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SEDIMENTOLOGY OF HUDSON BAY DISTRICT OF KEEWATIN 34, 44, and 54

(Report and 11 figures)

R. J. Leslie

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INTRODUCTION

During the summer of 1961 the Marine Sciences Branch and the Geological Survey of Canada initiated a study of physical oceanography and marine geology in Hudson Bay. The purpose of this paper is to report on the marine geologic phase of the investigation.

Hudson Bay is in north central Canada and is connected to the Atlantic Ocean by Hudson Strait (Figure 1). The bay has an area of about 520,000 sq. km, an average depth of 90 meters, and a maximum depth of about 280 meters. It is a modern example of the epeiric seas which periodically covered the continent in the geologic past.

Southampton, Coats, and Mansel Islands lie in the north-eastern part of the bay, and the main ship routes pass between them. Off the eastern shore the principal island groups are the Ottawa, Sleepers, Nastapoka, and Belcher Islands (Figure 2). There are no islands off the west coast except Marble Island and a few other small islands well to the north of Churchill.

The first geologist to explore the regions around Hudson Bay was Robert Bell of the Geological Survey of Canada. He worked in the area from 1875 until 1880, and traversed the country from the shores of Lake Huron to Moose Factory on James Bay. He also examined much of the coast of James and Hudson Bays, and explored the valleys of the Churchill, Nelson, Hayes, Attawapiskat, Albany, and Moose Rivers, describing the Paleozoic rocks of the region.

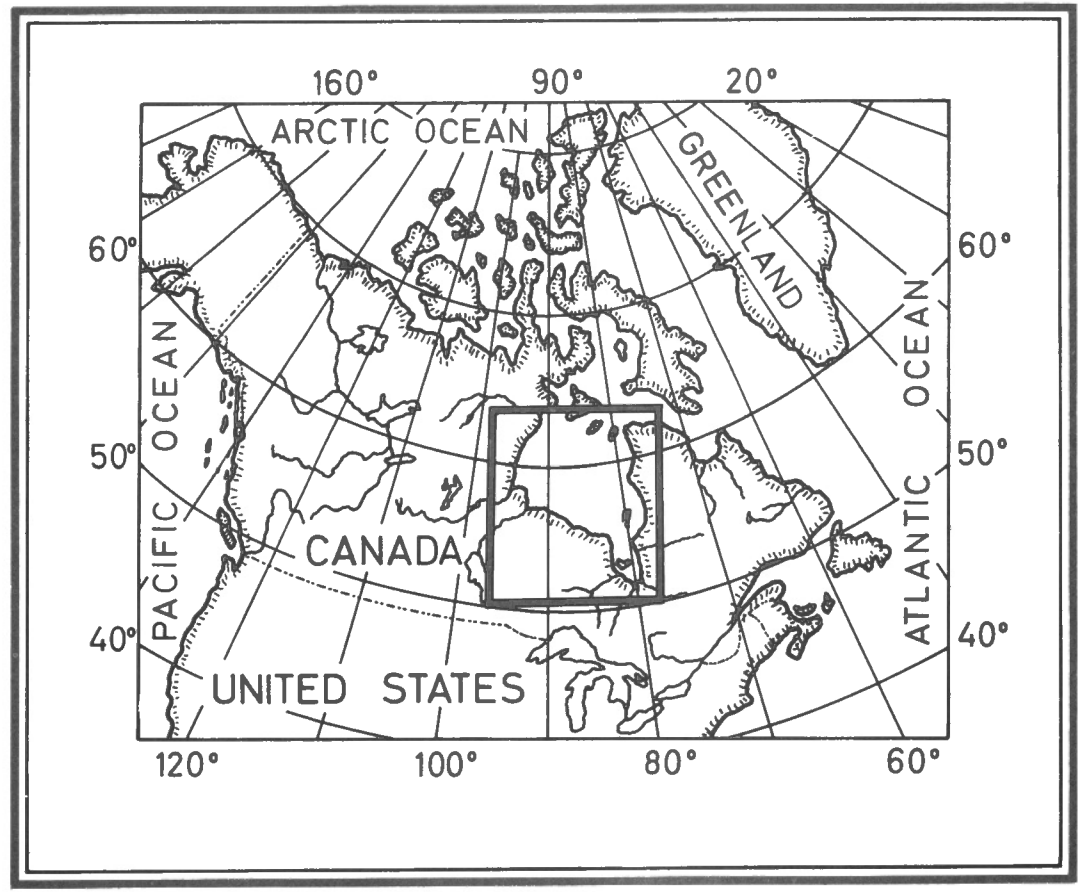

Fig. 1 Location map with Hudson Bay area outlined.

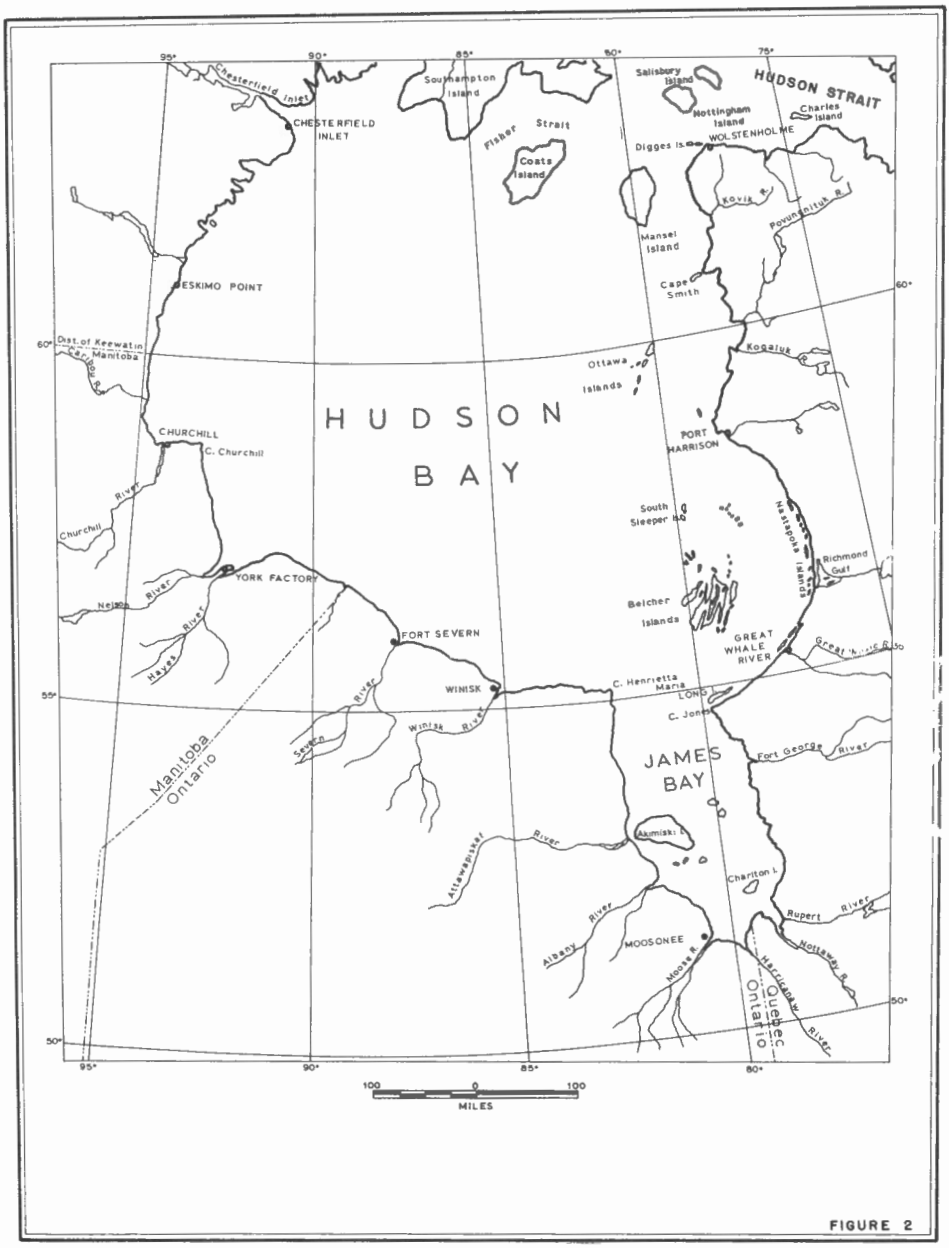

FIGURE 2

Fig. 2 Detailed location map of outlined area in Fig. 1.

In 1897, Tyrrell mapped most of the eastern coastline of Hudson Bay, and Lowe (1902) explored the coastline from Cape Wolstenholme to the south end of James Bay. Lowe (1906) also was geologist on Neptune in 1903 and 1904 during a scientific cruise in Hudson Bay, and described much of the geology and geomorphology of the northern coasts. Dowling (1902), Wilson (1903), Camsell (1905), O'Sullivan (1906), Dobbs (1906), and Baker (1911), did geologic mapping in the area, and Miller (1912) made a comprehensive report on all the previous work.

McInnes, in 1913, prepared a report on the basins of the Nelson and Churchill Rivers that covered 220,000 square miles, and included his own work and that of his predecessors. The Paleozoic rocks of the James and Hudson Bay region were discussed by Van Tuyl and Savage in 1919.

McLearn (1927) and Dyer (1929) reported on the strata exposed along the rivers west and south of James Bay, and Dyer and Crozier (1933) studied the Onakawana lignite field.

From 1948 to 1951, under the auspices of the Ontario Department of Mines, three vertical diamond drill holes were drilled for the purpose of providing additional information on the thickness and age of the sedimentary succession in the general James Bay Lowlands area. Martinson (1953) reported on the results of this operation.

Nelson (1950) examined the geology of the Churchill, Nelson, North, and South Knife River areas. This work extended the known distribution of Ordovician and Silurian strata an appreciable distance northward. The Devonian section of the James Bay Lowland was investigated by Fritz and Cranswick (1953).

Oceanographic features of the bay have been studied mainly by Hachey. In 1931 he described the general hydrography and hydrodynamics, and in 1935 discussed the circulation of water within the bay. Bajkov (1941), Lamont (1949), and Keith (1959) investigated ice conditions within the bay, and Trask (1932) described the sedimentary characteristics of several bottom samples taken from shallow water near the east coast. Forgeron (1958) reported on the sedimentology of Foxe Basin and the western entrance to Hudson Strait, and Campbell and Collin (1956) studied the oceanography of Foxe Basin. In 1960 Grainger discussed some oceanographic features of James Bay and southern Hudson Bay.

This report is part of a thesis[1] submitted to the University of Southern California. The writer wishes to express his gratitude to Dr. Kenneth O. Emery, formerly of the University of Southern California and now at Wood's Hole Oceanographic Institution, for assistance and recommendations. Many thanks are due F. G. Barber who was senior scientist on the Hudson Bay cruise, and to the captain and crew of M/V Theta from which samples were taken. Appreciation is extended to Dr. B. R. Pelletier of the Geological Survey of Canada, who directed the geologic portion of the project, and to John Butters, Jim Whittaker, Harry MacPhail, John Mackay, Al Stewart, and Carl Johnston of the Marine Sciences Branch, who gave untiring aid in the collection of samples. Special thanks are reserved for Dr. Orville L. Bandy, Dr. Richard O. Stone, and Dr. Donn S. Gorsline, of the University of Southern California, for their interest and for critical reading of the manuscript. All of the laboratory research involved in this report was conducted at the Allan Hancock Foundation of the University of Southern California.

1) Sedimentology and Foraminiferal Trends of Hudson Bay, Canada; M.S. Thesis, Department of Geology, University of Southern California, Los Angeles, California, 1963.

REGIONAL GEOLOGY AND GEOMORPHOLOGY

Hudson Bay is in the middle of the Canadian Shield (Figure 3). Most of the eastern side of the bay is bordered by hills rising from the shoreline to elevations of 2000 feet. These hills are underlain mainly by Archeozoic granite gneiss. A belt of folded Proterozoic metasedimentary rocks cuts the coast at Cape Smith, and there is a thin band of basic Proterozoic intrusive rocks fringing Richmond Gulf (Lowe, 1902). Granite gneiss of Archeozoic age underlies most of the region north of Churchill on the western side of the bay. Patches of Archeozoic volcanic and metasedimentary rocks occur within the gneiss, and some Proterozoic rocks crop out just south of Chesterfield Inlet (Harrison, 1957). In the souther part of Hudson Bay, the Belcher Islands represent a Proterozoic fold belt where interbedded lava, dolomite, and sedimentary iron ore are exposed.

Paleozoic rocks crop out on the southwest side of Hudson Bay from Churchill to the southern end of James Bay (Nelson, 1950). In this region are Ordovician, Silurian, and Devonian rocks, composed mainly of limestone and dolomite. There are also two patches of Mesozoic rocks of Upper Jurassic or Lower Cretaceous age that are composed mainly of terrestrial shale and siltstone with some interbedded coal (Dyer and Crozier 1933). The area occupied by the sedimentary rocks has subdued relief and is called the Hudson Bay Lowlands

Mansel Island and parts of Coats and Southampton Islands are also underlain by Paleozoic carbonate rocks (Lowe, 1906), and the eastern contact between Paleozoic and Precambrian rocks occurs under the waters of Hudson Bay.

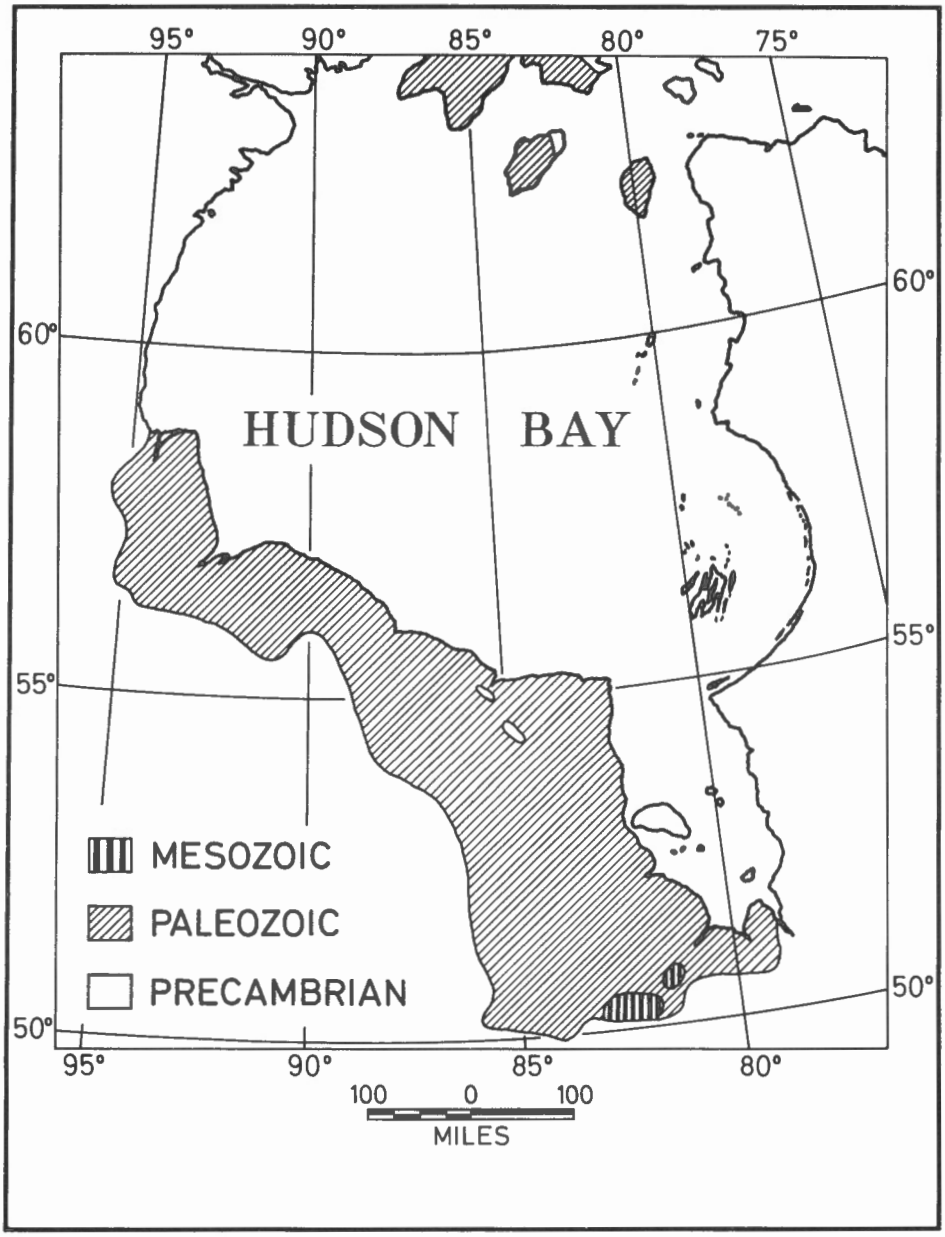

Fig. 3 General geology of the Hudson Bay area (Modified from: Anonymous, 1955).

OCEANOGRAPHY

Bottom Topography

Hudson Bay is a large, shallow, dish-shaped body of water with an average depth of 90 meters and a maximum depth of about 280 meters. G. A. Bell, as early as 1881, noted the remarkably smooth topography over most of the bay when he said, "that if, through any convulsion of nature, this vast basin was to be drained, we would find an immense plateau similar to the prairies of the west." However, the topography of the bay is not as simple as the above description would indicate, and an increased knowledge of the bathymetry revealed several interesting features.

In the central and northern parts of the bay there is an irregularly shaped basin with depths exceeding 200 meters, and with a trough extending from it towards Hudson Strait (Figure 4). The trough is thought to be the main channel of a submerged drainage system which once drained the area now covered by the water of the bay. There are indications that the channels of rivers flowing into the west side of the bay extend many kilometers into the bay, and converge to join the main channel leading into Hudson Strait. Another interesting topographic feature is the deep hole or trough located just off the northern shore of Digges Islands in the western end of Hudson Strait. The maximum depth of the trough is about 540 meters which is much deeper than any part of Hudson Bay. Glacial ice moving out of the bay presumably deepened the trough. In the center of the bay is a prominent shoal area of less than 50 meters depth that is surrounded on all sides by depths greater than 150 meters.

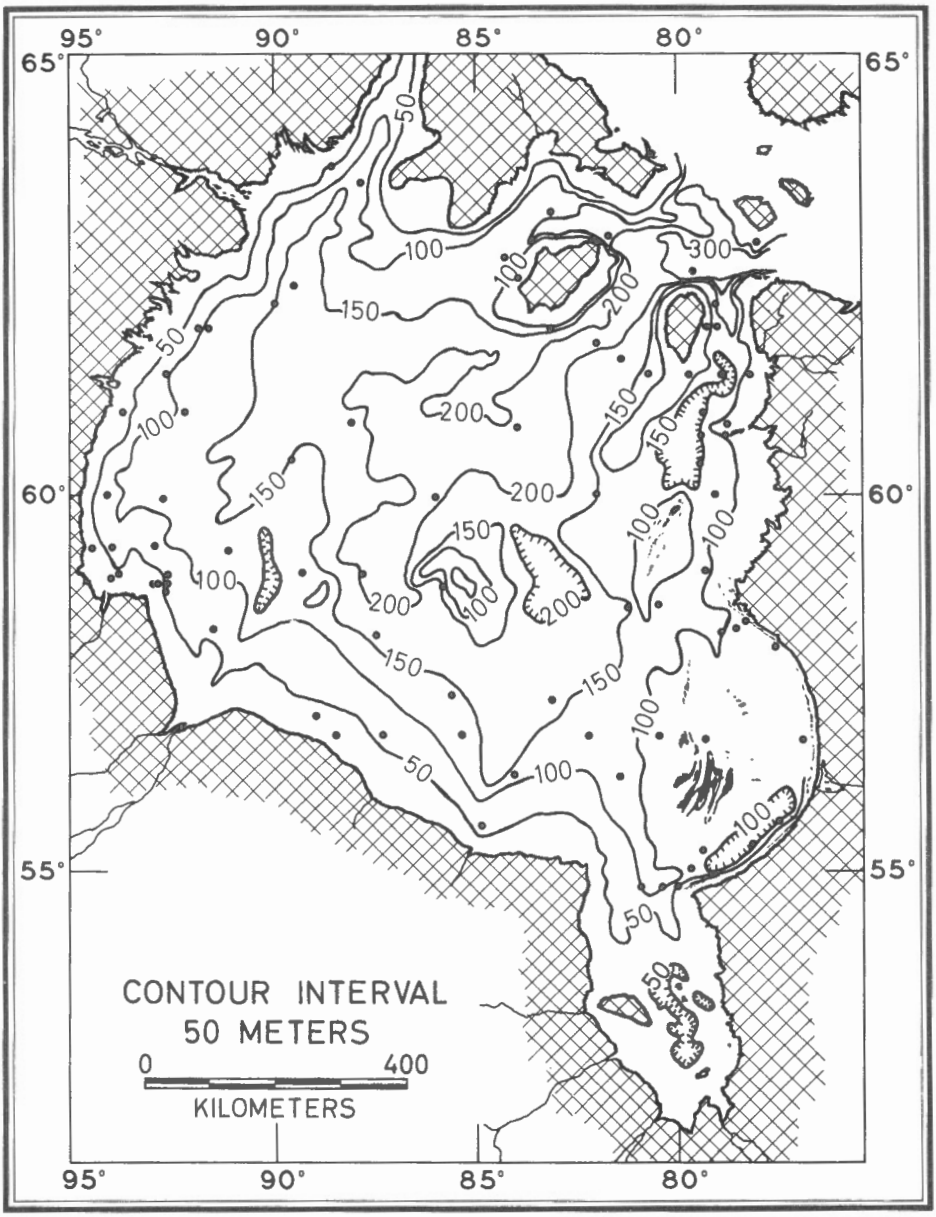

Fig. 4 Bottom topography of Hudson Bay (Contoured from soundings on Map 5000, Canadian Hydrographic Service, 1957).

Lithology is a controlling factor of the topography in much of Hudson Bay. On the southwest side the water is extremely shallow, islands are absent, the bottom is smooth and is underlain by flat-lying Paleozoic sedimentary rocks. In the eastern portion of the bay the water deepens rapidly offshore, the bottom is very irregular, and there are many islands. This area is underlain by folded Proterozoic metasedimentary rocks and Archeozoic crystalline rocks. It appears possible to determine the location within the bay of the contact between the Paleozoic and Precambrian rocks by observing where the change in bottom topography occurs.

Water Circulation and Tides

Water circulation in Hudson Bay is in a counterclockwise 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 (Figure 5). 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 3 1/2 to 6 meters (Manning, 1951). At Cape Henrietta Maria to the south the tidal range is about 2 meters, whereas on the east side the range is a maximum of 1 meter.

Water Temperature and Salinity

During the summer the surface 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).

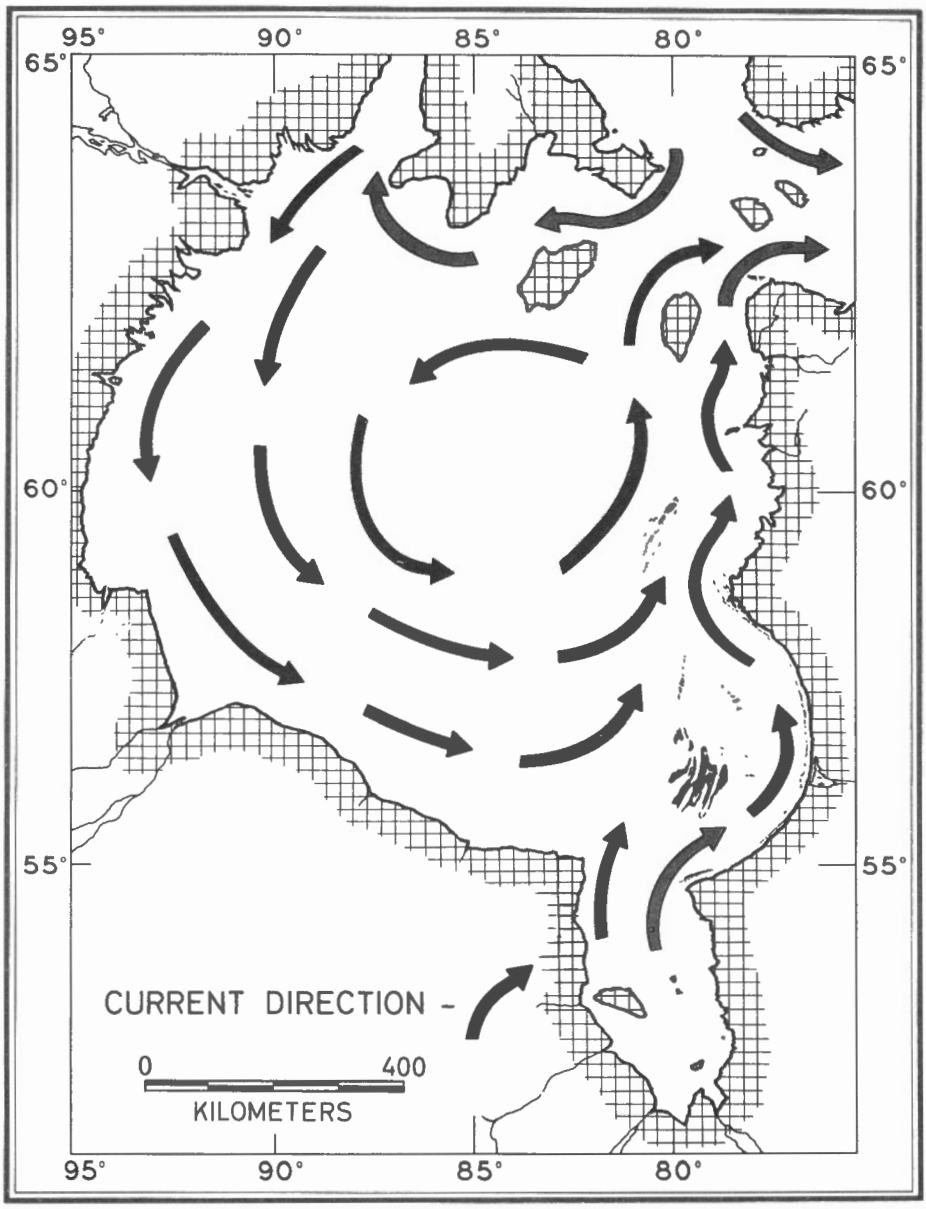

Fig. 5 Current directions in Hudson Bay during the summer (from Hachey, 1935).

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, runoff from the land diminishes and cooling of the surface water results in mixing with the deeper water. When ice forms on the surface the underlying water is fairly uniform from top to bottom.

Ice Conditions

Ice usually begins to form along the shores of Hudson Bay in October or early November, and it is not uncommon to observe ice 1 meter 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 (Anonymous, 1954). However, after a severe winter, ice may persist in some parts of the bay well into August.

SEDIMENTATION

Bottom samples from 85 stations in Hudson Bay, which were obtained with a Dietz-Lafond bottom snapper, form the basis for the sedimentological study (Figure 6). Size analyses were made on all the samples. The material less than 2 mm but greater than 0.062 mm in diameter, or the sand-size fraction, was analysed by using an Emery settling tube (Emery, 1938). The fraction of the sample less than 0.062 mm in diameter, or the silt and clay fraction, was analysed by the pipette method (Krumbein and Pettijohn, 1933). Rock fragments greater than 2 mm in diameter were removed and studied separately

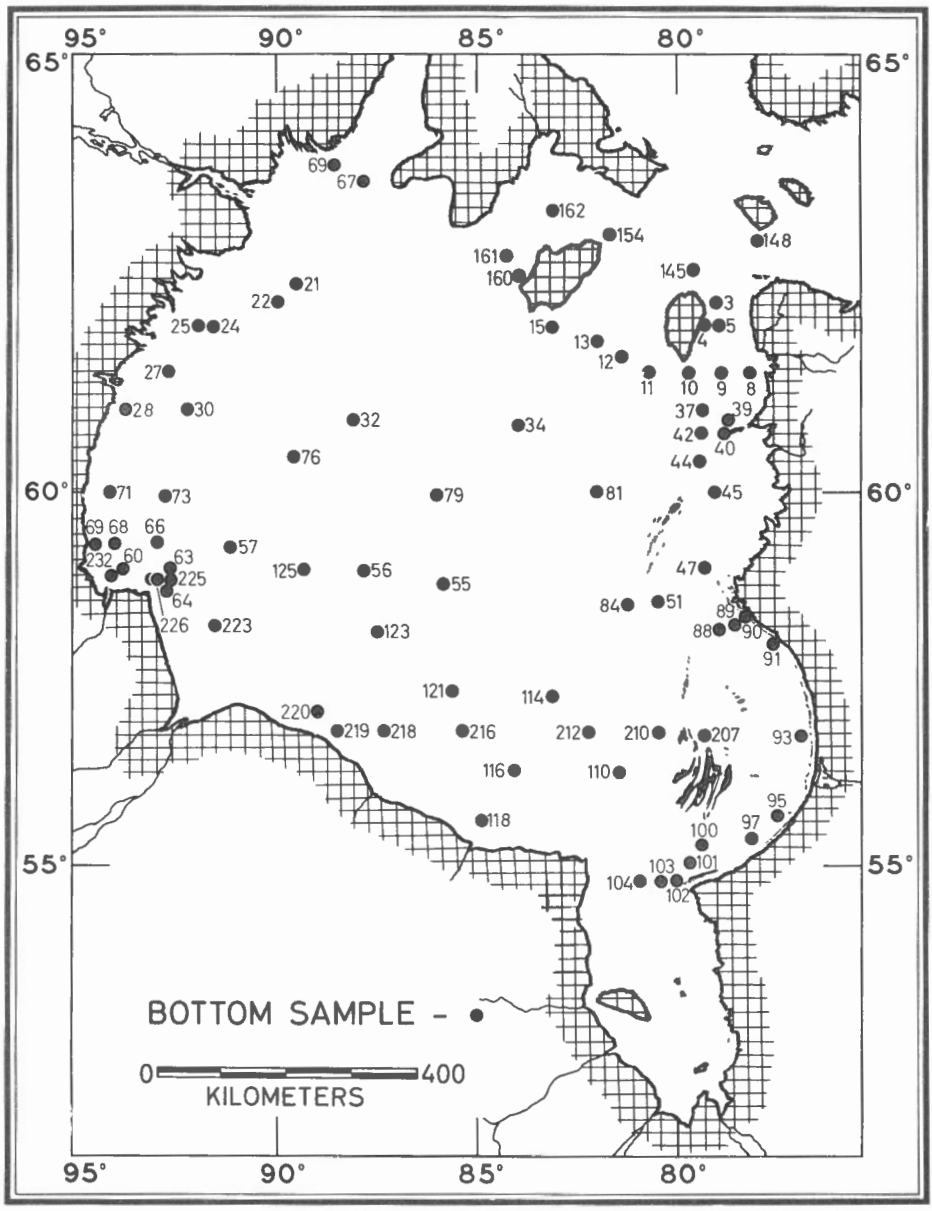

Fig. 6 Location of bottom samples taken from the M/V THETA in the summer of 1961.

as it is probable that such material occurring far from shore was deposited by ice rafting. Color of the sediment was estimated from the Rock-Color Chart of Goddard and others (1948). Calcium carbonate percentages in the sediment were determined by digestion of the sample in dilute hydrochloric acid. It is probable that a portion of the material that dissolved was magnesium carbonate. Organic carbon in the sediment was determined by means of the Leco Carbon Analyser. Carbonate carbon was first removed by digestion in dilute hydrochloric acid, and the remaining sediment and organic matter was burned in a closed system with a constant oxygen supply. The resulting carbon dioxide was measured and this measurement was then converted to give the percent of organic carbon in the sample. Carbon values can be converted to percent organic matter by multiplying by the factor 1.7 (Emery, 1960).

Ice-Rafted Sediment

The material in the sample with a diameter greater than 2 mm was classified as ice-rafted sediment. This coarse fraction is mainly composed of subangular fragments, and inasmuch as the majority of the samples were taken at distances greater than 30 kilometers from the shore, rafting is the logical agent of deposition. Such coarse material was separated because a single large pebble in a silt sample would greatly increase the medium diameter for that sample and thus mask the distribution pattern of the water-deposited sediment.

The shallow regions around Southampton, Coats, and Mansel Islands and off the southwest coast of the bay are the areas most influenced by ice rafting (Figure 7). In these regions high tides, which grind the ice into the bottom, and off-shore trending currents combine in transporting material. On the east side of the bay lower tides and currents trending alongshore tend to reduce rafting.

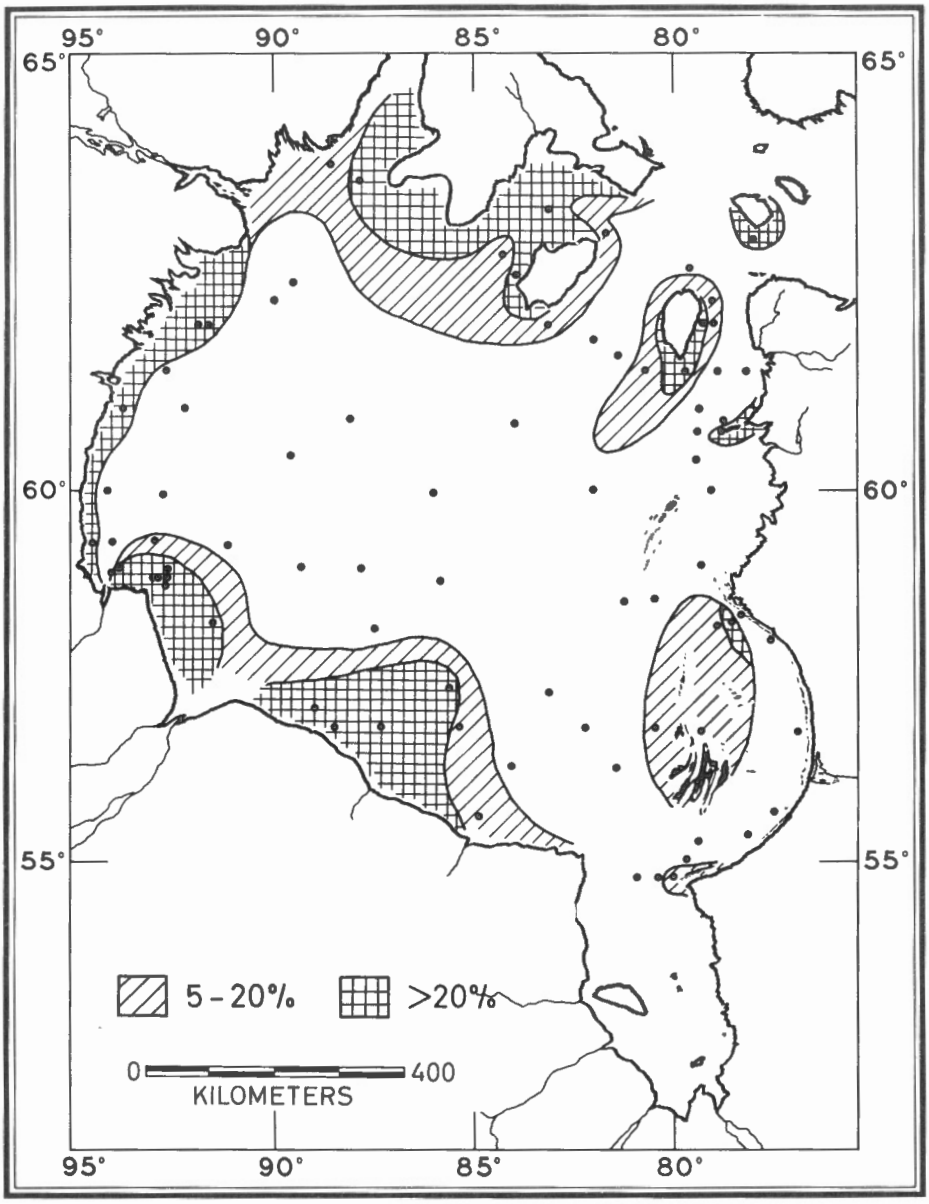

Fig. 7 Percent of ice-rafted material in the bottom sediments of Hudson Bay.

Examination of the ice-rafted material shows that most of it has a fairly local source. The portions of the bay which are bordered by carbonate rocks are characterized by rafted carbonate fragments, whereas the regions bordered by basic igneous rocks have rafted basic igneous material.

Ice rafting was mentioned by Perry (1961) in the Arctic Archipelago, and by Forgeron (1959) in Foxe Basin, as a major agent of sedimentation. Phleger (1952) stated that ice rafting of foraminifera had masked the depth ranges of benthonic foraminifera in the seas around the Arctic Islands. Similar masking of foraminiferal depth ranges was not found in central Hudson Bay (Leslie, 1963), and rafting is not an important agent of sedimentation in this central region. The large size of the bay, the tidal variations, and the current pattern are factors that limit the concentration of rafted material mainly to the southwestern and northern coastal regions.

Sediment Distribution

Distribution of bottom sediment less than 2 mm in diameter, or the predominantly water-deposited material, is shown in Figure 8. The major trend is from coarse material on the west side of the bay to fine material on the east. Two areas of clay bottom, the finest sediment in the bay, are located north and south of the Ottawa Islands near the east side of the bay. This is not the pattern which would be expected if the surrounding land topography played an important part in the sediment distribution, as the eastern shore is bordered by hills rising from the water's edge to a height of more than 1000 feet and the western shore is bordered by a gently sloping plain. High tides and corresponding tidal currents on the western side of the bay, as well as a general offshore current trend, are factors contributing to the deposition of coarse sediment in the area. Also larger rivers flow in to the western part of the

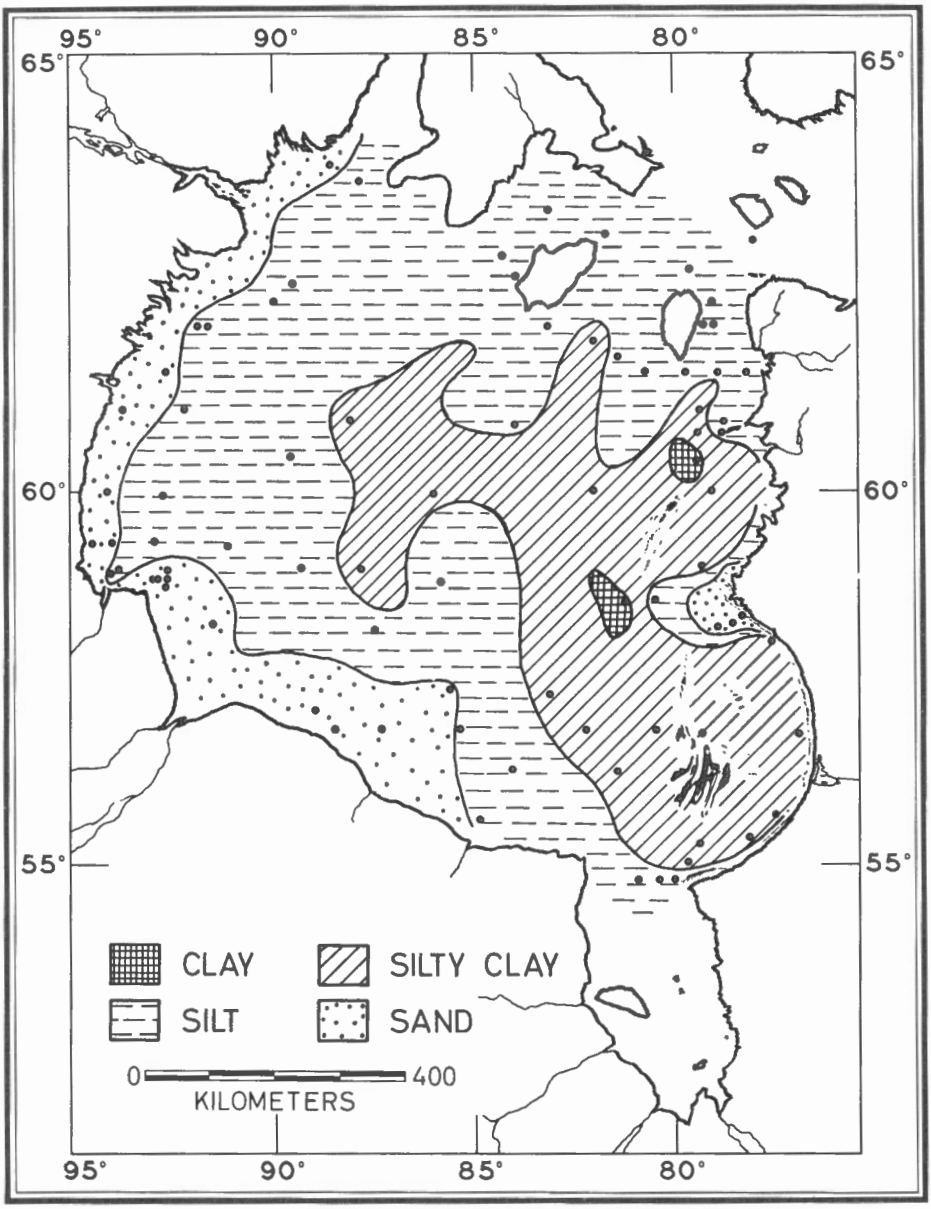

Fig. 8 Distribution of bottom sediment finer than 2 mm. in diameter, or the predominantly water-deposited material.

bay than in to the east, and carry coarse material from the many raised beaches and glacial deposits. When sediment reaches the clay areas near the Ottawa Islands it has been carried across the bay and all the coarse particles have settled out. Silt-size sediment is present in the submarine extensions of the river valleys on the west coast. These deeper regions are not as strongly affected by currents as the adjacent shallows, and thus provide a site for accumulation of finer sediment.

North and east of James Bay the bottom sediment consists mainly of medium grey silty clay. At Portland Promontory near Port Harrison the currents, which generally trend alongshore in the east, veer westward. This change results from the termination of the great arc in the southeastern coastline. In this region where the current trends offshore there is a corresponding increase in the sediment grain size. Elsewhere along the east coast the sediment close to shore is composed of fine grained, well sorted sand with a high quartz content.

Sediment Color

The northern and northwestern portions of the bay, the central shoal, and the northeastern coast have olive-green bottom sediment (Figure 9). This sediment is composed mainly of silt-size material with wide ranges of calcium carbonate content and organic matter. In the northwest portion there are small black spots in the sediment up to 0.5 cm in diameter. These represent reducing microenvironments around organic material in the sediment.

Off the southwest coast of Hudson Bay light olive-gray sediment is present. The material is of sand size, calcium carbonate percentages are between 30 and 50 per cent, and organic content is low. Color is due to detritus, much of which is limestone and dolomite. Fine sediment in the submarine extensions of the valleys of the Churchill, Nelson, and Winisk Rivers is olive green, similar to the sediment farther out in the bay.

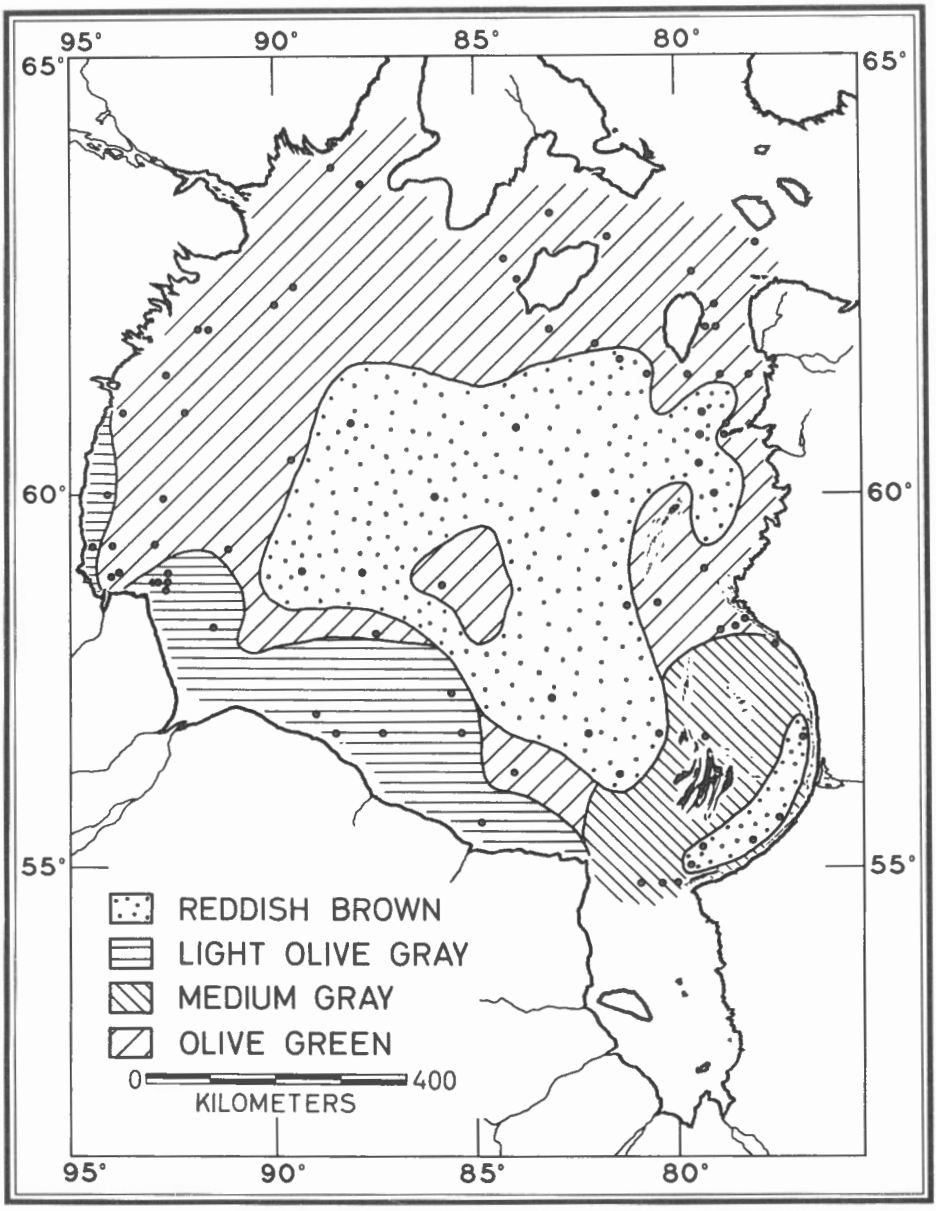

Fig. 9 Color of bottom sediments of Hudson Bay.

James Bay is the source of medium-gray sediment along the southeast coast and around the Belcher Islands. Rivers flowing in to James Bay drain the region to the south which is underlain by soft Mesozoic shales and siltstones. Much of this fine detritus is carried into James Bay and thence into Hudson Bay.

In the large central basin of the bay and in the trough between the Belcher Islands and the east coast reddish brown sediment is present. Sediment of this color is confined to the deep regions of silty clay and clay. The reddish brown zone has a maximum thickness of 8 cm. in the basin north of the central shoal, and thins in all directions from there. Origin of the layer is due to oxidation of slow settling sediment in water of high oxygen content. A reddish brown veneer is a common feature in the north, and has been reported from the Kara, Barents, and White Seas (Brunjevicz, 1938; Klenova, 1938).

Calcium Carbonate

There are three sources of calcium carbonate in the sediments of Hudson Bay: (1) shell material, (2) detrital limestone and dolomite fragments, and (3) redeposited glacial rock flour. In the region south of Southampton Island the percentage of calcium carbonate in the sediment is greater than 50 per cent (Figure 10). This high percentage is due primarily to detrital fragments of limestone and dolomite rafted from the shore. As a comparison, rocks with a composition similar to the sediment of this region would be classified as calcareous siltstone or silty limestone.

Sediment off the southwest coast of the bay contains 30 to 50 per cent calcium carbonate. This region is bordered and underlain by Paleozoic carbonate rocks that are the source for much of the calcium carbonate.

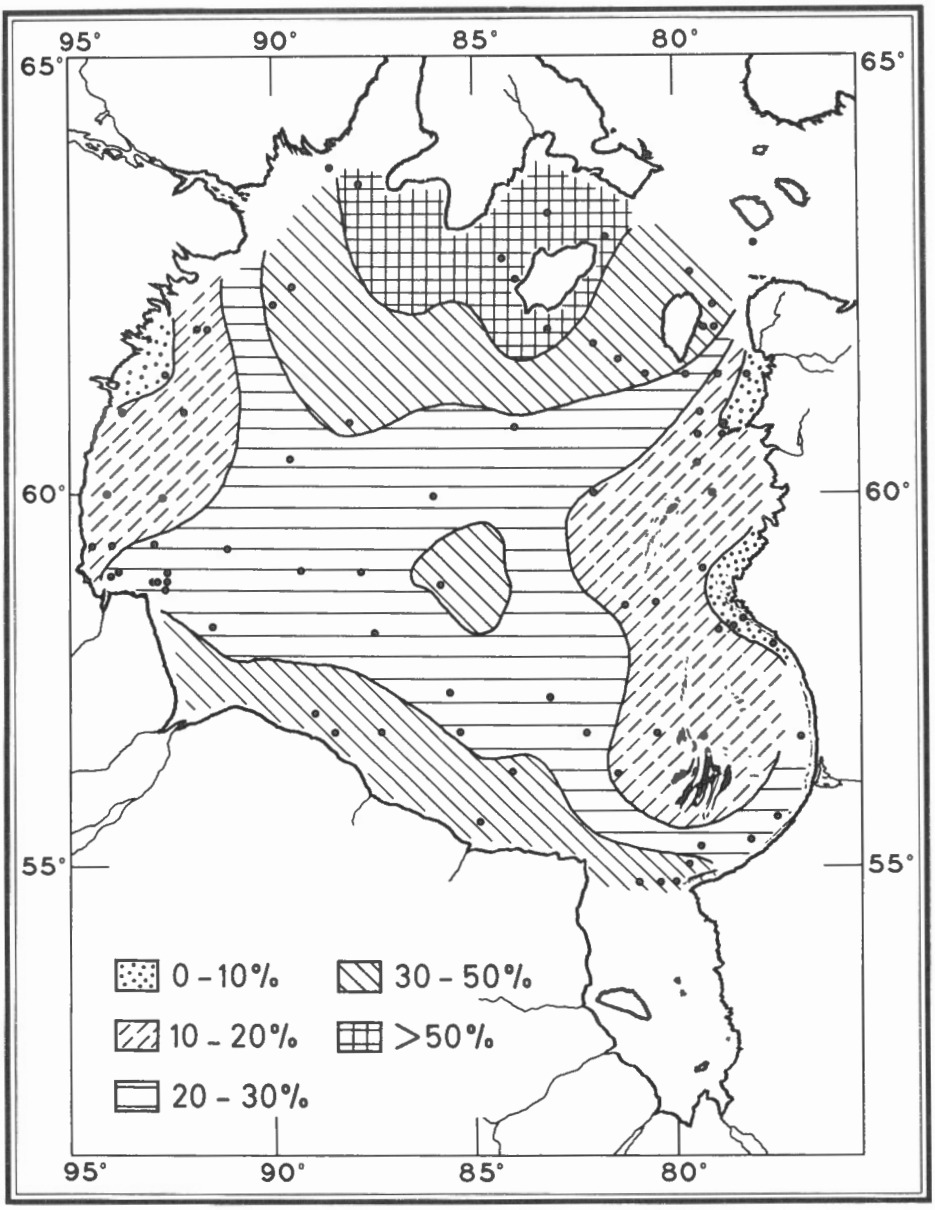

Fig. 10 Calcium carbonate percentages in the bottom sediment of Hudson Bay.

Also, along the coast are exposures of till. Glacial rock flour in the till contains a considerable amount of powdered calcium carbonate that is redeposited in the bay.

Most of the central portion of the bay has 20 to 30 per cent calcium carbonate in the bottom sediments. This region is crossed by currents from off Southampton Island and the Paleozoic areas to the south. Sediment from the central shoal has a higher calcium carbonate content than the surrounding basins. This sediment also has a higher foraminiferal number (Leslie, 1963), which could account for the increased calcium carbonate. Carbonate rocks may underlie the shoal and, if exposed, could contribute to the calcium carbonate in the sediment.

The regions of lowest calcium carbonate are off the northwest and eastern coast of Hudson Bay. These areas are bordered mainly by Precambrian igneous rocks which contribute little calcium carbonate to the sediment; also the current pattern in the bay is such that carbonate from other regions is not deposited.

Organic Carbon

The amount of organic carbon in the bottom sediment of Hudson Bay ranges from 0.14 to 0.74 per cent (Figure 11). Areas of clay near the east coast have the highest organic carbon content. These high values associated with the clay are expected as the light organic matter settles slowly and is therefore deposited with the fine detritus. High organic values also occur in the silt-size sediment in the northwest. This is a region of slow sedimentation that is relatively unaffected by ice rafting. Therefore the organic content is not masked, and black microenvironments, previously mentioned as characteristic of the sediment of this region, are an indication of the organic material present.

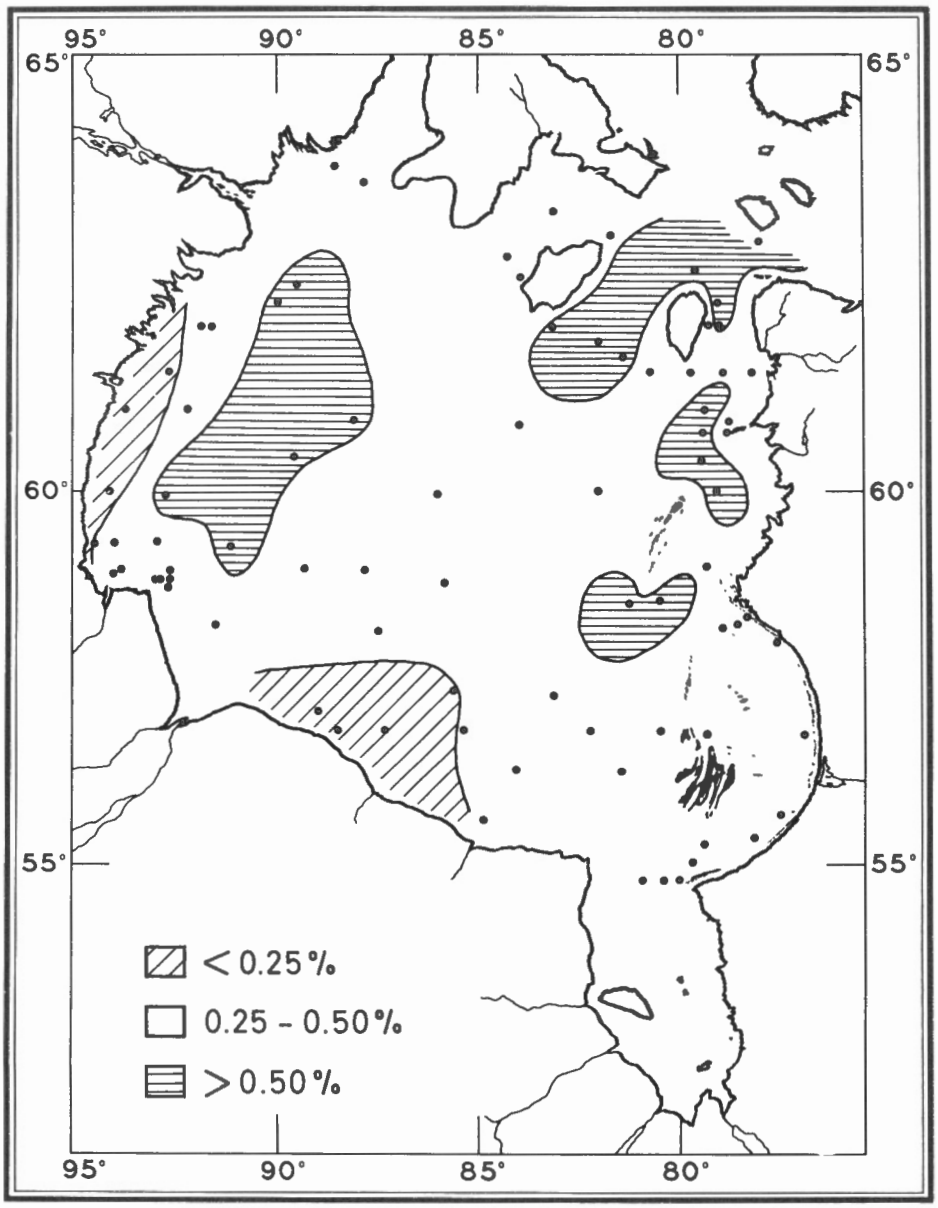

Fig. 11 Percent organic carbon in the bottom sediment.

Organic content is high in the channel between Coats and Mansel Islands. This is the western extension of the deep trough north of Cape Wolstenholme and is an area of deposition of fine sediment with corresponding high organic values.

In the central portion of the bay the organic content is from 0.25 to 0.50 per cent. The reddish brown color of the silty clay in the central basin indicates that some of the organic material has been oxidized which explains the lower values. On the west side of the bay are two regions having less than 0.25 per cent organic carbon. Sediments in these regions are the coarsest in the bay, and a corresponding decrease in the organic content is expected.

Consideration of the organic content in the entire bay gives a value comparable to the 0.9 per cent organic matter (1.7 x organic carbon) determined by Emery (1960) for the mainland shelf off southern California.

Thickness of Recent Marine Sediment in Hudson Bay

The variation in the thickness of recent marine sediment in Hudson Bay is from zero thickness in the tidal flats off the west coast, where glacial till and rock outcrop is exposed at low tide, to a few meters in the central basin. In Omarolluk Sound in the Belcher Islands a bottom corer encountered basaltic rock after passing through about 3 meters of marine clay. In the southwest bay area the Aldon depth recorder gave a second echo from what appeared to be bedrock at a depth ranging from about 4 to 7 meters below the sediment surface. In the eastern part of the bay the irregular bottom topography indicates ridges of probable rock outcrop between troughs of sedimentation. According to B. R. Pelletier (personal communication) the sediment in these troughs is up to 20 meters in thickness as indicated by sub-bottom profiles.

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APPENDIX

Station Number	Latitude North	Longitude West	Depth (m)	Median Diam.	Per Cent Org. C	Per Cent $CaCO_3$
3	62°16'	79°02'	165	0:0068	0.62	36.9
5	62°00'	79°00'	140	0.0047	0.55	39.2
8	61°26'	78°10'	55	0.108	0.14	6.4
9	61°25'	78°51'	100	0.0044	-	17.5
11	61°21.5'	80°44'	109	0.0058	0.38	28.1
12	61°37'	81°23'	185	0.0026	0.69	31.1
13	61°48'	82°00'	201	0.0054	0.62	37.1
15	62°00'	83°08'	51	0.0082	0.60	59.7
21	62°30'	89°30.5'	165	0.011	0.74	38.4
22	62°16'	90°00'	154	0.0095	0.70	30.5
24	62°00'	91°39'	95	0.041	0.46	10.6
26	62°00'	91°54'	51	0.0192	0.32	34.8
27	61°29'	92°41.5'	90	0.075	0.20	6.9
30	61°00'	92°15'	115	0.0168	0.46	14.1
32	60°54'	88°05'	168	0.0039	0.65	30.2
34	60°46'	84°00'	179	0.004	0.26	27.6
37	61°00'	79°20'	154	0.0026	0.64	16.2
39	60°51'	78°25'	97	0.0094	0.45	9.4
40	60°43'	78°47'	56	0.023	0.40	11.8
42	60°43'	79°24'	142	0.002	0.68	13.7
44	60°23'	79°25'	161	0.0017	0.71	16.5
45	60°00'	79°02'	124	0.0025	0.57	13.2
47	59°03'	79°18'	110	0.0034	0.49	10.7
51	58°37'	80°29'	119	0.0038	0.56	15.6

Station Number	Latitude North	Longitude West	Depth (m)	Median Diam.	Per Cent Org. C	Per Cent $CaCO_3$
55	58° 51'	85° 50'	100	0.0044	0.39	35.1
56	59° 01'	87° 49'	201	0.0024	0.41	23.1
57	59° 19'	91° 10'	115	0.0056	0.66	20.9
60	59° 00'	93° 54'	33	0.020	0.42	27.1
63	59° 00'	92° 40'	91	0.067	0.25	19.2
64	58° 47'	92° 43'	73	0.064	0.43	22.4
66	59° 21'	93° 00'	65	0.023	0.44	22.4
68	59° 20'	94° 04'	70	0.028	0.31	17.1
69	59° 20'	94° 34'	33	0.125	0.28	13.2
71	60° 00'	94° 10'	84	0.062	0.15	6.1
73	59° 57'	92° 46'	93	0.013	0.67	17.8
76	60° 26'	89° 36'	137	0.0175	-	22.5
79	59° 57.5'	86° 02'	280	0.0023	0.38	21.4
81	60° 00'	82° 00'	150	0.0034	0.44	17.1
84	58° 35'	81° 14'	194	0.0014	0.66	17.2
88	58° 17'	78° 53'	50	0.038	0.40	21.3
89	58° 19'	78° 32'	96	0.215	0.39	8.6
90	58° 25'	78° 17'	52	0.130	0.13	4.5
91	58° 05'	78° 33'	106	0.0004	0.39	10.4
93	56° 50'	76° 54'	88	0.0025	-	-
95	55° 43'	77° 30'	108	0.0022	0.42	24.3
97	55° 24'	78° 09'	94	0.0024	0.37	27.1
100	55° 18'	79° 24'	82	0.0023	0.43	29.6
101	55° 03'	79° 41'	96	0.0036	0.46	32.3
102	54° 46'	80° 00'	36	0.086	0.52	26.2
103	54° 46'	80° 24'	108	0.006	0.31	38.0

Station Number	Latitude North	Longitude West	Depth (m)	Mediam Diam.	Per Cent Org. C.	Per Cent $CaCO_3$
104	54° 46'	80° 58'	88	0.004	0.43	34.7
110	56° 20.5'	81° 28'	136	0.0032	0.40	19.5
114	57° 24'	83° 07'	192	0.0021	0.49	22.2
116	56° 22'	84° 04'	158	0.014	0.35	30.6
118	55° 39'	84° 55'	52	0.0115	0.26	36.9
121	57° 26'	85° 38'	102	0.054	0.19	29.3
123	58° 13'	87° 30'	180	0.0072	0.33	21.2
125	59° 02'	89° 20'	136	0.018	0.34	19.1
130	58° 41.5'	83° 25'	208	0.0018	-	-
148	62° 58'	78° 00'	180	0.287	0.48	41.5
154	63° 02'	81° 41'	252	0.0066	-	-
161	62° 49'	84° 17'	144	0.024	0.51	55.5
167	63° 37.5'	87° 52'	136	0.034	0.26	58.3
169	63° 49'	88° 34'	64	0.062	-	-
194	57° 44'	88° 36'	81	0.031	-	-
196	56° 10'	78° 58'	64	0.0076	0.43	8.9
198	55° 50'	79° 12'	56	0.0024	-	-
207	56° 51.6'	79° 18'	70	0.004	-	-
210	56° 54'	80° 26'	120	0.0026	0.49	19.6
212	56° 54'	82° 12'	120	0.0042	0.45	24.0
216	56° 54'	85° 25'	106	0.020	0.36	22.8
218	56° 54'	87° 20'	64	0.150	-	-
223	58° 17'	91° 34'	72	0.152	-	-
225	58° 53'	92° 41'	90	0.029	0.32	26.7
226	58° 53'	92° 55'	50	0.052	0.15	45.9
232	58° 57.5'	94° 04.5'	30	0.0255	0.35	22.0

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