on the inner Newfoundland Shelf over approximately the last 2500 years.

The greater abundance of agglutinated forms in Notre Dame Bay than on the main northeast Newfoundland Shelf throughout most of the Holocene indicates a local presence of consistently colder or lower salinity water due to postglacial bottom water cooling conditions which were not manifested on a regional scale. There is a large variability in environment as evidenced by rapid faunal changes in the late Pleistocene; this is indicative of the sensitivity of foraminifera to changes in bottom water conditions proximal to the centers of ice sheet growth. These variations are obscured in the depositional sequence farther out on the shelf due to greater distance from the ice front causing a reduction in influence of glacial fluctuation effects.

CONCLUSIONS: In summary the following points can be made;

- In the Late Pleistocene, deposition occurred proximal to the glacial front with abundant foraminifera, changing to a period of fast sedimentation producing barren deposits.
- The following interval was a long period of "warm" ice margin conditions, interrupted in early postglacial time by

a high meltwater runoff event. This resulted in estuarine conditions with high sedimentation rates inshore, the effects of which were dissipated offshore with increasing distance from the meltwater source due to greater mixing and higher salinity of the open shelf waters.

- The disappearance of the "warm" ice margin fauna with the emergence of abundant pollen represents the base of the Holocene, which appears at a shallower depth downcore in Notre Dame Bay than in outer Notre Dame Channel, indicating locally slower sedimentation due to a lack of substantial terrestrial sediment influx and large distance from the main sediment sources on the shelf banks.

- Substantial early Holocene cooling was followed by a gradual warming period peaking in the mid-Holocene.

- In the last 2500 years, significant bottom water cooling has taken place on the inner northeast Newfoundland Shelf, resulting in conditions colder than at any time since the last deglaciation.

- The Holocene faunas indicate consistently lower salinity and colder bottom water conditions in Notre Dame Bay than farther out on the shelf before 2500 years BP, followed by homogeneously cold inner shelf conditions until the present, possibly representing the presence of conditions conducive to a glacial onset.

SYSTEMATIC TAXONOMY:

The 37 benthonic species studied are listed here in alphabetical order with respect to genus. The genus names used here are in accordance with Loeblich and Tappan (1964).

Adercotryma glomerata (Brady)

Plate 1, Fig.5.

Lituola glomerata BRADY, 1878, v.1, p.433, pl.20, fig.1a-c.

Adercotryma glomerata (Brady). LOEBLICH and TAPPAN, 1953, v.121, p.26, pl.8, fig.1-4; WILLIAMSON, 1983, p.208, pl.1, fig.16.

Ammotium cassis (Parker)

Lituola cassis PARKER in DAWSON, 1870, p.177, fig.3.

Ammobaculites cassis (Parker). CUSHMAN, 1920, p.63, pl.12, fig.5.

Ammotium cassis (Parker). LOEBLICH and TAPPAN, 1953, p.33, pl.2., figs.12-18; WILLIAMSON, 1983, p.211, pl.2, fig.2.

Brizalina pseudopunctata (Hoeglund)

Bolivina pseudopunctata HOEGLUND, 1947, p.273, pl.24, fig.5, pl.32, figs. 23-24.

Buccella frigida (Cushman)

Plate 1, Figs.16,17.

Pulvinulina frigida CUSHMAN, 1922, p.12.

Eponides frigidus (Cushman). CUSHMAN, 1931, p.37, pl.9, figs.16-17.

Buccella frigida (Cushman). ANDERSON, 1952, p.144, figs.4-6; WILLIAMSON, 1983, p.223, pl.4, figs.4-5.

Cassidulina reniforme (Norvang)

Plate 1, Fig.2.

Cassidulina crassa reniforme NORVANG, 1945, p.41, tf.6e-h.

Cassidulina crassa d'Orbigny. SCOTT et al , 1980, p.226, pl.4, figs.1-2.

Cassidulina reniforme (Norvang). SEJRUP and GUIBAULT, 1980, pp.79-85, tf.1-3.

Cibicides lobatulus (Walker and Jacob)

Nautilus lobatulus WALKER and JACOB, 1798, p.642, pl.14, fig.36.

Cibicides lobatulus (Walker and Jacob). PARKER, 1952, p.427, pl.6, fig.26; WILLIAMSON, 1983, p.226, pl.4, figs.10-11.

Cribrostomoides crassimargo (Norman)

Haplophragmium crassimargo NORMAN, 1892, p.17.

Labrospira crassimargo (Norman). HOEGLUND, 1947, p.11, fig.1, text-figs. 121-125.

Cribrostomoides crassimargo (Norman). LESLIE, 1965, p.158, pl.2, fig.2a,b; WILLIAMSON, 1983, p.209, pl.1 figs.6-7.

Cyclogyra involvens (Reuss)

Operculina involvens REUSS, 1850, p.370, pl.46, fig.30.

Cyclogyra *involvens* (Reuss). LOEBLICH and TAPPAN, 1961, p.290.

Eggerella *advena* (Cushman)

Plate 1, Fig.9.

Verniulina *advena* CUSHMAN, 1922, p.141.

Eggerella *advena* (Cushman). Cushman, 1947, p.51, pl.5, figs.12-15; WILLIAMSON, 1983, p.214, pl.2 fig.3.

Elphidium *bartletti* (Cushman)

Elphidium *bartletti* CUSHMAN, 1933, p.4, pl.1, fig.9; WILLIAMSON, 1983, p.224, pl.5, fig.10.

Elphidium excavatum (Terquem) forma *clavata* Cushman

Plate 1, Fig.15.

Elphidium incertum (Williamson) var. *clavatum* CUSHMAN, 1930, p.20, pl.7, fig.10.

Elphidium clavatum Cushman. BUZAS, 1965, p.23, pl.3, figs.3-4.

Elphidium excavatum forma *clavata* Cushman. MILLER *et* *al* , 1982, p.27, pl.1, figs.3-8, pl.3, figs.2-8; WILLIAMSON, 1983, p.224, pl.5, fig.9.

Eoeponidella *pulchella* (Parker)

Phinanaella *pulchella* PARKER, 1952, p.420, pl.6, figs.18-20.

Asterigerina *pulchella* (Parker). LOEBLICH and TAPPAN, 1964, Protista 2 (2) c 592.

Eoeponidella *pulchella* (Parker). HAMAN, 1973, pp.101-103.

Epistominella takayanagii Iwasa

Plate 1, Figs.11-13.

Epistominella takayanagii IWASA, 1955, p.16, text-fig.4.

Fursenkoina fusiformis (Williamson)

Plate 1, Fig.14.

Bulimina pupoides d'Orbigny var. fusiformis WILLIAMSON, 1858, p.63, pl.5, figs.129-130.

Virgulina fusiformis (Williamson). FEYLING-HANSSEN, 1964, p.307, pl.14, figs.15-18.

Fursenkoina fusiformis (Williamson). SCHNITKER, 1971, p.200, pl.10, fig.1; WILLIAMSON, 1983, p.226, pl.5, fig.1.

Globobulimina auriculata (Bailey)

Bulimina auriculata BAILEY, 1851, p.12, pl.1, figs.25-27.

Globobulimina auriculata (Bailey) var. arctica , HOEGLUND, 1947, p.254, text-fig.266, 267, 270, 271.

Globobulimina auriculata arctica (Hoeglund). LESLIE, 1965, p.161, pl.9, fig.6 a-c.

Globobulimina auriculata (Bailey). COLE, 1981, p.90; WILLIAMSON, 1983, p.221, pl.3, fig.17.

Globobulimina pacifica Cushman

Globobulimina pacifica CUSHMAN,1927, p.67. GALLOWAY and WISSLER, 1927, p.74; WILLIAMSON, 1983, p.221, pl.3, fig.16.

Gyroidina soldanii d'Orbigny

Rotalia soldanii d'ORBIGNY, p.278, fig.36.

Gyroidina soldanii d'Orbigny var. *altiformis* STEWART. PHLEGER and PARKER, 1952, p.22, pl.11, figs.15-16.

Gyroidina soldanii d'Orbigny. COLE, 1981, p.112, pl.14, fig.7; WILLIAMSON, 1983, p.228, pl.5, figs,.5-6.

Haynesina orbiculare (Brady)

Plate 1, Fig.10.

Nonionina orbicularis BRADY, 1881, p.415, pl.21, fig.5.

Haynesina orbiculare (Brady). BANNER and CULVER, 1978, p.188.

Islandiella teretis (Tappan)

Plate 1, Fig.1.

Cassidulina laevigata d'Orbigny. BRADY, 1884, p.428, pl.54, figs.1-3.

Cassidulina teretis TAPPAN, 1951, p.7, pl.1, fig.30 a-c.

Islandiella teretis (Tappan). VILKS, 1969, p.49, pl.3, fig.5; WILLIAMSON, 1983, p.219, pl.3, fig.19.

Genus *Lagena* Walker and Jacob

Genus *Lagena* WALKER and JACOB in KANMACHER, 1798.

Genus *Miliolina* deMontfort

Genus *Miliolina* deMONTFORT, 1808.

Nonion barleeanum (Williamson)

Nautilus pompiloides FICHEL and MOLL, 1798, p.31, pl.2, fig a-c.

Nonion pompilioides (Fichel and Moll). CUSHMAN, 1930, p.4, pl.2, figs.1-2.

Nonion barleeanum (Williamson). CUSHMAN and HENBEST, 1940, p.9, fig.13.

Nonionellina labradorica (Dawson)

Plate 1, Figs.3,4.

Nonionina labradorica DAWSON, 1860, p.191, fig.4.

Nonion labradorica (Dawson). CUSHMAN, 1927, p.148, pl.2, figs.7-8.

Nonionellina labradorica (Dawson). SCHAFER and COLE, 1978, p.28, pl.9, fig.4; WILLIAMSON, 1983, p.227, pl.4, figs.14-15.

Quinqueloculina seminulum (Linne)

Serpula seminulum LINNE, 1758, p.786.

Miliolina seminulum (Linne). BRADY, 1884, p.157, pl.5, fig.6.

Quinqueloculina seminulum (Linne). CUSHMAN, 1917, p.44, pl.11, fig.2; WILLIAMSON, 1983, p.215, pl.3, fig.1.

Recurvoides turbinatus (Brady)

Haplophragmium turbinatus BRADY, 1881, p.50.

Recurvoides turbinatus (Brady). PARKER, 1952, p.402, pl.2, figs.23-24; WILLIAMSON, 1983 p.209, pl.1, fig.17.

Reophax arctica Brady

Plate 1, Fig.7.

Reophax arctica BRADY, 1881, p.99, pl.2, fig.2; WILLIAMSON, 1983, p.206, pl.1, fig.8.

Reophax fusiformis (Williamson)

Proteonina fusiformis WILLIAMSON, 1858, p.1, pl.1, fig.1.

Reophax fusiformis (Williamson). BRADY, 1884, p.290, pl.30, figs.7-11.

Reophax nodulosa Brady

Reophax nodulosa BRADY, 1879, v.19, p.52, pl.4, figs.7-8; WILLIAMSON, 1983, p.207, pl.1, fig.14.

Reophax scotti Chaster

Reophax scotti CHASTER, 1892, p.57, pl.1, fig.1; WILLIAMSON, 1983, p.207, pl.1, fig.11.

Saccammina diffluqiformis (Brady)

Reophax diffluqiformis BRADY, 1879, p.51, pl.4, fig.3 a-b.

Proteoina fusiformis (Brady). PHLEGER and PARKER, 1951, p.2, pl.1, figs.4-5.

Saccammina diffluqiformis (Brady). TODD and BRONNIMAN, 1957, p.52, pl.1, fig.15; WILLIAMSON, 1983, p.205, pl.1, fig.3.

Spiroplectammina biformis (Parker and Jones)

Plate 1, Fig.6.

Textularia agglutinans d'Orbigny var. biformis PARKER and JONES, 1865, p.370, pl.15, figs.23-24.

Spiroplectammina biformis (Parker and Jones). CUSHMAN, 1927, p.23, pl.5, fig.1; WILLIAMSON, 1983, p.211, pl.2, fig.5.

Textularia torquata Parker

Plate 1, Fig.8.

Textularia torquata PARKER, 1952, p.403, pl.3, figs.9-11; WILLIAMSON, 1983, p.212, pl.2, fig.4.

Trifarina fluens (Todd)

Angulogerina fluens TODD, in CUSHMAN and TODD, 1947, p.67, pl.16, figs.6-7.

Trifarina fluens (Todd). FEYLING-HANSSEN in FEYLING-HANSSEN et al ., 1971, p.242, pl.7, figs.12-15, pl.18, fig.10.

Triloculina trihedra Loeblich and Tappan

Triloculina trihedra LOEBLICH and TAPPAN, 1953, p.45, pl.4, fig.10; WILLIAMSON, 1983, p.216, pl.3, fig.3.

Trochammina lobata Cushman

Trochammina lobata CUSHMAN, 1944, p.18, pl.2, fig.10.

Trochammina nana (Brady)

Haplophragmium nana BRADY, 1881, p.50.

Trochammina nana (Brady). CUSHMAN, 1920, p.80, pl.17, fig.1.

Trochammina ochracea (Williamson)

Rotalina ochracea WILLIAMSON, 1858, p.55, pl.4, fig.112, pl.5, fig.113.

Trochammina ochracea (Williamson). CUSHMAN, 1920, p.75, pl.15, fig.3.

PLATE 1

Figure 1: *Islandiella teretis* (Tappan); Ventral view.

Figure 2: *Cassidulina reniforme* Norvang; Apertural view.

Figure 3: *Nonionellina labradorica* (Dawson); Apertural view.

Figure 4: *Nonionellina labradorica* (Dawson); Side view.

Figure 5: *Adercotryma glomerata* (Brady); Side view.

Figure 6: *Spiroplectammina biformis* (Parker and Jones); Side view.

Figure 7: *Reophax arctica* (Brady); Side view.

Figure 8: *Textularia torquata* Parker; Side view.

Figure 9: *Eggerella advena* (Cushman); Side view.

Figure 10: *Haynesina orbiculare* (Brady); Side view.

Figure 11: *Epistominella takayanagii* Iwasa; Dorsal view.

Figure 12: *Epistominella takayanagii* Iwasa; Apertural view.

Figure 13: *Epistominella takayanagii* Iwasa; Ventral view.

Figure 14: *Fursenkoina fusiformis* (Williamson); Side view.

Figure 15: *Elphidium excavatum* f. *clavatum* Cushman; Side view.

Figure 16: *Buccella frigida* (Cushman); Dorsal view.

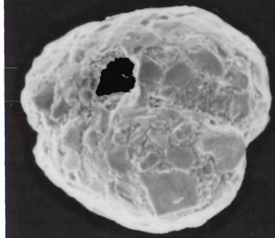
Figure 17: *Buccella frigida* (Cushman); Ventral view.

1

2

3

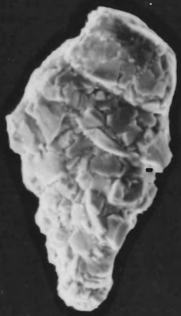
4



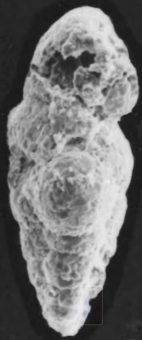
5

6

7



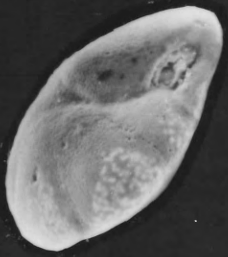
8



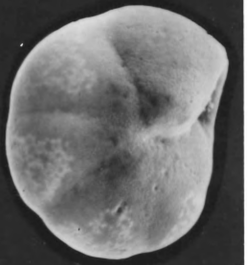
9

10

11



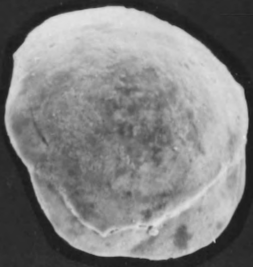
12



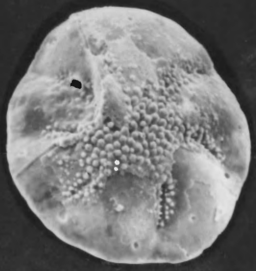
13

14

15



16



17

REFERENCES:

Ansersen, H.V., Buccella , a new species of Rotalid foraminifera. Jour. Wash. Acad. Sci., v.42, p.143-151.

Bailey, J.W., 1851, Microscopical examinations of soundings made by the U.S. coast survey of the Atlantic coast of the U.S. Smithson. contrib. to knowl., v.2, p.1-15.

Banner, F.T., and Culver, S.J., 1978. Quaternary Haynesina N.Gen., and Paleogene Protelphidium Haynes; their morphology, affinities and distribution. Journal of Foraminiferal Research, 8(3), pp.177-207.

Brady, H.B., 1878, On the reticularian and radiolarian Rhizopoda (Foraminifera and Polycystina) of the North Polar expedition of 1875-1876. Ann. Mag. Nat. Hist., v.1, (ser.5) p.425-440.

Brady, H.B., 1879, Notes on some of the Reticularian Rhizopoda of the "Challanger" expedition. Quart. Jour. Micro. Sci. v.19, p.20-63.

Brady, H.B., 1884, Report on the Foraminifera dredged by the H.M.S. Challanger during the years 1873-1876. Challenger Rept. Zoology, v.9, p.1-814.

Brown, R.M., 1970. The Elements of Palaeontology, pp.234-239. Cambridge University Press, New York.

Buzas, M.A., 1965, The distribution and abundance of foraminifera in Long Island Sound. Smithsonian Misc. Coll., v.149, p.1-89.

Chaster, G.W., 1892, Report upon the Foraminifera of the Southport Society of Natural Science. First Rept. Southport Soc. Nat. Sci. 1890-1891.

Cole, F., 1981. Taxonomic Notes on the Bathyal Zone Foraminifera Species Off Northeast Newfoundland. Bedford Inst. Oceanogr. Rept. Ser. BI/R/81-7.

Cushman, J.A., 1917, A monograph of the Foraminifera of the North Pacific Ocean. Pt.6, Miliolidae. U.S. National Mus. Bull., no.17, p.1-108.

Cushman, J.A., 1920, The Foraminifera of the Atlantic Ocean. Pt.2, Lituolidae. U.S. National Mus. Bull., no.104, p.1-111.

Cushman, J.A., 1922, The Foraminifera of the Atlantic Ocean, Pt.3, Textularidae, U.S. National Mus. Bull.,

no.1-104, p.1-149.

Cushman, J.A., 1927, An outline of the re-classification of the Foraminifera. Contr. Cushman Lab. Foramin. Res., v.3, p.1-105.

Cushman, J.A., 1930, The Foraminifera of the Atlantic Ocean, Pt.7: Nonionidae, Camerinidae, Peneroplidae and Alveolinellidae: U.S. National Mus. Bull., 104, 79p., pls.1-18.

Cushman, J.A., 1931, The Foraminifera of the Atlantic Ocean, Pt.8, Rotaliidae, Amphisteginidae, Calcarinidae, Cymbaloporellidae, Globarotaliidae, Anomalinidae, Planorbulinidae, Rupertiidae and Homotremidae. U.S. National Mus. Bull., no.104, p.1-179.

Cushman, J.A., 1933, New Arctic foraminifera collected by Capt. R.A. Bartlett from Fox Basin and off the northeast coast of Greenland, Smithsonian Misc. Coll., v.89, no.9, pp.1-8.

Cushman, J.A., 1944, Foraminifera from the shallowwater of the New England coast. Contr. Cushman Lab. Foramin. Res., no.12, 1-37.

Cushman, J.A., 1947, New species and varieties of Foraminifera from off the southeast coast of the United States. Contr. Cushman Lab. Foramin. Res., v.23, pt.4, p.86-92.

Cushman, J.A., and Henbest, L.G., 1940. Geology and Biology of North Atlantic deep sea cores. Part 2. United States Geological Survey Prof. Paper 196-A, 15p., pl.8-10.

Cushman, J.A., and Todd, R., 1947. A foraminiferal fauna from Amchikta Island, Alaska: Cush. Lab. Foram. Res., Contr., v.23, p.60-72.

Dale, C.T., and Haworth, R.T., 1979. High Resolution Reflection Seismic Studies on Late Quaternary Sediments of the Northeast Newfoundland Continental Shelf. Geol. Surv. Can., Current Res., Part B, Pap. 79-1B, pp. 357-364.

Dawson, G.M., 1870, On Foraminifera from the Gulf and River St. Lawrence. Can. Nat. and Quart. Jour. Sci., v.5, p.172-180.

Dawson, J.W., 1860, Notice of Tertiary fossils from Labrador, Maine, etc. and remarks on the climate of Canada, in the newer Pliocene or Pleistocene period.

Can. Nat. and Quart. Jour. Sci., v.5, p.188-200.

deMontfort, D., 1808. Conchyliogie systematique et classification methodique des coquilles. v.1, p.1-409.

Elverhoi, A., Leistol, O.and Nagy, J., 1980. Glacial Erosion, Sedimentation and Microfauna in the Inner Part of Fongsfjorden, Spitsbergen, Saertry KK av Norsk Polarinstitutt, 172:33-59.

Feyling-Hanssen, R.W., 1964, Foraminifera in Late Quaternary deposits from the Oslofjord area. Norges. Geol. Unders. Nr. 225.

Feyling-Hanssen, R.W., Jorgensen, J.A., Knudsen, K.L. and Anderson, A.L., 1971. Late Quaternary Foraminifera from Vendsyssel, Denmark and Sandes, Norway: Bull. Geol. Soc. Denmark, v.21, pt.2,3, 317p., 26pl.

Fichel, L. and Moll, J.P., 1798, Testacea microscopia aliaque esc generibus Argonauta et Nautilus ad naturam delineata et descripta. Wein. Camesina.

Galloway, J.J., and Wissler, S.J., 1927, Pleistocene foraminifera from Lomita Quarry, Palos Verdes Hills, California. Jour. Palaeo., v.1, p.35-87.

Gregory, M.R., 1970, Distribution of Benthonic Foraminifera in Halifax Harbour, Nova Scotia. Ph.D. thesis at Dalhousie University, Halifax.

Haman, D., 1973. Status of the foraminiferal genera Asterellina and Eoeponidella ; Micropaleontology, v.19, no.1.

Hoeglund, H., 1947. Foraminifera in the Gullmar Fjord and Skagerak. Zool. Bidrag. Fran. Uppsala Bd. 26, p.1-328.

Iwasa, S., 1955. Biostratigraphy of the Iszawagawa Group in Honjo and its environ, Akita Prefectur. Journal of the Geological Society of Tokyo, 61(712), pp.1-18.

Lazier, John, R.N., 1982.Seasonal Variability of Temperature and Salinity in the Labrador Current. J. Mar. Res., 40:341-356.

Leslie, R.J., 1965, Ecology and palaeoecology of Hudson Bay foraminifera. Bedford Inst. Oceanogr. Rept. 65-6, p.1-28.

Linne, C., 1758, Systema naturae per regna tria naturae, secundum classes, ordines, genera, species cum characteribus differentiis, synonimus locis. no.1, p.1-824. Engleman, G. (Lipsiae).

Loeblich, A., and Tappan, H., 1953, Studies of Arctic Foraminifera. Smithson. Misc. Coll., v.121, no.7.

Loeblich, A., and Tappan, H., 1961b. Suprageneric classification of the Rhizopodea. Journal of Paleontology, v.35, p.245-330.

Loeblich, A., and Tappan, H., 1964, Sarcodina, chiefly Thecamoebians and Foraminiferida. In Moore, R.C. (Ed.) Treatise on invertebrate palaeontology, Part C, Protista.

MacPherson, J.B., 1982. Postglacial Vegetation History of the Eastern Avalon Peninsula, Newfoundland, and Holocene Climatic Change Along the Eastern Canadian Seaboard. Geogr. Phys. Quaternaire, XXXVI:175-196.

Miller, A.A.L., Mudie, P.J., and Scott, D.B., 1982. Holocene history of Bedford Basin, Nova Scotia: foraminifera, dinoflagellate, and pollen records. Can. Jour. Earth Sci., v.19, no.12, p.2342-2367.

Miller, A.A.L., Scott, D.B. and Medioli, F.S., 1982a. Elphidium excavatum (Terquem): ecophenotypic versus subspecific variation. J. Foram. Res., 12: 116-144.

Miller, Ann A.L., Scott, D.B.and Smith, D., 1985. Postglacial Paleoceanography, Northeast Newfoundland Shelf. G.S.C. Open File 1194.

Mudie, P.J., Keen, C.E., Hardy, I.A. and Vilks, G., 1984. Multivariate Analysis and Quantitative Paleoecology of Benthic Foraminifera in Recent and Late Quaternary Sediments, Northern Canada. Mar. Micropaleontol., 8:283-313.

Norman, A.M., 1892, Rhizopoda. Pt. VIII. Museum Normanianium, Durham, England.

Norvang, A., 1945. Foraminifera. In The zoology of Iceland 3, Pt.2. Munksgaard, Copenhagen, 79p.

Orbigny, A.D., d', 1826, Tableau Methodique de la class des cephalopods, III order, foraminiferes. Annls. Sci. Nat. ser.1, v.7, p.245-314.

Parker, F.L., 1952, Foraminiferal distribution in the Long Island Sound Buzzards Bay area. Bull. Mus. Comp. Zool. Harvard, v.106, p.425-473.

Parker, W.K., and Jones, T.R., 1865, On the Foraminifera from the North Atlantic and Arctic Oceans including Davis Str. and Baffin Bay. Philos. Trans., v.155, p.325-441.

Phleger, F.B, and Parker, F., 1951, Gulf of Mexico Foraminifera. Geol. Soc. Am. Mem. no.46.

Reuss, A.E., 1850, Newes Foraminiferen aus den Schichten des Osterrichischen Tertiarbeckens. K. Akad. Wiss. Wein. Math-natur. cl. Denkschr., v.1, p.365-390.

Schafer, C.T. and Cole, F.E., 1978, Distribution of Foraminifera in Chaleur Bay, Gulf of St. Lawrence. Geol. Surv. Can. Paper 77-30, p.1-55.

Schnitker, D., 1971, Distribution of Foraminifera on the North Carolina continental shelf. Tulane studies in Geol. and Paleo., v.8, no.4, p.169-215.

Scott, D.B., in press, Benthonic Foraminifera in New Jersey Transect- v.95 of Initial Report, Deep Sea Drilling Project.

Scott, D.B., Schafer, C.T., and Medioli, F.S., 1980. Eastern Canadian estuarine foraminifera: a framework for comparison. Journal of Foraminiferal Research, 10, pp.205-234.

Scott, D.B., Mudie, P.J., Vilks, G. and Younger, D.C., 1984. Latest Pleistocene -Holocene Paleoceanographic Trends on the Continental Margin of Eastern Canada: Foraminiferal, Dinoflagellate and Pollen Evidence: Mar. Micropaleontol., 9:181-218.

Sejrup, H.-P., and Guibault, J.-P., 1980. Cassidulina reniforme and C. obtusa (Foraminifera), taxonomy, distribution and ecology. Sarsia, 65, pp.79-85.

Sutcliffe, W.J.Jr., Loucks, R.H. and Drinkwater, K.F., 1976. Coastal Circulation and Physical Oceanography of the Scotian Shelf and the Gulf of Maine. J. Fish. Res. Board Can., 33:98-115.

Tappan, H., 1951, Northern Alaska Index Foraminifera. Contr. Cushman Fdn. Foramin. Res., v.2, pt.1, p.1-8.

Todd, R., and Bronniman, P., 1957, Recent foraminifera and Thecamoebians from the eastern Gulf of Paria. Cushman Fdn. Foramin. Res., Spec. Publ., no.3, p.1-43.

Vilks, G., 1969, Recent foraminifera in the Canadian Arctic. Micropalaeo., v.15, p.35-60.

Vilks, G., 1981. Late Glacial-postglacial Foraminifera Boundary in Sediments of Eastern Canada, Denmark, and Norway. Geoscience Canada, 8.

Vilks, G., Hardy, I., and Josenhans, H.W., 1984. Late Quaternary Stratigraphy of the Inner Labrador Shelf. Current Research, Part A, Geol. Surv. Can., Pap.84-1A, p.57-65.

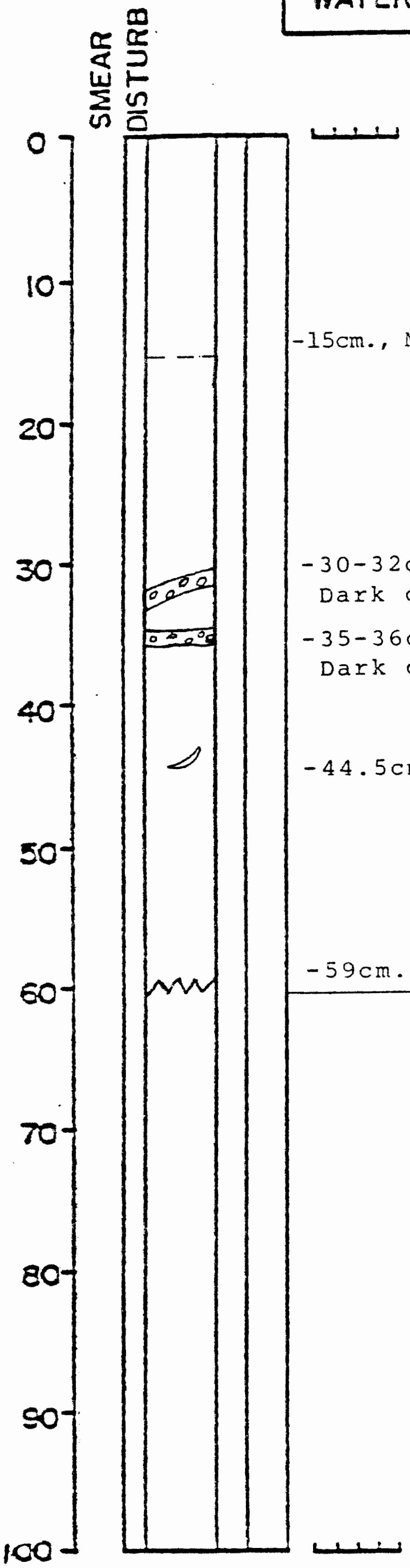
Walker, G., and Jacob, E., 1798, In Adams essays on the microscope, containing a practical description of the most improved microscopes; a general history of insects. A description of 383 animacula. Dillon and Keaton, London.

Williamson, M.A., 1983. Benthic Foraminiferal Assemblages in the Continental Margin of Nova Scotia: a Multivariate Approach. Unpublished Ph.D. Thesis, Dalhousie University, Halifax, 269pp.

Williamson, W.C., 1858, On the Recent Foraminifera of Gr. Britain. Ray. Soc. Publs., v.20, p.1-107.

APPENDIX 1

CORE 80-03-26TWC **DEPTH IN CORE** 0-59cm.
LOCATION NW end of outer Notre Dame Bay, NFLD shelf.
Described by: Kevin MacNeil
WATER DEPTH 267m.



DESCRIPTION

SAMPLE RECORD

-0-15cm. Clay, silty.
-Dark olive gray 5Y 3/2.
-Mottled contact at 15cm

-15cm., Mottled contact.

-15-59cm. Clay, silty.
-Olive gray 5Y 4/2.
-Thick laminae(dark gray
-Angular clasts(diameter 5-10mm.) scattered throughout.

-30-32cm., Gravel band. Dark olive gray.

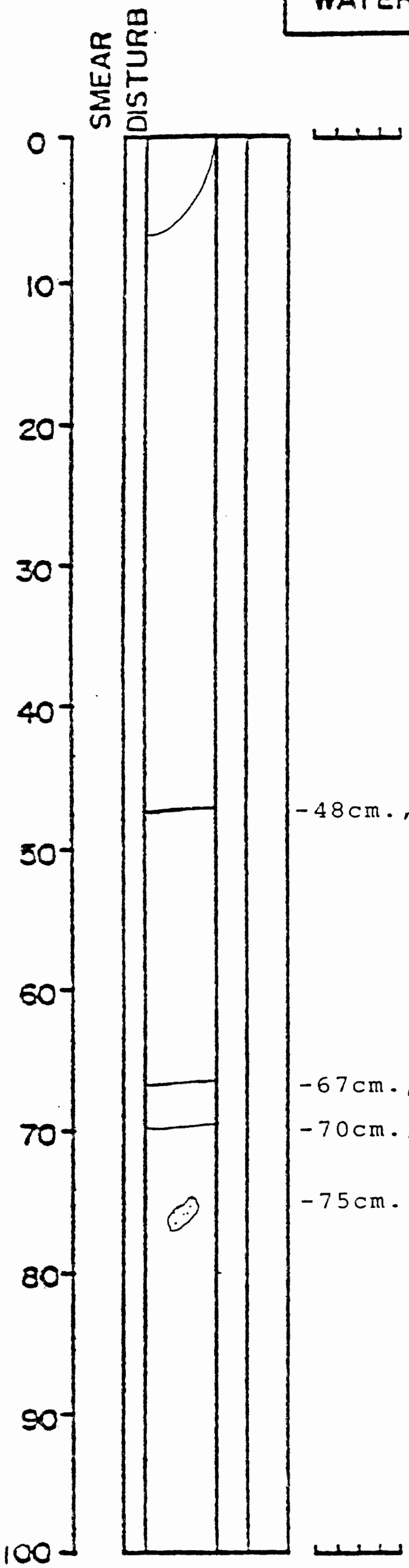
-35-36cm., Gravel band. Dark olive gray.

-44.5cm., Shell fragment.

-59cm. End of section.

General comments:

CORE 80-030-26PC **DEPTH IN CORE** 0-100cm.
LOCATION NW end of outer Notre Dame Bay, NFLD shelf.
Described by: Kevin MacNeil
WATER DEPTH 267m.



DESCRIPTION

SAMPLE RECORD

-0-6cm. Semi-void.

-6-100cm. Clay, silty.
-Olive gray 5Y 4/2.
-Semi-stiff, mottled.
-Gradations downcore to light gray color.
-Angular clasts (diameter 2-5mm.) scattered throughout.

-48cm., Black lamination.

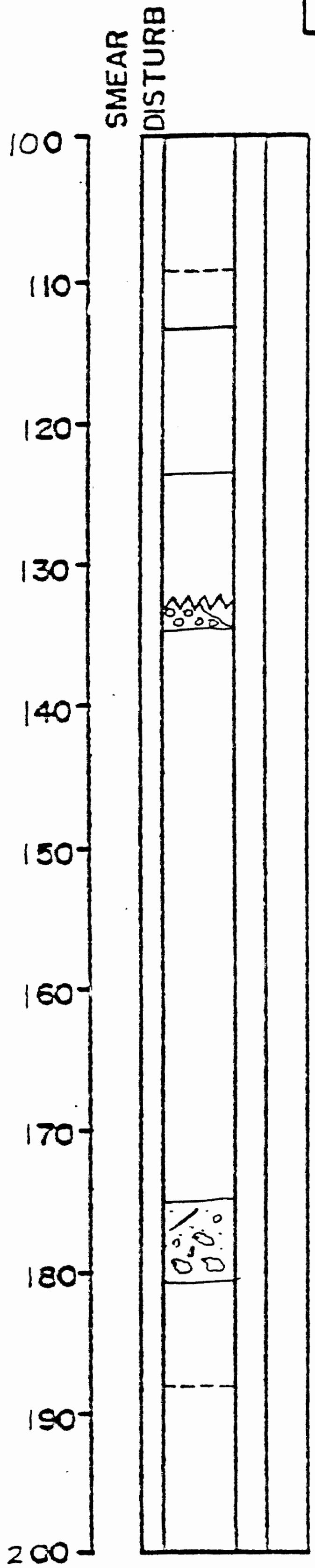
-67cm., Black lamination.

-70cm., Black lamination.

-75cm., Sub-angular clast, 2cm. diameter.

General comments:

CORE 80-030-26PC **DEPTH IN CORE** 100-200cm.
LOCATION NW end of outer Notre Dame Bay, NFLD shelf.
Described by: Kevin MacNeil
WATER DEPTH 267m.



-110cm., Gradational color contact.
-113cm., Dark band.

-124cm., Abrupt contact.

-133cm. End of section.
-133-135cm., Gravel band.

-189cm., Gradational cotact.

DESCRIPTION

-100-110cm. Clay, silty.
-Olive gray 5Y 4/2.
-Semi-stiff.
-Angular clasts.

-110-124cm. Clay, silty, gravelly.
-Grayish brown 2.5Y 5/2.
-Semi-stiff.

-124-133cm. Clay, silty.
-Dark grayish brown, 2.5Y 4/2.
-Soft.

-133-175cm. Clay, silty.
-Dark grayish brown, 2.5Y 4/2.
-Soft.
-Subrounded clasts(1-3 mm. diameter), scattered throughout.

-175-181cm. Gravel unit.
-Dark grayish brown, 2.5Y 3.5/2.

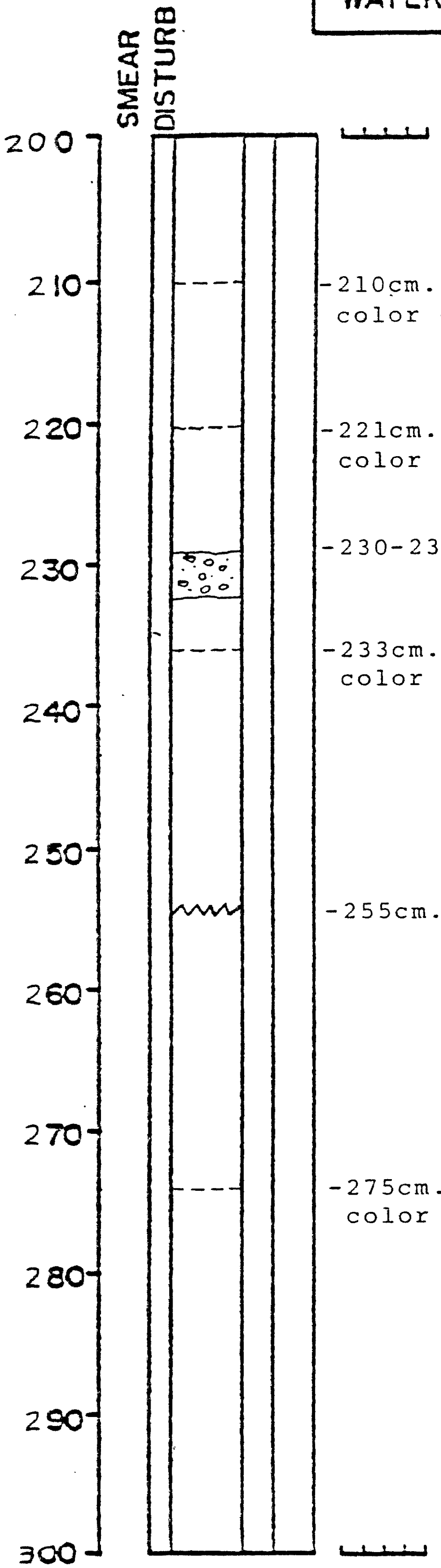
-181-189cm. Clay, silty.
-Dark grayish brown, 2.5Y 4/2, Soft.

-189-200cm. Clay, silty, gravelly.
-Dark grayish brown, 2.5Y 3.5/2.
-Soft.
-Angular clasts(5-10mm. diameter).

SAMPLE RECORD

General comments:

CORE 80-030-26PC **DEPTH IN CORE** 200-300cm.
LOCATION NW end of outer Notre Dame Bay, NFLD shelf.
Described by: Kevin MacNeil
WATER DEPTH 267m.



-210cm., Gradational color contact.

-221cm., Gradational color contact.

-230-233cm., Gravel band.

-233cm., Gradational color contact.

-255cm., End of section.

-275cm., Gradational color contact.

DESCRIPTION

-200-210cm. Clay, silty, gravelly.
-Dark grayish brown, 2.5Y 3.5/2, Soft.

-210-221cm. Clay, silty.
-Olive gray (greenish), 5Y 4/2.
-Soft.

-221-233cm. Clay, silty, gravelly, Soft.
-Transitional from Olive gray to medium grayish brown.

-233-255cm. Clay, silty, gravelly, Soft.
-Medium grayish brown, 2.5Y 4.5/2.
-Large subangular clasts (up to 2cm. diameter), from 233-248cm.

-255-275cm. Clay, silty, gravelly, Soft.
-Medium grayish brown, 2.5Y 4.5/2.
-Large subangular clasts from 255-267cm.

-275-300cm. Clay, silty
-Dark grayish brown, 10YR 4/2.
-Small scale black mottling, Soft.
-Angular clasts (up to 1cm. diameter), scattered throughout.

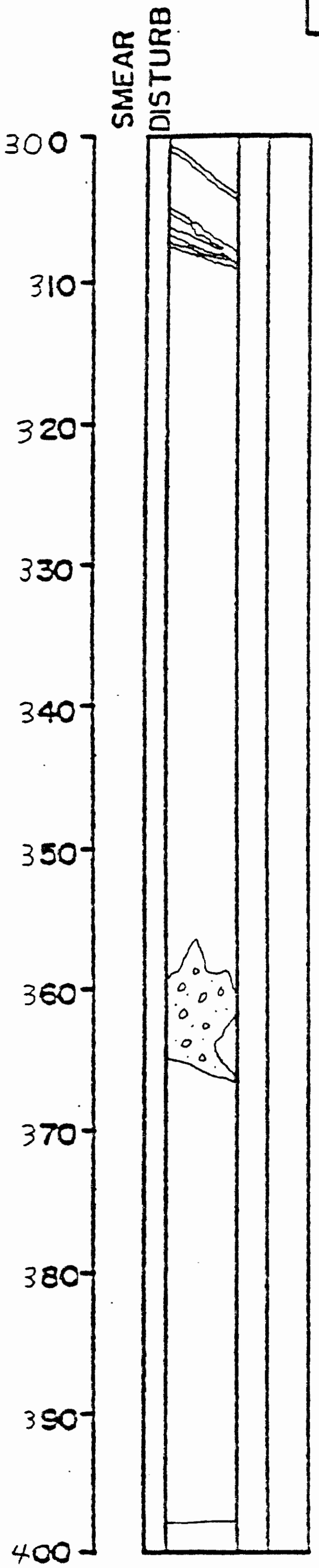
SAMPLE RECORD

General comments:

CORE 80-030-26PC **DEPTH IN CORE** 300-400cm.

LOCATION NW end of outer Notre Dame Bay, NFLD shelf

WATER DEPTH 267m. **Described by:** Kevin MacNeil



-301-303cm., Diagonal band.

-304-308cm., Triple diagonal banding.

-357-365cm., Gravelly band.

-399cm., Abrupt contact.

DESCRIPTION

-300-399cm. Clay, silty

-Dark grayish brown, 10YR 4/2.

-Small scale black mottling, Soft.

-Angular clasts (up to 1cm. diameter), scattered throughout.

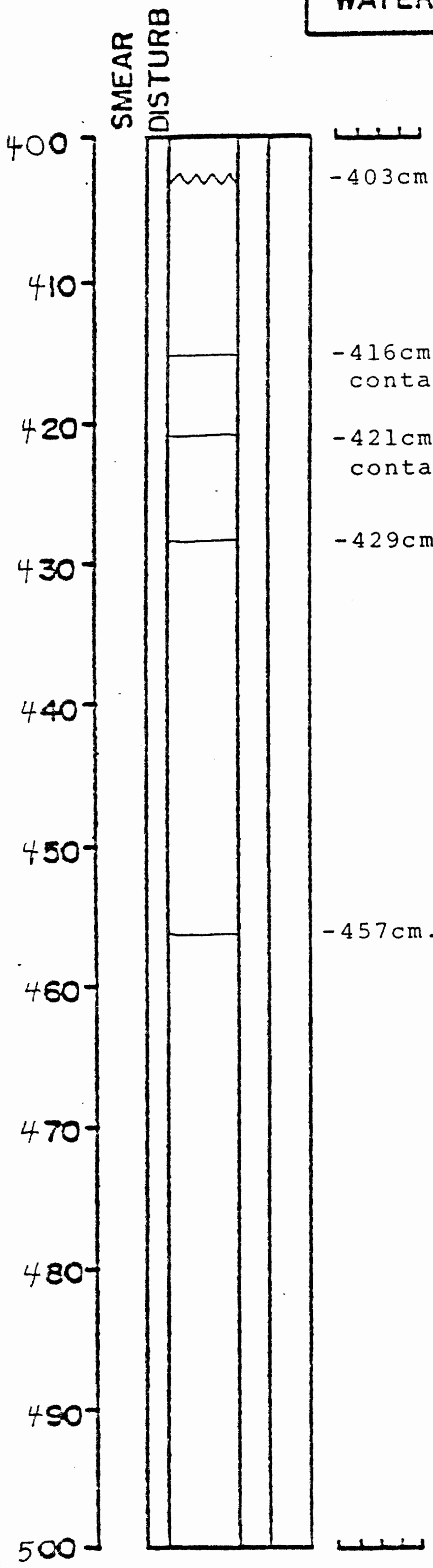
-399-400cm. Clay.

-Medium gray, 10YR 4.5/1

SAMPLE RECORD

General comments:

CORE 80-030-26PC **DEPTH IN CORE** 400-500cm.
LOCATION NW end of outer Notre Dame Bay, NFLD shelf.
Described by: Kevin MacNeil
WATER DEPTH 267m.



-403cm., End of section.

-416cm., Abrupt color contact (gray to brown).

-421cm., Abrupt color contact (brown to gray).

-429cm., Abrupt contact.

-457cm., Abrupt contact.

DESCRIPTION

-400-403cm. Clay, silty.
-Interlaminated 10YR 4/2 and 10YR 4.5/1 clays.
-403-406cm. Clay, silty.
-Dark grayish brown, 10YR 4/2, Soft.
-406-429cm. Clay, silty.
-Interlaminated 10YR 4/2 and 10YR 4.5/1 clays.
-Gravelly, coarsening up

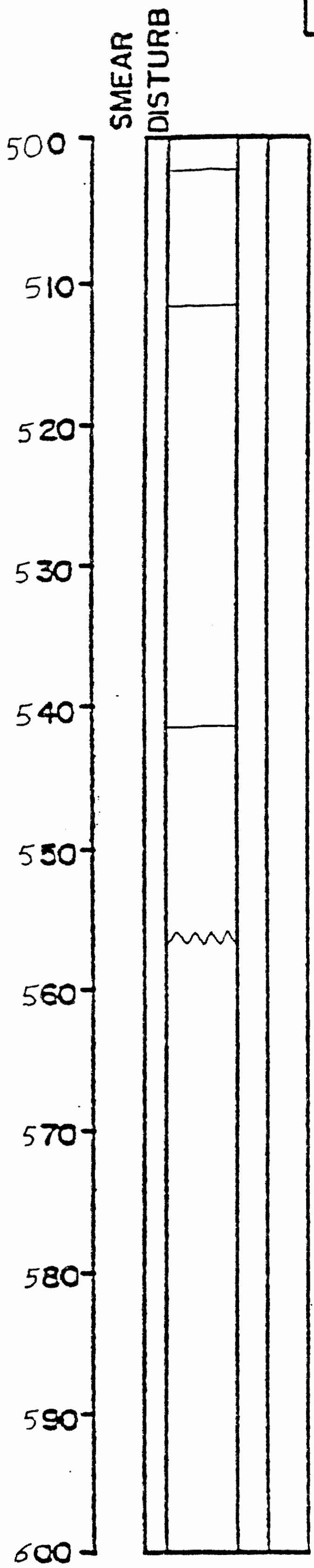
-429-457cm. Clay, silty.
-Interlaminated clays of 7.5YR 5/2 (brown) and 10YR 4.5/1 (gray) color.
-Gravelly, clasts up to 1cm. diameter.

-457-500cm. Clay, sandy, gravelly.
-Interlaminated clays of 10YR 4.5/1 (medium gray) and gravelly to sandy clays of 2.5YR-4/2 (red) and 7.5YR 5/2 (brown) colors.

SAMPLE RECORD

General comments:

CORE 80-030-26PC **DEPTH IN CORE** 500-557cm.
LOCATION NW end of outer Notre Dame Bay, NFLD shelf.
Described by: Kevin MacNeil
WATER DEPTH 267m.



DESCRIPTION

SAMPLE RECORD

-501cm., Abrupt contact.

-512cm., Abrupt contact.

-542cm., Abrupt contact.

-557cm., End of section.

-500-501cm. Clay, sandy, gravelly.
-Interlaminated clays of 10YR 4.5/1(medium gray) and gravelly to sandy clays of 2.5YR 4/2(red) and 7.5YR 5/2 (brown) colors.

-501-512cm. Clay, sandy.
-Brown 7.5YR 5/2.
-Semi-stiff.

-512-542cm. Clay, gravelly.
-Interlaminated gravelly (brown,red) bands and non-gravelly(gray) bands.

-542-557cm. Gravel, muddy.
-Dark brown 7.5YR 4/2.
-Dominated by large clasts(up to 4cm. in diameter).

General comments: