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FORAMINIFERAL STUDY OF A CROSS-SECTION OF HUDSON BAY, CANADA

34, 44, and 54

(Report and 5 figures)

R. J. Leslie

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By

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MINES AND TECHNICAL SURVEYS

CANADA

NOTE

The text, illustrations, and format of this report are as submitted by the author.

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ABSTRACT

There are three distinctive foraminiferal faunas in an east-west cross-section of Hudson Bay. They are: (1) a near shore fauna, (2) a central basin fauna, and (3) a central high fauna. Eggerella advena is the dominant species at the shallow stations, and Textularia torquata is the important species in the basins. The central high has a distinctive fauna, including high percentages of Cassidulina norcrossi, Bulimina exilis, and Astrononion gallowayi.

Planktonic foraminifera are represented by Globigerina pachyderma, which is present at only three stations and in numbers less than 1 per cent. The concentration of planktonics in bottom sediments of Hudson Bay probably increases toward the entrance of Hudson Strait where more typical marine conditions exist.

Ice rafting has had little effect upon foraminiferal distribution. Evidence from sediment studies indicates that only the two stations farthest west have been influenced. Sediment size is closely related to bottom topography and current direction in the bay. Since the grain size and bottom topography are related, the foraminiferal population varies with each.

Ostracodes occur only at the western end of the section. Diatoms are present in all the samples, but are most abundant on the western side of the bay. Radiolarians were not found in any of the samples, and if they are living in Hudson Bay, it is near the entrance to Hudson Strait.

INTRODUCTION

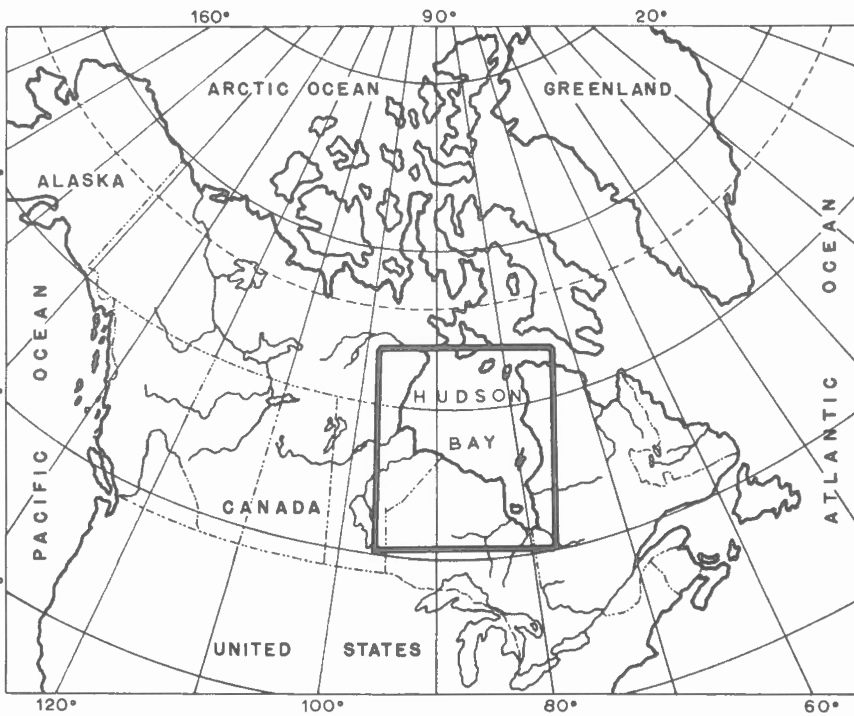
General

This paper comprises a study of the distribution of foraminifera in an east-west cross-section of Hudson Bay, with emphasis on the environmental factors that affect their distribution. It represents the initial work on seventy sediment samples taken throughout the bay during August and September, 1961. The sampling program was part of a study of physical oceanography and marine geology sponsored by the Marine Sciences Branch and the Geological Survey of Canada.

Hudson Bay is in north central Canada and is connected to the Atlantic Ocean by Hudson Strait (see figure 1). The bay is 900 miles long, 450 miles wide, and is the ninth largest sea in the world with a total area of 472,000 square miles. It has an average depth of 140 meters and a maximum depth of 250 meters.

Previous Work

Cushman described the foraminifera of three samples from Hudson Bay and three from James Bay in 1921. The Hudson Bay samples were from the southeast coast, and were recovered from less than 20 meters of water. He described more than thirty species from these samples, and compared the fauna to collections made by Brady (1881) from off Novaya Zemlya and by Parker and Jones (1865) from Baffin Bay and Davis Strait. He concluded from the comparisons that the foraminifera of Hudson Bay are more closely allied to



LOCATION MAP — HUDSON BAY AREA OUTLINED

FIGURE 1

regions to the east than to regions to the west. In 1948 Cushman published a paper on Arctic Foraminifera in which he figured many of the species found in Hudson Bay.

Foraminifera from four stations in Hudson Strait were identified by Dr. F.J.E. Wagner of the Geological Survey and listed in the data record of a tidal and oceanographic survey of the strait made by Farquharson and Sauer (1959). The similarity of the faunal assemblage from Hudson Strait and from Hudson Bay is striking.

Other important work on Arctic foraminifera has been carried out by Green (1960) on the central Arctic Basin, Anderson, 1961, 1963) on foraminifera of the Arctic and Bering Seas, and Phleger on foraminifera from the Canadian and Greenland Arctic (1952). Loeblich (1953) and Tappan (1953) published a taxonomic study of Arctic foraminifera, and in 1960 Bé discussed Arctic planktonic foraminifera.

Acknowledgments

The author wishes to express his gratitude to Dr. Orville L. Bandy of the University of Southern California for assistance and recommendations. Many thanks are also due the Captain and crew of the M/V Theta from which the samples were taken, and to F. B. Barber who was Senior Scientist on the Hudson Bay cruise. Appreciation is also extended to Dr. B. R. Pelletier, of the Geological Survey of Canada, who directed the geologic portion of the project. Recognition is given to Dr. Donn Gorsline and Dr. Richard O. Stone for critical reading of the manuscript.

Method of Study

Samples were obtained with a Dietz-Lafond bottom snapper. The portion of sediment used in foraminiferal analysis was cut with a knife from the upper 2 cm of the sediment and placed in a container with rose bengal organic dye and alcohol.

Processing of the sediments was conducted in the Micropaleontology Laboratory of the Allan Hancock Foundation at the University of Southern California. The samples were dried and weighed, washed through a 250 mesh (0.061 mm) screen, dried, and concentrated using perchlorethylene as a floating medium. The organic material and tests that floated were then collected in glass vials. A microsplitter was used to split the concentrate since it provided a fast and accurate method of obtaining a convenient representative fraction of the foraminifera.

After making the faunal counts, the percentage per species per station was tabulated, as well as the percentage of arenaceous, hyaline, and porcelaneous tests. In this work hyaline refers to the calcareous perforate benthic species. Percentage of planktonic species and living species per station was calculated, and the foraminiferal number (number of foraminifera per gram of sediment) was determined.

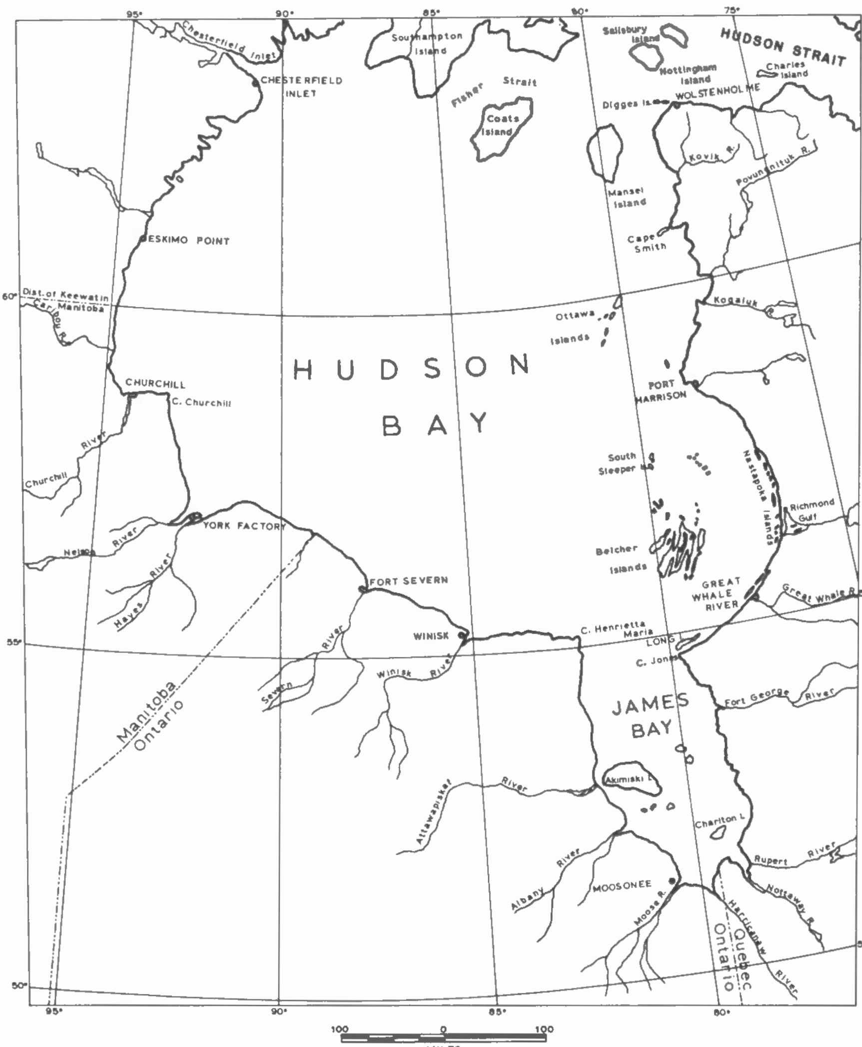
PHYSICAL SETTING

Bathymetry

Depths of the bay range for the greater part between 100 and 200 meters. Off the western shore the 100 meter depth is reached at a distance of 20 to 50 miles from the coast. Off the eastern shore depths increase rapidly to values in excess of 100 meters, but the bottom is irregular and from 50 to 100 miles offshore numerous islands are present (see figure 2). In the central and northern portion of the bay there is an irregularly-shaped basin with depths that exceed 200 meters, and from this basin a narrow trough of similar depth extends into the western entrance of Hudson Strait. Figure 3 shows the location of the section with reference to bathymetry. Two prominent topographic features cut by the cross-section are a central high of less than 50 meters below sea level flanked to the east by a basin greater than 200 meters deep.

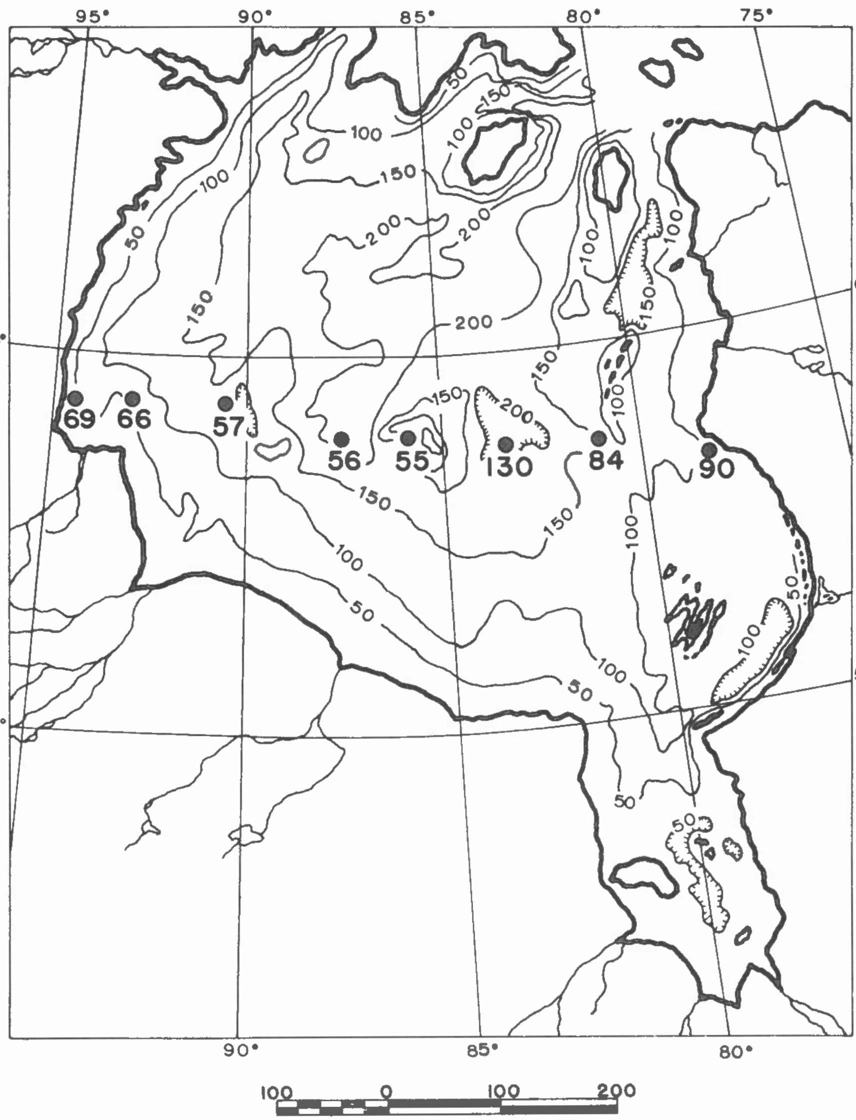
Oceanography

Water circulation in Hudson Bay is in a counter-clockwise direction; that is, the flow on the west side is to the south and on the east side to the north (Hachey, 1935). There is inflow of water from Foxe Channel and Roes Welcome Sound, and outflow from the bay into Hudson Strait. Tidal currents are strong between the islands at the western entrance to the strait, as well as in the estuaries on the west side of the bay where the tide rises from 11 to 18 feet (Manning, 1951). At Cape Henrietta Marie to the south the



GEOGRAPHIC MAP OF STUDY AREA

FIGURE 2



HUDSON BAY BOTTOM TOPOGRAPHY AND STATION LOCATIONS

FIGURE 3

tidal range is about 6 feet, whereas on the east side the range is from 2 to 3 feet.

During the summer the surface water of Hudson Bay is affected by fresh water entering from rivers and streams. In August the temperature and salinity of surface water grade from 9°C and 23°/oo at the mouth of James Bay to 4°C and 32°/oo at the western entrance to Hudson Strait (Hachey, 1931). Water below a depth of about 25 meters is not influenced by the runoff, so this deep water is fairly uniform throughout the bay with temperatures from -1°C to -2°C and a salinity of about 32°/oo. In the fall, run-off from the land diminishes, and cooling of the surface water results in mixing with the deeper water so that by the time ice forms on the surface the underlying water is fairly uniform from top to bottom.

Ice usually begins to form along the shores of Hudson Bay in October or early November, and it is not uncommon to observe ice 3 feet thick in Churchill Harbor in December (Keith, 1959). It was previously thought that the central portion of the bay remained ice-free during the winter, but aircraft patrols since 1949 have revealed that the entire bay freezes over (Lamont, 1949). In late March or early April the rivers of the southern bay region begin to open, and by July most of the bay is usually ice-free. However, after a severe winter, ice may persist in some parts of the bay well into August.

FORAMINIFERA

General

A total of sixty-two species were identified from the eight stations in the cross-section (see table 1). The foraminifera per gram ranged from 316 at station 66 in 65 meters of water to 12 at station 130 in 208 meters of water, the deepest station in the section.

Due to insufficient dye rather than lack of any living forms, none of the foraminifera from station 66 was stained. At station 69 the highest total of 32 per cent of the fauna was found to be living at the time of sampling. Arenaceous and hyaline tests made up the bulk of all the foraminifera, while porcelaneous tests were present at only four stations in minor quantities.

At station 55, located on the west slope of the central shoal, the fauna was quite different from that at the other mid-bay stations. Also, thirty-seven species were identified from the station sample, which was the greatest of any station in the section.

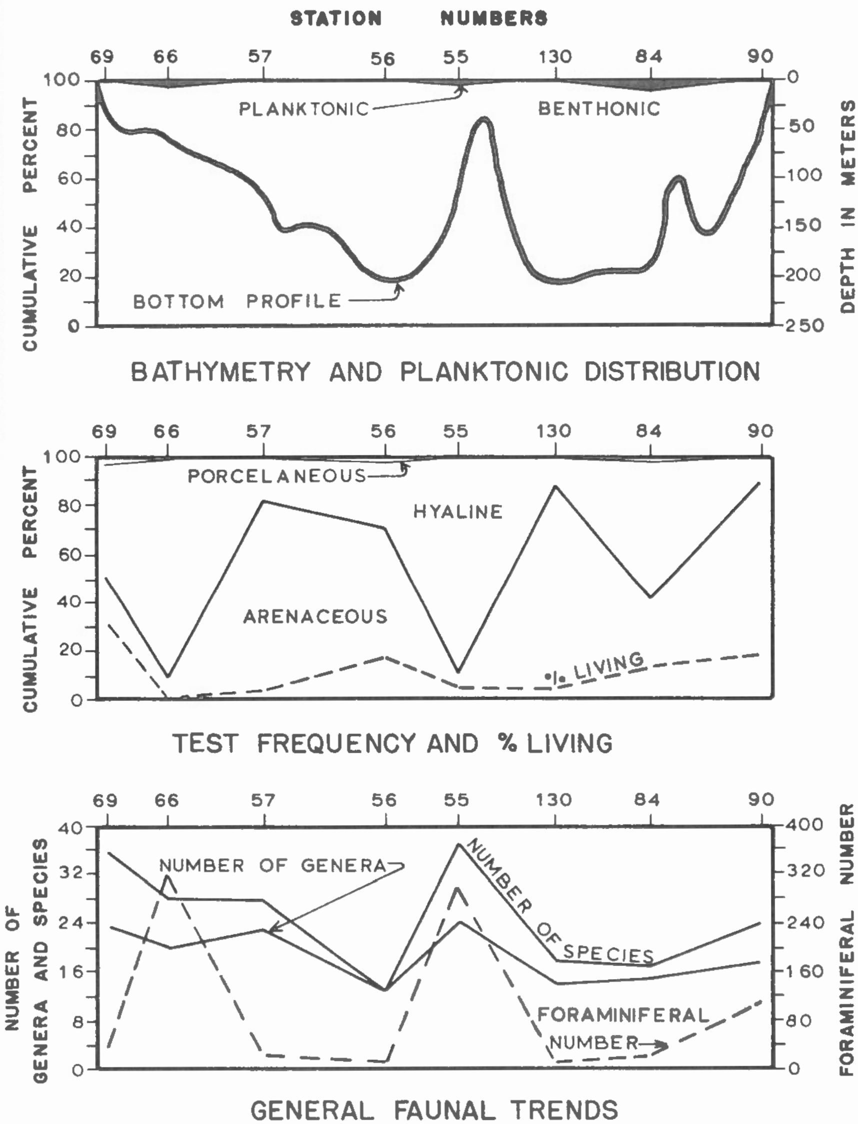
Planktonic Foraminifera

Planktonic foraminifera were found at only three stations, and in numbers less than 1 per cent of the total fauna (see figure 4). Globigerina pachyderma was the single species identified. It was present in various growth stages and was thin-shelled. This

STATION NUMBER	69	66	57	56	55	[illegible]	84	90
DEPTH IN METERS	33	65	115	201	100	2[illegible]8	194	52
PLANKTONIC POPULATION								
GLOBIGERINA PACHYDERMA		100			100		100	
BENTHONIC POPULATION								
ADERCOTRYMA GLOMERATA			7	10	3	20	13	
ALVEOLOPHRAGMIUM CRASSIMARGO	X		1	10		5		
ANGULOGERINA ANGULOSA	1	2	1		4	1	X	
ASTRONONION GALLOWAYI	15	18	2		16	1	13	2
BOLIVINA PACIFICA	9	2	X		2			
BUCCELLA TENERRIMA		3	8	2	9	2	4	3
BULIMINA EXILIS			2	2	23	5	19	X
CASSIDULINA ISLANDICA	7	41	1		3	1	15	1
CASSIDULINA LATICAMERATA		1	X		7		1	
CASSIDULINA NORCROSSI	1	X	4	8	16	2	4	
CIBICIDES LOBATULUS	X	X			X			
DENTALINA BAGGI					X			
DENTALINA FROBISHERENSIS					X			
DENTALINA ITTAI		1			X			X
DENTALINA PAUPERATA					X			
EGGERELLA ADVENA	46	3	5		1	5	1	52
ELPHIDIELLA ARCTICA	X	2			X			
ELPHIDIUM BARTLETTI	4	1	X		X			X
ELPHIDIUM INCERTUM	1	4	X		1		X	4
ELPHIDIUM ORBICULARE	2	5	X		X			X
FISSURINA MARGINATA		3						
FISSURINA SERRATA			X		X			X
GLANDULINA LAEVIGATA	X							
GUTTULINA GLACIALIS	1		X					
HAPLOPHRAGMOIDES MAJOR			4		X			X
HIPPOCREPINA INDIVISA	X							
HYPERAMMINA ELONGATA			X	5	X	X		
LAGENA APIOPLEURA					X			
LAGENA GRACILLIMA					X			
LAGENA LAEVIS	1	X			X		1	
LAGENA MERIDIONALIS				1				
LAGENA MOLLIS		X	X		1			
LAGENA PARRI	X							
LAGENA SEMILINEATA	X							
LAGENA STRIATOPUNCTATA	X							
NONION ZAANDAMAE			X	14	1	1		
NONIONELLA ATLANTICA	X							X
NONIONELLA LABRADORICA			X		2			X
OOLINA COSTATA	X	2	X					
OOLINA LINEATA	X	X			X			
OOLINA LINEATOPUNCTATA					X			
OOLINA MELO	X	X						
PATELLINA CORRUGATA		2						
POLYMORPHINA SP.	X							
PYRGO WILLIAMSONI	X							
QUINQUELOCULINA AGGLUTINATA	1	X						
QUINQUELOCULINA ARCTICA	1			2				
QUINQUELOCULINA STALKERI	2	2					X	
QUINQUELOCULINA SUBROTUNDA	1							X
REOPHAX ARCTICA	X	1	4		2	6		5
REOPHAX CURTUS	1		X	25				2
SACCAMMINA DIFFLUGIFORMIS	1	X	4	6	1	9	4	1
SIGMOMORPHINA SP.	X							
SPIRILLINA VIVIPARA				1			X	
SPIROPLECTAMMINA BIFORMIS		X	9		1	1	4	10
TEXTULARIA TORQUATA	2	4	45	8	3	30	18	6
TRILOCULINA TRIGONULA					X			
TROCHAMMINA QUADRILOBA				6		2		X
TROCHAMMINA ROTALIFORMIS			X			6		6
TROCHAMMINA SQUAMATA	1	1			X	2		6
TROCHAMMINELLA ATLANTICA						1	1	1
FORAMINIFERAL NUMBER	35	316	28	12	303	12	23	113
PERCENTAGE LIVING FORAMINIFERA	32		4	17	6	6	14	17
PERCENTAGE HYALINE TESTS	43	88	19	27	88	13	58	11
PERCENTAGE PORCELANEOUS TESTS	5	2		3			1	
PERCENTAGE ARENACEOUS TESTS	52	10	81	70	12	87	41	89
NUMBER OF GENERA	23	21	23	14	26	16	16	17
NUMBER OF SPECIES	35	29	28	14	37	19	18	23
PERCENTAGE PLANKTONIC FORAMINIFERA		0·8			0·5		4·0	
OSTRACOD NUMBER	0·4	0·5						

FORAMINIFERAL LIST AND PERCENTAGE OCCURRENCE

TABLE I



HUDSON BAY FORAMINIFERAL TRENDS

FIGURE 4

agrees with Be (1960) who has stated that, in _G. pachyderma_, features such as a crystalline thickening of the test and the addition of a final reduced chamber are attained in mature stages which live below 200 meters in depth.

The concentration of planktonics in bottom sediments of Hudson Bay probably increases toward the entrance of Hudson Strait where more typical marine conditions exist.

Foraminiferal Distribution

Near-Shore

Station 69 on the west side of the bay and station 90 on the east side are the shoreward stations in the cross-section. _Eggerella advena_ represents approximately 50 per cent of the foraminifera at these stations, and is relatively unimportant elsewhere in the section (see figure 5). The depth range of important occurrences of _E. advena_ in Hudson Bay, from this study, is 33 to 52 meters. This agrees well with investigations by Phleger (1952) in the Arctic Islands, who reported this species from eleven stations, ten of which were from less than 50 meters of water. Anderson (1961), in the western Arctic, reported _E. advena_ in all stations from deltaic to upper bathyal, but found the greatest occurrence on the inner shelf at depths from 22 to 48 meters.

Basins

Textularia torquata is the dominant species in the deep water stations of the section, as shown in figure 5. It is of minor importance in faunas from depths less than 100 meters. Phleger (1952) reported a similar depth relationship for this species. Other foraminifera found in important numbers only in the deep water stations are Adercotryma glomerata, Reophax curtus, and Nonion zaandamae.

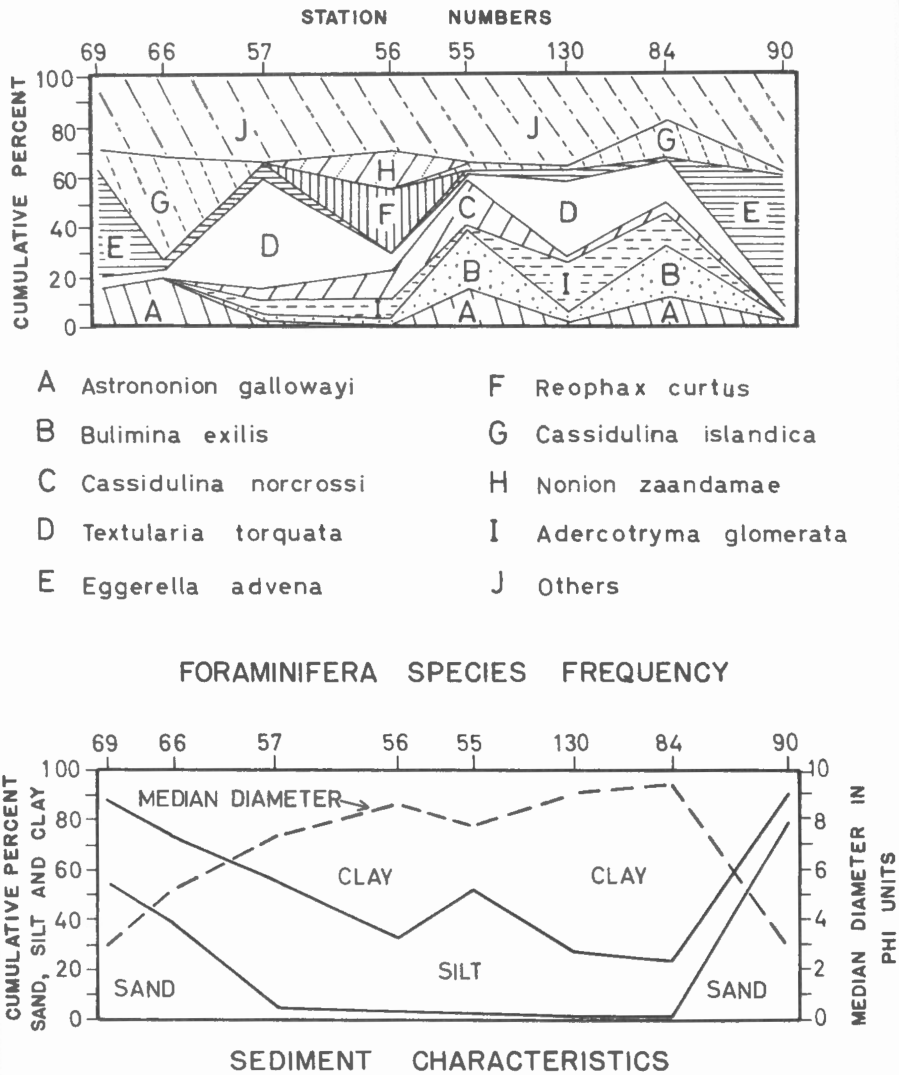
Central Shoal

The foraminiferal fauna of the central shoal differs greatly from those of the adjacent areas. Hyaline tests make up 88 per cent of the population, contrasted to 27 per cent at station 56 to the west, and 13 per cent at station 130 to the east. Station 57, farther to the west, is only 15 meters deeper but has a completely different fauna. Since only 6 per cent of the foraminifera at station 55 were living, it is possible that shallow water species have been transported down-slope from higher on the shoal.

Cassidulina norcrossi is an abundant species from station 55, as is Bulimina exilis and Astrononion gallowayi. The only occurrence of Dentalina baggi was also at this station, and the large specimens of this species (some longer than 2 mm) were quite distinctive. This was also the site of the only important occurrence of Nonionella labradorica, and the environmental conditions must be favorable to its growth as many of the specimens were living and of robust size.

Ice Rafting

Many authors have reported on sediment transportation by drift



HUDSON BAY
FORAMINIFERA AND SEDIMENT DISTRIBUTION

FIGURE 5

ice as an important factor that influences the character of bottom deposits in polar regions. Inasmuch as foraminifera are part of the bottom sediment, ice transport will have a great effect on their distribution. Phleger (1952) described mixing of faunas due to ice rafting around the Arctic Islands which resulted in masking the true depth zonation of the foraminifera involved.

In the section across Hudson Bay ice rafting appears to be of minor importance. The current pattern in the bay is such that only the southwestern regions are strongly affected. In this area the currents trend offshore and large tides grind the ice into the bottom. An analysis of the sediment from each station was made and the effect of ice rafting was considered. The per cent of material in the sample greater than 2 mm in diameter is believed to be a good indication of rafting importance since it is probable that such material occurring far from shore was deposited in this way. At station 69, 33 per cent of the sediment was larger than 2 mm; at station 66, sediment coarser than 2 mm composed 14 per cent of the sample, and samples from all the other stations contained either a small fraction of a per cent or no material of this size. Concentration of ice-rafted material mainly on the west side of the bay was confirmed by investigation of 90 other samples throughout the bay.

Foraminiferal evidence agrees with these data as far as can be interpreted from this study. The shallow and deep water populations are distinctive and show little evidence of masking. However, an investigation of the foraminiferal populations in depths shallow enough to be disturbed by the ice is necessary to determine the distribution of species from these shallow depths throughout the remainder of the bay. Also, samples of sediment from drift ice should be examined to determine the foraminifera they contain.

Relationship of Foraminifera to Bottom Sediments

As shown in figure 4, the median diameter of the bottom sediments decreases progressively from station 69 on the west side of Hudson Bay to station 56 in the west central portion of the bay. There is a slight increase in sediment size at station 55 on the western slope of the central shoal, then a decrease to station 84 which is 100 miles from the eastern shore of the bay. This sediment pattern agrees with the current circulation in the bay, which trends offshore on the west and along shore on the east. It is evident that circulation within the bay, rather than adjacent land topography, is the controlling factor in sedimentation, since the eastern coast is much more rugged than the lowland area on the west.

In general, it appears that sediment type is not a major factor influencing foraminiferal distribution in the bay. Eggerella advena is found at both shallow ends of the section where there is an abundance of sand. However, it has been reported from similar depths in many regions of the Arctic, some of which in all probability have different sediment types.

Reophax curtus is an arenaceous species that makes its test from large sand grains, yet it is found in abundance only at station 56 where the sediment contains less than 5 per cent sand. It is evident that this animal could find material for its test much more easily in a sand environment, but prefers its present location for other reasons.

OSTRACODS, DIATOMS, AND RADIOLARIANS

Ostracods are present in samples from only the two western stations of the section. Both ornamented and smooth-shelled species were observed. Most of the specimens were living and all are about the same size. The ostracod number in the two samples is much lower than the foraminiferal number. Several large rivers empty into the west side of Hudson Bay, and they may have an influence on the ostracod population.

Diatoms are present at all the stations, but are most abundant at stations 66 near the west coast. Large runoff from adjacent land areas and current concentration within the bay may provide more nutrients in this area.

None of the samples contained radiolarians. This is not surprising since even at depth the highest salinity is only $32^{o}/oo$, and at the surface in the summer it ranges from $27^{o}/oo$ at the eastern end of the section to $30^{o}/oo$ at the western end. If any radiolarians are present in the bay they would be nearer the entrance to Hudson Strait where water conditions more nearly approach normal marine.

CONCLUSIONS

1. There are three distinctive foraminifera faunas in an east-west cross-section of Hudson Bay: (a) near shore; (b) central basins, and (c) central shoal.

2. Eggerella advena is dominant at stations on either end of the section, in depths from 33 to 52 meters. Abundance of E. advena at this depth range is typical throughout the Arctic, and it is an important member of Anderson's (1961) Inner Shelf Fauna.

3. Planktonic Foraminifera are represented by the lone species Globigerina pachyderma, which is present at only three stations and in numbers less than 1 per cent. The tests represent all stages of growth and are thin-shelled, which agrees with Bé's (1960) report that thick, crystalline tests in G. pachyderma indicate a living depth greater than 200 meters.

4. The fauna from the deep stations in the section are characterized by high percentages of Textularia torquata. The findings in Hudson Bay agree with the work of Phleger (1952) who reported only one occurrence of this species at depths less than 100 meters around the Arctic Islands.

5. The central shoal in Hudson Bay has a distinctive fauna including high percentages of Cassidulina norcrossi, Bulimina exilis, and Astrononion gallowayi. The fauna is composed of 88 per cent hyaline tests as compared to 27 per cent and 13 per cent at adjacent stations to the east and west.

6. Ice rafting has had little effect upon foraminiferal

distribution. Evidence from sediment studies indicates that only the two stations farthest west have been influenced. The current pattern and large size of the bay tend to reduce faunal masking by ice rafting.

7. Sediment size is closely related to bottom topography and current direction in the bay. Since the grain size and bottom topography are related, the foraminiferal population varies with both.

8. Ostracods occur at station 69 and 66 at the western end of the section. Influx of food from the western rivers may affect their distribution.

9. Centric and pennate diatoms are present in all the samples, but are abundant only at station 69 on the western side of Hudson Bay. Heavy runoff and current concentration probably increase nutrient content in the water of this region, which enables the support of a large diatom population.

10. Radiolarians were not found in any of the samples, and if they are living in Hudson Bay it is probably near the entrance to Hudson Strait where more normal marine conditions exist.

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APPENDIX

FAUNAL REFERENCE LIST

Planktonic Species

Globigerina pachyderma (Ehrenberg) - Aristerospira pachyderma Ehrenberg, 1861, K. Akad. Wiss. Berlin, Monatsber., 276 pp.

Benthonic Species

Adercotryma glomerata (Brady) - Lituola glomerata Brady, 1878, Ann. Mag. Nat. Hist., ser. 5, v. 1, p. 433, pl. 20, fig. 1a-c.

Alveolophragmium crassimargo (Norman) - Haplophragmium crassimargo Norman, 1892, Museum Normanianum, pt. 7-8, p. 17, pl. 35, fig. 4.

Angulogerina angulosa (Williamson) - Uvigerina angulosa Williamson, 1858, Roy. Soc., p. 67, pl. 5, fig. 140.

Astrononion gallowayi Loeblich and Tappan, 1953, Smithsonian Misc. Coll., v. 121, p. 90, pl. 17, figs. 4-7.

Bolivina pacifica Cushman and McCullock - Bolivina acerosa Cushman subsp. pacifica Cushman and McCullock, 1942, Allan Hancock Pacific Expeditions, v. 6, n. 4, p. 185, pl. 21, figs. 2-3.

Buccella tenerrima (Bandy) - Rotalia tenerrima Bandy, 1950, Jour. Pal., v. 24, n. 3, p. 278, pl. 42, fig. 3.

Bulimina exilis Brady - Bulimina elegans d'Orbigny subsp. exilis Brady, 1884, Rep. Voy. Challenger, v. 9 (Zoology), p. 399, pl. 50, figs. 5-6.

Cassidulina islandica Norvang, 1945, The Zoology of Iceland, v. 2, pt. 2, p. 41, figs. 7-8.

Cassidulina laticamerata Voloshinova, 1939, In Fursenko, A.V. (ed.), Neftinayi geologorazvedochnyi Institut, Trudy (Transactions of the Oil Geological Institute), ser. A, fasc. 116, p. 84 (Russian), 88 (English).

Cassidulina norcrossi Cushman, 1933, Smithsonian Misc. Coll., v. 89, n. 9, p. 7, pl. 2, fig. 7.

Cibicides lobatulus (Walker and Jacob) - Nautilus lobatulus Walker and Jacob, 1798, in Kanmacher, F., Adam's Essays on the microscope, ed. 2, p. 642.

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STATION LOCATIONS

Station Number	(n) Latitude	(w) Longitude
55	58° 51'	85° 50'
56	59° 01'	87° 49'
57	59° 19'	91° 10'
66	59° 21'	93° 00'
69	59° 20'	94° 34'
84	58° 35'	81° 14'
90	58° 25'	78° 17'
130	58° 41.5'	83° 25'

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