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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 63-11

PETROLOGICAL SCIENCES DIVISION

MARINE GEOLOGY, PEARY CHANNEL, DISTRICT OF FRANKLIN

POLAR CONTINENTAL SHELF PROJECT

(Report and 4 figures)

D. R. Horn

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By

D. R. Horn

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MARINE GEOLOGY, PEARY CHANNEL, DISTRICT OF FRANKLIN

Polar Continental Shelf Project

INTRODUCTION

This is a preliminary account of a marine geological survey of Hassel and Massey Sounds and Peary and Sverdrup Channels, Sverdrup Islands area, District of Franklin (Fig. 1). The study was carried out from mid-March to mid-August, 1961, and was given logistic support by the coordinator of the Polar Continental Shelf Project. Sampling was conducted within an area of 10,000 square miles.

The aims of the investigation are: (1) to interpret the history of terrigenous materials in an area of arid polar climate, from source through major drainage routes to a final resting place in the marine environment; (2) to outline and interpret the distribution of Recent sediments accumulating in the channels; (3) to identify and analyze microfossils in layered cores in an attempt to determine the late-Pleistocene and Recent history of the Queen Elizabeth Islands; and (4) to determine the main characteristics of the sea-floor topography. The study involved the collecting of 155 source-rock and fluvial samples, 150 grab samples in the near-shore environment, and 44 cores from offshore areas. Descriptions of the samples and cores are given in the appendices, and some tentative interpretations are presented later in the report.

The Geological Survey of Canada began marine geological studies of the continental shelf and inter-island channels of the Arctic Archipelago in 1960. Preliminary reports of this continuing program have been prepared by Pelletier (1962)[1] and Wagner (1962).

Transportation in the field was by a Bell G-2A helicopter while collecting bedrock and fluvial samples, by two Eskimo dog teams while sampling in the shallow marine environment of coastal areas, and by a Sikorsky 55 helicopter in offshore regions of the channels. Ski-equipped Otter aircraft cached fuel and provisions for the party. A Decca Lambda network provided an accurate means of navigation.

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[1] Dates or names and dates in parentheses refer to publications listed in the References.

The writer wishes to thank R. M. Eaton, senior hydrographer of the P. C. S. P., who provided preliminary hydrographic charts of the study area, and A. E. Collin, senior oceanographer with the project, for making available the results of oceanographic studies. D. W. Scafe, I. Zemmels, B. Seed and dog team drivers Andrew and Pilipoosie of Resolute Bay, provided assistance during the course of the field season. E. L. Bousfield and D. E. McAllister of the National Museum of Canada identified specimens of marine life. The efforts of these men are greatly appreciated.

WORKING METHODS

Representative samples were taken from lithological units outcropping on the eastern half of Ellef Ringnes Island and from northern Amund Ringnes Island (Fig. 3). The recent geological map by Heywood (1959) served as a base map while collecting source-rock material. Because the main rivers are of nearly the same length, grab samples of fluvial sediments were collected at the headwaters and at points 2, 4, 8, and 16 miles downstream, with a final station taken at the mouth of each stream. The station spacing was designed to give equal coverage in drainage basins and to distinguish the principal variations in texture due to sedimentary transport downstream. Altimeter readings were noted at the stations to determine stream gradients, and to define possible relationships between the gradients and distance of travel of the fluvial sediments. From mid-March to late-July the channels were covered with sea ice ranging in thickness from 8 to 13 feet. The ice formed a stable platform during bottom sampling. The starting point of each inshore marine traverse was at the mouth of a major stream, and a series of stations was spaced at logarithmic intervals (00, 50, 100, 200, 400, 800, 1,600, 3,200, and 6,400 feet) from shore, distances being measured with a surveyor's chain. This system of station spacing was established so that samples would provide a maximum amount of information in areas very close to shore where rapid facies changes occur. Holes were drilled through the ice with an electrically powered 5-inch ice-auger and samples were taken using a Phleger gravity corer. The shallow depths near shore permitted the use of a manually operated winch.

A preliminary hydrographic chart was compiled by members of the project's hydrographic team just before the beginning of the coring operations in offshore areas of the channels (Eaton, 1961). This chart, which outlines the main features of the submarine physiography, was of considerable value in selecting the locations of coring stations. Stations were placed at equally spaced intervals along traverses that ran at right angles to or parallel with the axes of main physiographic features. Cores were recovered using a gravity corer

equipped with a 100-pound weight. Modifications to the corer were necessary so that the apparatus would fit through a 12-inch hole in the sea ice. The tool was then used as a gravity corer with a 6-foot (183 cm) coring barrel, 1 1/2 inches (4 cm) in diameter. Penetration was generally limited to 3 feet (91 cm), but most cores included a surface layer and at least a short length of a second layer. Holes were drilled through the sea ice by means of a two-man, gasoline-powered, 12-inch ice-auger, and the coring gear was lowered and raised by a portable gasoline-driven power winch. Cores were stored in plastic liners, capped, sealed with rubberized tape, coated with wax, and shipped to the laboratory in special boxes filled with wax.

SUBMARINE PHYSIOGRAPHY

General Features

Prior to the hydrographic surveys of the Polar Continental Shelf Project, very little detailed information was available on the bottom configuration in the area of the Queen Elizabeth Islands. A bathymetric chart of the Arctic Ocean was completed by Russian workers in 1940, and was revised in 1948, 1954, and 1958 (Anon., 1954; Ostrekin, 1954; Sachs et al., 1955; and Hope, 1959). The 1948 chart and subsequent editions provided the first outlines of submarine topography in this region. The drift of Fletcher's Ice Island, T-3 (station Bravo during the I.G.Y.), from May 1955 to November 1958, enabled United States scientists to collect further information on the continental shelf and slope lying off the northernmost islands of the archipelago (Crary and Goldstein, 1959, p. 15, Fig. 6; and Plouff et al., 1961, p. 712, Fig. 4). The P.C.S.P.'s 1960 and 1961 hydrographic programs have outlined the general character of the sea-floor morphology in the Sverdrup Islands area. Interpretations of bathymetric data collected in 1960 have been reported by Pelletier (1962), and the present paper deals with the soundings taken within the channels in 1961.

The following observations were made regarding the submarine physiography of the channels: Hassel Sound has the form of a single trough (Figures 1 and 2) with a general floor level at 300 metres. A narrow basin at the southern end of the sound reaches a depth of 500 metres, and a second but smaller deep at its northern end has a depth in the order of 400 metres. Two troughs separated by a medial rise run the length of Massey Sound, with the crest of the rise at a depth of 200 metres. East and west of this feature are troughs which are 500 metres and 300 to 400 metres deep, respectively. Peary Channel consists of two troughs, also separated by a medial rise. Depths of 600 to 700 metres to the east of the rise and 500 metres in

the western trough were recorded. The medial rise, extending northward from the northern tip of Amund Ringnes Island, is 350 to 400 metres deep. Another rise, only 100 metres deep, links Meighen and Axel Heiberg Islands. The Fay Islands, which rise 800 feet above sea-level, are a part of this topographic feature. The bottom topography of Sverdrup Channel consists of two parts: a terrace 10 miles wide which runs parallel with the east coast of Meighen Island and extends to a depth of 100 metres, and a trough running in a northerly direction along the eastern part of the channel with a maximum recorded depth of 450 metres.

Louise and Haakon Fiords, on the east coast of Ellef Ringnes Island, were sounded extensively in an attempt to determine their nature. The Y-shaped headward end of Louise Fiord consists of two distinct troughs that form the arms of the Y. The troughs come together at the narrow central part of the fiord and continue eastward as a single trough toward Peary Channel. The fiord has a general floor level at 300 metres below sea-level, and has an undulating longitudinal and U-shaped transverse profile. The floor of the fiord drops abruptly 200 to 300 metres at the point where the fiord reaches the western trough of Peary Channel. Haakon Fiord is similar to Louise Fiord in bottom topography, but is shallower and broader. Depths are in the order of 100 to 200 metres, and eastward the floor of the fiord passes without marked discordance into the main trough of Hassel Sound.

The general features of sea-floor morphology are: (1) Channels have undulating longitudinal profiles with a wide U shape in cross-section; (2) topographic features are linear or elongate and parallel the northwest structural grain of the region; (3) coastlines are commonly straight and trend in a northwest direction; (4) elongate basins contain a string of deeps along the axes of the trough-shaped channels; (5) basin depths commonly exceed those recorded on the continental shelf lying to the north by 200 or 300 metres; (6) there is a discordance between the floor levels of Louise Fiord and the western trough of Peary Channel; (7) three discontinuous terrace levels are apparent along the trough walls and occur at 50-100, 140-170, and 240-250 metres; and (8) fiords have U-shaped transverse and irregular longitudinal profiles.

Interpretation of Submarine Physiography

A study of the submarine topography of the channels and associated fiords leads to the following conclusions: (1) Glacial scour has been the main factor in the development of sea-floor physiography; (2) fiords and bays occupy the sites of former tributary valleys and the

channels mark the location of pre-existing trunk valleys; (3) the presence of three terrace levels on the trough walls may indicate several periods of glacial scour or normal valley widening by rivers; (4) the discordance of sea-floor levels at the junction of Louise Fiord and Peary Channel resembles a hanging valley produced by more extensive glacial deepening along the channel; (5) the undulatory nature of the fiords and channels in longitudinal profile may reflect either differential glacial excavation or the deposition of moraine; (6) straight coastlines paralleling the linear submarine topographic features suggest an origin by means of glacial scour; and (7) the northern terminations of the two troughs occupying Peary Channel may represent the northern limit of glacial erosion at some time during the Pleistocene (Pelletier, 1962, Fig. 6).

SEDIMENTS

Provenance

The surface of the source areas on Ellef Ringnes and Amund Ringnes Islands is flat to gently rolling. Predominant rocks consist of a sequence of conformable marine and non-marine Cretaceous black shales and sandstones with minor amounts of thin-bedded limestone (Heywood, 1957). The average elevation of the islands is 400 feet; however, Mesozoic or Cenozoic diabase dykes interrupt the nearly flat lying strata and weather into narrow ridges some 900 feet in elevation, and sills form resistant cap-rocks on typical 'butte and mesa' topography, reaching elevations in the order of 800 feet. Late Tertiary, circular, diapiric intrusions occur on the Ringnes Islands and weather into rugged forms with an average elevation of 800 feet.

The mean total of all forms of precipitation at Isachsen over the last 8 years is 3.8 inches per year (Pilot of Arctic Canada, 1961, climatological tables). Run-off occurs only during the early part of the summer and continues for a period of 6 weeks (St. Onge, 1960). Mass wasting and rockfall are the most important forms of subaerial weathering, with carbonates and anhydrite stable under the arid polar climatic conditions in the region. Sampling in source areas was greatly facilitated by a lack of soil cover and the lithological uniformity and simple structural relationships of the formations outcropping in the drainage basins.

Fluvial Sediments

All drainage basins in the study area were systematically sampled and the stream gradients determined. Three major trends of fluvial sediments were described by Pelletier (1962, p. 4): a downstream decrease in grain-size; improved sorting downstream; and a decrease downstream in total quantity and number of species of heavy minerals. These trends also seem to apply in the area investigated in 1961, with two additional characteristics becoming apparent.

An overall decrease in grain-size in the downstream direction does exist, but, in some streams on eastern Ellef Ringnes Island, large deposits of boulders and cobbles fill parts of the stream beds. This material interrupts the normal trend of the fluvial sediments. Its exotic composition suggests either a glacial origin, or that the coarse sediment has been derived from outliers of the late Tertiary Beaufort Formation.

Streams exhibit a rapid decrease in gradient a few miles upstream from their mouths. The reduction in gradient results in a large decrease in stream velocity and competence, and the main sediment load is deposited a few miles upstream from the coast. The break in the gradient is marked by the development of wide braided channels in the lower reaches of the streams. As a result, only the finer fractions of the fluvial load are delivered at the mouths of the streams. The change in gradient is considered to mark the limit of a former marine transgression and may represent the rise of sea-level that followed the last glaciation.

Recent Marine Sediments

The Recent marine sediments are divided into two distinct zones. A near-shore zone that is characterized by a predominance of sand and silt and follows the coastlines, and an offshore zone that is beyond all influence of coastal drainage and is an area of accumulation of clay with secondary amounts of silt. Sediments from both areas reflect the overall bimodal composition of source rocks outcropping on the islands. The coarser fractions consist of quartz sand derived from poorly consolidated Cretaceous sandstones and unconsolidated late-Tertiary Beaufort material. The matrix, on the other hand, is apparently derived in the main from the disintegration of thick sequences of Cretaceous black shale.

Near-shore marine sediments are poorly sorted muddy sand and silt, and form a zone of variable width along the coastlines. In areas where the drainage is poorly developed, near-shore sediments

extend less than a mile from shore, whereas off major stream outlets they reach a distance of approximately 3 miles from the adjacent shorelines. There is an overall decrease in grain size with increasing distance from shore. Bottom configuration does not appear to play an important role in governing sediment distribution in the near-shore environment. Sediment distribution within this zone can be directly attributed to the relative volumes of terrigenous materials being carried by individual streams.

A low degree of sorting is characteristic of all samples collected from the shallow marine environment and is considered to be the result of ineffective sorting combined with the influence of multiple transporting agents operating within this depositional area. It is suggested that poor sorting in near-shore areas is due to a combination of factors such as very low tides (12 to 18 inches), apparently negligible currents, restricted wave development due to a solid cover of ice or large amounts of floating sea ice, and a churning-up of recently deposited sediments in shallow waters by grounded ice. The sediments are, therefore, not subjected to the normal sorting processes that operate along coasts in other parts of the world. Moreover, there appear to be three agents of sedimentary transport moving terrigenous material to the site of deposition: (1) ice-rafting of material during the summer break-up period; (2) wind-blown sediment which is carried onto the ice all through the year; and (3) normal sediment contributed by streams during run-off. The bulk of the sediment is provided by the streams and the overall distribution of the material can be shown to be related to this agent. However, 1 to 5 per cent or more of the inshore sediments consists of material of coarser texture than is generally carried by the streams, and does not follow the pattern of normal sediment accumulation. These larger grains are thought to have dropped from melting sea ice during the summer.

Also present are other features of the near-shore environment which may be unique to Arctic regions.

1. Initial run-off commonly occurs before shoreline leads have had time to develop. As a result, stream waters loaded with sediments flood out across the sea ice. Terrigenous material deposited on the ice in this manner is either dropped in place during summer melting, or is transported after break-up to other areas and deposited far from its normal site of deposition.

2. The mean gradient of the deltas is 7 per cent, which is considerably greater than that of most deltas. The steep deltas probably are reflections of the steep foreshores which may in turn reflect recent subsidence, deepening during the Pleistocene through glacial scour, or a relatively low rate of sedimentation, or a combination of these factors.

3. Run-off is greatly reduced in the latter part of the summer, and stream flow over the wide braided channels ceases, exposing large areas of recently deposited unconsolidated material that can be readily transported by the wind. Observation of the wind-blown sediment on the sea ice indicates that aeolian material is particularly abundant off the mouths of the major streams, and it appears that the unconsolidated fluvial sediments form a major source of the wind-blown sediment.

4. After summer break-up, the wind blows sea ice in and out from the shore. This ice grooves and ploughs the sediment accumulating in shallow waters, and frequently large floes are forced into stream mouths, disrupting stream flow and pushing sediment into barriers across stream outlets.

Cores Recovered in Offshore Areas

Forty-four cores were taken in offshore areas of the channels (see Figure 3 and Appendix B). Core descriptions are based on inspection through plastic core liners and examination by means of binocular microscope. Most of the cores consist of a surface layer of dark brown silty clay underlain by dark grey to black interbedded silt and clay. The boundary between the two layers is marked by a sharp colour change which generally coincides with textural and faunal differences.

The surface layer appears uniform throughout and can be traced shoreward to material being deposited at the present time in the near-shore environment. Although dating of this layer has not yet been undertaken, the material is considered to be the most recent sediment to accumulate in the channels. The reasons for this assumption are: the layer occupies the highest stratigraphic position in the marine sedimentary sequence; similar material is known to be accumulating today in inshore areas; and the surface layer of cores collected in other parts of the Arctic Ocean bears comparable lithological characteristics (Sachs et al., 1955, p. 11; Ericson and Wollin, 1959). The nature of the boundary separating the layers suggests that continuous sedimentation has taken place in at least the deeper parts of the channels throughout the period of time represented by the two layers.

Sediments of the surface layer accumulating in the offshore environment consist of clay with varying amounts of silt, and the layer is almost continuous on the floors of the interconnecting channels. The character of this layer is generally uniform, both laterally and vertically. In areas where textural changes do occur, the

grains are coarser in size and their distribution appears to be governed by bottom topography and weak currents. Sand is present on topographic highs such as the medial rise in Peary Channel and the central area of Hassel Sound. Coarser textures in these regions are attributed to weak currents flowing over these features, resulting in sediment winnowing with a gradual concentration of the coarse sediment fractions. The surface layer is thinner and coarser grained over topographic highs on the sea floor, thickening slightly and becoming finer textured in adjacent basins and troughs. The axes of maximum sedimentation follow the axes of the main troughs within the channels. The mean thickness of this layer is 34 cms.

The second layer is predominantly dark grey to black, pebble-bearing muddy sand and silt, with clays in deeper parts of the channels. From brief binocular-microscope examination some trends are apparent. Cores collected at depths of less than 190 metres penetrated a short distance into an oxidized soil layer lying immediately beneath the surface sediment layer. The soil contains plant remains, reddish yellow ironstone bands, and has a lag gravel at its surface. Coarse sands were present at depths of 200 metres, grading downward through progressively finer material into a coarse silt layer that extends to approximately 400 metres. Below 400 metres the second layer consists of clay.

Features of the second layer lead to the following conclusions: (1) a soil was developed on former land surfaces exposed during a lower stand of the sea, when the islands stood at an elevation of at least 200 metres higher relative to sea-level than they do today; (2) channels were narrower, stream gradients greater, and the near-shore sediment zone extended from what is now represented by the area lying between the 200- and 400-metre contours; (3) areas beyond the 400-metre contour line were sites of clay accumulation; (4) fresh angular granules and small pebbles of basic igneous and sedimentary rocks randomly distributed in the sediments of the second layer appear to represent ice-rafted material; (5) continuous sedimentation has taken place in deeper parts of the channels—at depths greater than 200 metres—during the period of time represented by the cores; and (6) environmental conditions during deposition of the second layer were not like those of today as the microfauna is much sparser than in the surface layer.

FAUNAL ASPECT

Results of preliminary studies of Recent Arctic marine faunas have been reported by Wagner (1962). Further studies are being made by the same worker, but some field observations are presented here.

Chalky white calcareous foraminiferal tests were a major constituent of the sediments only in the region of the medial rise in Peary Channel, and it would appear that conditions elsewhere were generally unfavourable for their development. The rise in Peary Channel is at a depth which places it within the zone of relatively warm waters of the Atlantic layer, and calcareous foraminiferal populations appear to be restricted to these waters. At depths greater or less than the limits of the Atlantic layer, temperatures are lower, and there is an apparent reduction in the number of calcareous forams in the sediments accumulating there. Arenaceous foraminifera were present in some of the samples collected in the near-shore sediments and are reported to be abundant in the colder waters of the shallow marine environment[1].

A macrofauna consisting of a few species of thick-shelled pelecypods, small fish, several ophiuroids, and a large number of Amphipoda occupied the shallow coastal waters that front on the Arctic Ocean. Inshore parts of the channels supported a similar fauna. The Amphipoda were identified by D. L. Bousfield of the National Museum of Canada as Gammarus setosis and Themisto libellula. The fish were identified as being Myoxocephalus quadricornis by D. E. McAllister of the same organization. A single sea-fan and the cast of a sea-spider were found on a narrow tidal flat on northern Amund Ringnes Island. Algal mats cover irregular areas along sandy shorelines. Seals were first seen in late June and were numerous in July and August.

Considerable interest is being shown in layered cores from the Arctic, as they provide a method of deducing the climatic history of the region. The cores recovered in offshore parts of the channels illustrate a marked decrease in faunal content in the second layer of cores[2]. The scarcity of fauna in that layer is attributed to cooler water in the Arctic Basin at that time (see Belov and Lapina, 1958; Ericson and Wollin, 1959; and Ewing and Donn, 1960).

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[1] Vilks, G., Geological Survey of Canada, unpublished data.

[2] Vilks, G., idem.

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APPENDICES

APPENDIX A

Description of Surface Sediments, Inshore Samples

Station[1] No.	Depth (metres)	Description
		ELLEF RINGNES ISLAND, LOUISE FIORD
1	0	Sand, black, very coarse grained, predominantly platy black shale fragments, poorly sorted, subrounded to rounded, 10% frosted quartz grains
2	3	Sand, dark brown, very coarse grained, muddy and silty
3	6	Silt, very dark greyish brown, coarse-grained, muddy, occasional grains of fine sand
4	9	Silt, dark brown, coarse-grained, very muddy
5	18	Silt to very fine sand, dark brown, muddy, poorly sorted, well rounded
6	35	Silt, very dark greyish brown, coarse-grained, very muddy, moderately well sorted, well rounded, 5% very fine sand
7	58	Sand, black, very fine grained, very muddy, poorly sorted, well rounded
8	63	Silt, very dark brown, medium- to coarse-grained, extremely muddy, less than 5% fine sand, poorly sorted, well rounded
9	100	Silt, very dark greyish brown, coarse-grained, extremely muddy, very poorly sorted, well rounded
10	89	Clay, very dark brown, 40% medium- to coarse-grained silt, poorly sorted, well rounded

[1] See Figure 4 for locations of stations.

APPENDIX A (cont.)

Station No.	Depth (metres)	Description
		LOUISE FIORD (cont.)
11	60	Clay, very dark brown, 20% medium- to coarse-grained silt, poorly sorted, well rounded
12	167	Clay, very dark brown
13	0	Sand, very dark greyish brown, medium-grained; 25% sand, coarse-grained; 10% sand, very coarse grained; poorly sorted, well rounded, rock fragments
14	1	Sand, very dark greyish brown, fine-grained, poorly sorted, rounded to well rounded; rock fragments
15	2	Silt, very dark greyish brown, medium-grained, muddy; 5% sand, very fine-grained
16	7	Clay, dark olive-grey, silty
17	11	Clay, dark olive-grey, fine silt
18	21	Clay, dark olive-grey, fine silt and less than 5% coarse sand
19	90	Clay, dark olive-grey, fine silt and sand
20	212	Clay, dark olive-grey, fine silt
21	237	Clay, dark olive-grey, very fine silt
22	198	Clay, dark olive-grey, very fine silt
23	10	Sand, very dark greyish brown, fine-grained, poorly sorted, rounded
24	25	Sand, very dark brown, fine- to medium-grained, fair sorting, rounded, trace of glauconite
25	53	Sand, very dark brown, fine-grained, muddy, trace of glauconite and organic remains

APPENDIX A (cont.)

Station No.	Depth (metres)	Description
		LOUISE FIORD (cont.)
26	53	Sand, very dark greyish brown, fine-grained, highly silty, poorly sorted, rounded
27	96	Sand, dark brown, very-fine- to fine-grained, muddy, poor to fair sorting, rounded, trace of glauconite
28	91	Clay, very dark brown
29	241	Clay, very dark greyish brown
30	247	Clay, very dark greyish brown, very fine silt
31	75	Clay, very dark brown, 20% medium silt and 5% very fine sand
32	240	Clay, very dark greyish brown, 25% very fine sand and coarse silt, subrounded to well rounded
33	276	Sand, very dark brown, fine-grained, muddy and silty, well rounded, occasional microfossil fragment
34	274	Sand, very dark brown, fine- to medium-grained, slightly muddy, angular to rounded
35	230	Sand, very dark brown, medium-grained, slightly muddy, 10% very coarse sand; rock fragments
		HAAKON FIORD
36	15	Sand, black, fine-grained, muddy, poorly sorted
37	19	Sand, black, fine-medium grained, muddy, poorly sorted, 10 to 15% coarse sand
38	20	Sand, very dark grey, fine-grained, very muddy, poorly sorted

APPENDIX A (cont.)

Station No.	Depth (metres)	Description
		HAAKON FIORD (cont.)
39	21	Sand, black, fine- to medium-grained, muddy, subrounded to rounded
40	29	Sand, black, muddy, fine-grained
41	42	Sand, very dark grey, fine-grained, muddy and silty
42	65	Sand, very dark brown, fine-grained, muddy, 5% medium sand
43	107	Sand, black, very fine grained, muddy and silty
44	120	Silt, very dark brown, medium- to coarse-grained, extremely muddy
45	164	Clay, black, 15% fine to medium silt
46	201	Clay, dark brown, 30% very fine sand and coarse silt
47	28	Sand, dark olive-grey, fine-grained, muddy, poorly sorted, trace of organic material
48	39	Sand, dark olive-grey, fine-grained, muddy, poorly sorted
49	59	Clay, dark olive-grey, fine silt
50	71	Clay, dark olive-grey, fine silt
51	299	Clay, dark olive-grey, trace of fine silt
52	253	Clay, very dark greyish brown, very fine sand and coarse silt
53	193	Clay, dark olive-grey, fine silt
54	92	Sand, dark olive-grey, very-fine- to fine-grained, muddy, black organic material

APPENDIX A (cont.)

Station No.	Depth (metres)	Description
		HAAKON FIORD (cont.)
55	135	Clay, dark olive-grey, with very fine sand, rock fragments, foraminifera
		HELICOPTER BAY
56	2	Sand, black, very fine-grained, fair sorting, rounded, resembles soil, muddy
57	18	Sand, dark olive-grey, fine-grained, muddy, fair sorting, subrounded to rounded, rock fragments
58	24	Sand, very dark greyish brown, fine-grained, muddy, black and brown organic material
59	42	No sample
60	66	Sand, very dark greyish brown, very fine grained, muddy, poorly sorted, rare granule-sized rock fragments
61	101	Sand, very dark greyish brown, fine-grained. rare granule-sized rock fragments
62	132	Mud, very dark greyish brown
63	18	Sand, medium greyish brown, medium-grained, muddy, poorly sorted
64	5	Sand, dark greyish brown, medium-grained, poorly sorted, no clay
65	14	Sand, dark greyish brown, medium-grained, poorly sorted, no clay
66	24	Sand, dark greyish brown, fine-grained, muddy, poorly sorted
67	30	Mud, dark brown

APPENDIX A (cont.)

Station No.	Depth (metres)	Description
		HELICOPTER BAY (cont.)
68	32	Mud, dark brown
69	18	Mud, medium olive-grey
		DIVERGENT RIVER
70	2	Sand, dark greyish brown, medium-grained, poorly sorted
71	11	Sand, very dark greyish brown, medium-grained, poorly sorted
72	18	Sand, very dark greyish brown, fine- to medium-grained, poorly sorted
73	37	Silt, very dark greyish brown
74	63	Sand, dark brown, very fine-grained, poorly sorted, extremely muddy
75	101	Silt, dark brown, extremely muddy
76	137	Sand, dark brown, very fine-grained, poorly sorted, extremely muddy
		HOODOO RIVER
77	13	Sand, very dark greyish brown, medium-grained, silty and muddy, poorly sorted, subrounded to rounded, organic material
78	17	Silt, black, coarse-grained, muddy
79	22	Silt, black, medium- to coarse-grained, muddy
80	74	Silt, black, fine-grained, muddy
81	230	Clay, black, with coarse silt

APPENDIX A (cont.)

Station No.	Depth (metres)	Description
		AMUND RINGNES ISLAND
82	0	Clay, black
83	3	Silt, very dark brown, muddy
84	5	Sand, very dark brown, coarse-grained, muddy, with fine silt, very poorly sorted
85	9	Silt, black, coarse-grained, muddy
86	17	Sand, very dark brown, very fine-grained, muddy, poorly sorted, angular to subrounded
87	35	Sand, black, fine- to very-fine-grained, muddy, poorly sorted, angular to subrounded, resembles soil
88	55	Sand, very dark brown, medium-grained, clean, subrounded to rounded, trace of clay and silt
89	81	Silt, very dark brown, coarse-grained, muddy, organic material
90	78	Sand, very dark brown, very fine-grained, muddy, subrounded to rounded, carbon flakes
91	0	Sand, black, very fine-grained, muddy, poorly sorted, angular to subrounded, black organic fragments
92	3	Sand, black, medium-grained, muddy, poorly sorted, subrounded to rounded
93	8	Sand, dark brown, fine-grained, muddy, poorly sorted
94	50	Sand, very dark brown, medium-grained, moderately well sorted, angular to rounded, no mud

APPENDIX A (cont.)

Station No.	Depth (metres)	Description
		AMUND RINGNES ISLAND (cont.)
95	24	Sand, black, medium-grained, muddy, poor sorting, subrounded to well rounded
96	55	Sand, dark greyish brown, medium-grained, fair sorting
97	56	Mud, dark greyish brown
		CAPE SVERRE
98	3	Gravel, dark greyish brown, granular, with poorly sorted sand matrix
99	3	Gravel, dark greyish brown, granular with occasional fine pebbles, coarse-grained sand matrix
100	8	Sand, medium brown, very coarse-grained, poorly sorted, extremely muddy
101	10	Sand, medium brown, coarse-grained, poorly sorted, with occasional granules
102	19	Sand, medium brown, coarse-grained, poorly sorted, muddy
103	26	Sand, dark brown, coarse-grained, poorly sorted, muddy
104	49	Sand, dark brown, very coarse grained, granular, extremely muddy

APPENDIX B

Description of Offshore Core Samples

Core. No.	Depth (metres)	Location	Layer	Thickness (cms)	Lithology
1[1]	228	Hassel Sound	Surface	41	Mud, very dark brown; 10% very fine sand
			Second	61	Mud, very dark grey; 5% very fine sand, 1% fine sand
2	358	Hassel Sound	Surface	27	Mud, very dark greyish brown; 5-10% coarse silt to very fine sand
			Second	85	Mud, very dark olive-grey
3	352	Hassel Sound	Surface	58	Clay, black; 5% coarse silt, chalky-white microfossils
4	478	Hassel Sound	Surface	24	Mud, black; rare angular medium-grained sand; grains
			Second	68	Mud, very dark greyish brown; 5-10% fine- to medium-grained sand, rare microfossils

[1] See Figure 3 for location.

5	297	Hassel Sound	Surface	41	Sand, very dark brown; very fine grained, muddy, trace of coarse silt
			Second	38	Clay, dark olive-grey; 15% silt
6	180	Hassel Sound	Surface grab	0	Sand, black; medium-grained, muddy and silty, poor sorting, well rounded
7	288	Hassel Sound	Surface grab	0	Sand, black; medium-grained, less than 5% coarse-grained sand, well-rounded pebble with coal-black flecks of organic matter
8	295	Hassel Sound	Surface	11	Sand, dark yellowish brown; medium-grained, moderately well sorted, subrounded to rounded, occasional rock fragments
			Second	13	Sand, black, medium-grained; muddy, poorly sorted, 10% well-rounded granules
9	160	Hassel Sound	Surface	43	Sand, very dark grey, fine-grained, muddy and silty, poorly sorted, subrounded
			Second	37	Clay, black; 5% silt
10	546	Hassel Sound	Surface	83	Clay, very dark brown; 10% silt, 1% medium-grained sand
11	452	Hassel Sound	Surface	76	Mud, very dark grey-brown

APPENDIX B (cont.)

Core No.	Depth (metres)	Location	Layer	Thickness (cms)	Lithology
12	182	Hassel Sound	Surface	8	Soil, yellowish red; sandy coarse-grained; fine fibrous plant remains (rootlets?), chalky-white microfossils
			Second	86	Mud, black; common angular granules of dark grey mudstone
13	486	Massey Sound	Surface	51	Clay, dark brown; 5% silt, trace of medium-grained sand
			Second	38	Sand, very dark grey; fine- to coarse-grained, poorly sorted with large amount of muddy matrix, well rounded; trace of angular sand-sized grains of red siltstone
14	448	Massey Sound	Surface	51	Clay, very dark brown; 5% silt
			Second	64	Mud, very dark grey
15	500	Massey Sound	Surface	46	Clay, very dark brown; 5% silt
			Second	35	Clay, very dark grey; 10-15% silt

16	300	Massey Sound	Surface	60	Clay, very dark greyish-brown; 10-15% silt
			Second	33	Mud, very dark grey
17	192	Massey Sound	Surface	22	Mud, dark greyish brown; 25% very fine sand; arenaceous and calcareous foraminifera
			Second	17	Sand, very dark grey; fine to coarse-grained, muddy, poorly sorted, angular
18	286	Massey Sound	Surface	0	Sandy soil, very dark brown; fine- to medium-grained; occasional angular pebbles of black shale
19	455	Massey Sound	Surface	107	Clay, very dark brown; 20% silt. No distinct layer break but sediment becomes greyer and silt content decreases to 10% in lower part of core
20		Peary Channel	Surface	30	Mud, black; very rare coarse silt and fine sand
			Second	34	Clay, very dark brown; 5-10% silt, 1% angular coarse sand

APPENDIX B (cont.)

Core No.	Depth (metres)	Location	Layer	Thickness (cms)	Lithology
21		Peary Channel	Surface	18	Mud, very dark grey; 10-15% coarse sand; foraminifera
			Second	33	Clay, very dark brown; 15% silt, less than 5% angular medium-grained sand
22		Peary Channel	Surface	38	Clay, very dark brown; 10-15% very fine sand
			Second	41	Clay, very dark grey-brown; less than 5% silt
23		Peary Channel	Surface	56	Clay, very dark brown; 10-15% very fine sand
			Second	43	Clay, very dark grey-brown
24		Peary Channel	Surface	49	Clay, very dark brown; 5-10% very coarse silt and very fine sand; bryozoa(?), echinoid spines(?)
			Second	36	Clay, very dark brown; 10% silt

25	340	Peary Channel	Surface	20	Mud, light to medium brown; 5% very fine sand; chalky-white foraminifera tests
			Transition zone	15	Transitional change from surface layer lithology to that of second layer without a defined break
			Second	20	Mud, black; 10-15% very-fine- to medium-grained sand; sand varies greatly in degree of rounding and is poorly sorted
26	394	Peary Channel	Surface	18	Mud, brown; trace of very fine grained sand; flakes of black organic material; chalky-white foraminifera tests
			Transition zone	10	Transition from sediments of surface layer to that of second layer is gradational and without an identifiable break
			Second	23	Sand, black; very-fine- to fine-grained, extremely muddy, very poorly sorted
27	328	Peary Channel	Surface	17	Mud, brown; 5% medium-grained sand, trace of silt-sized red shale fragments; chalky-white foraminifera tests
			Transition zone	10	Gradational boundary between layers without a defined break
			Second	17	Sand, black; fine- to medium-grained, extremely muddy, angular and rounded grains, very poorly sorted

APPENDIX B (cont.)

Core No.	Depth (metres)	Location	Layer	Thickness (cms)	Lithology
28	385	Peary Channel	Surface	38	Mud, dark yellow-brown; 25% coarse sand; abundant chalky-white foraminifera tests
			Second	13	Sand, black, very-fine- to fine-grained, very muddy, poorly sorted
29	405	Peary Channel	Surface	24	Sand, very dark greyish brown; fine- to medium-grained; very muddy, poorly sorted, rare granules; abundant chalky-white foraminifera tests
			Second	9	Sand, black; very-fine- to fine-grained, extremely muddy, poorly sorted
30	402	Peary Channel	Surface	31	Sand, dark yellow-brown; coarse-grained, muddy, chalky-white foraminifera tests common
			Second	22	Mud, black, 25% fine to coarse sand; sand fraction is poorly sorted, degree of rounding varies from angular to well rounded
31	237	Peary Channel	Surface	20	Clay, dark greyish-brown; less than 5% coarse silt; trace of foraminifera tests and spines
			Transition zone	15	Gradational boundary

			Second	18	Sand, very dark grey, fine- to medium-grained; muddy, poorly sorted, angular to well rounded
32	510	Peary Channel	Surface	25	Sand, brown, very-fine- to fine-grained, very muddy, trace of granules and fine pebbles; abundant chalky-white foraminifera tests; common minute spines—echinoid(?)
			Second	17	Mud, very dark grey; 15% very-fine- to fine-grained sand, trace of medium-grained sand; flakes of carbonitized wood
33	679	Peary Channel	Surface	38	Silt, very dark greyish brown, coarse-grained; very muddy with trace of fine sand and foraminifera tests
34	450	Peary Channel	Surface	31	Clay, dark brown; 15% very fine silt; trace of chalky-white foraminifera tests
			Second	6	Silt, black, coarse-grained; extremely muddy, poorly sorted; common red shale rock fragments and flakes of carbonitized wood of silt size
35	583	Peary Channel			No sample
36	601	Peary Channel	Surface	37	Clay, very dark greyish brown; trace of medium- to coarse-grained silt
			Second	41	Clay, black; 15% coarse silt

APPENDIX B (cont.)

Core No.	Depth (metres)	Location	Layer	Thickness (cms)	Lithology
37	168	Peary Channel	Surface	25	Sand, very dark greyish brown, fine- to medium-grained, very muddy, poorly sorted; trace of coarse-grained sand; trace of chalky-white foraminifera tests
			Second	23	Gravel, black; pebbles reach 1 cm in size and consist of black mudstone, quartz and basic igneous rock fragments; matrix is poorly sorted, very fine to very coarse muddy quartz sand, angular to subrounded; pebbles are faceted and pitted with some exhibiting fresh fracture surfaces; trace of carbonitized wood
38	77	Sverdrup Channel	Surface grab	3	Soil, very dark greyish brown, sandy and pebbly; pebbles are siltstone and basic igneous rock and bear encrusting foraminifera and bryozoan colonies
39	254	Sverdrup Channel	Surface grab	0	Gravel, black, extremely muddy
40	379	Sverdrup Channel	Surface	38	Mud, dark greyish brown; 15% very fine to fine sand; 1% chalky-white foraminifera tests
			Second	48	Sand, black, fine-grained; extremely muddy, very poorly sorted

41	450	Sverdrup Channel	Surface	27	Clay, dark greyish brown; 5% silt
			Second	39	Sand, very dark grey, medium- to coarse-grained, angular and well rounded grains, poorly sorted; trace of green mineral—glauconite(?)
42	81	Sverdrup Channel	Surface	5	Mud, dark grey brown; 10-15% silt
			Second	3	Soil, black
43	173	Sverdrup Channel	Surface	22	Clay, very dark brown; 20% sand, medium- to coarse-grained, subrounded to subangular
			Second	13	Sand, black, medium-grained, extremely poorly sorted, muddy; rare granules of white siltstone
44	347	Sverdrup Channel	Surface	45	Clay, medium greyish brown; 5% silt, very fine grained
			Second	20	Clay, very dark brown; 10% silt, fine-grained

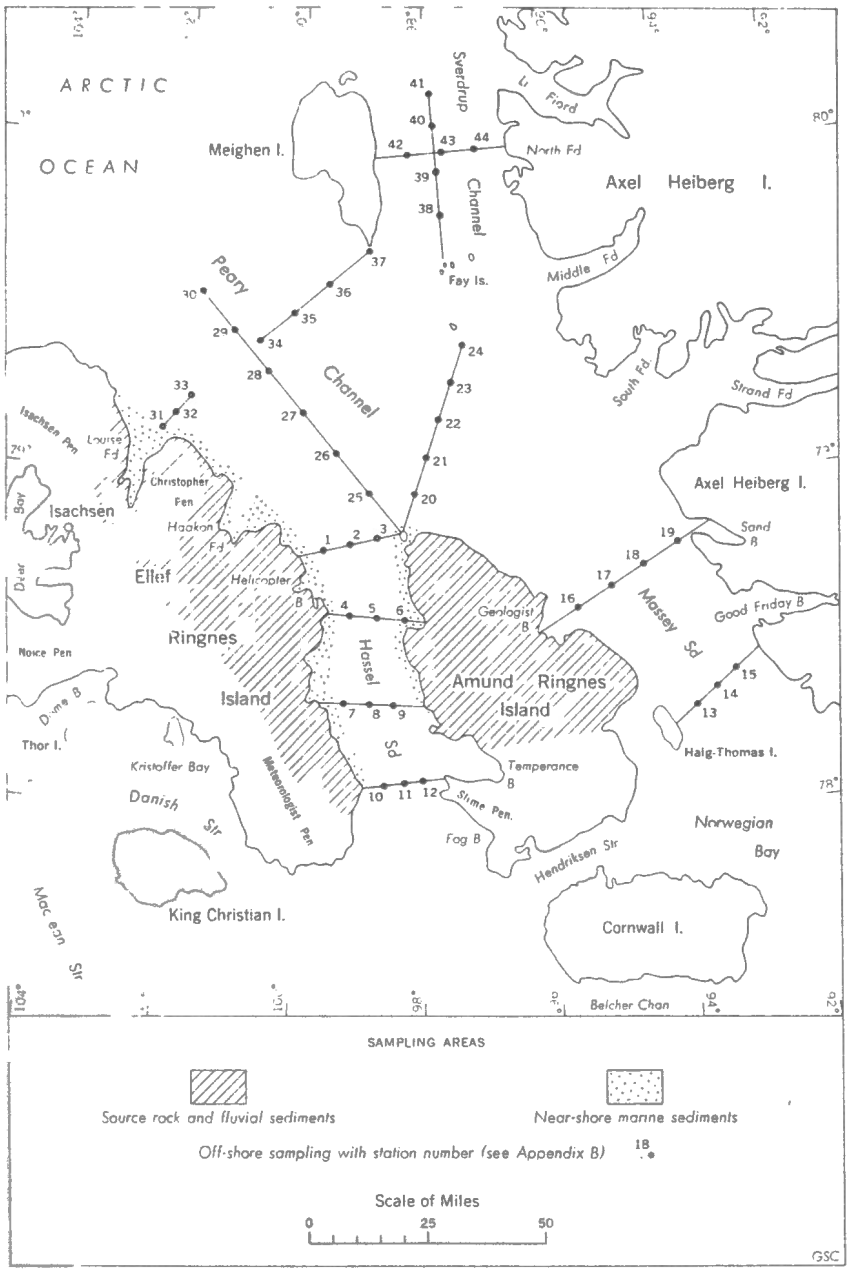

Figure 3. Location of sampling, Sverdrup Islands area

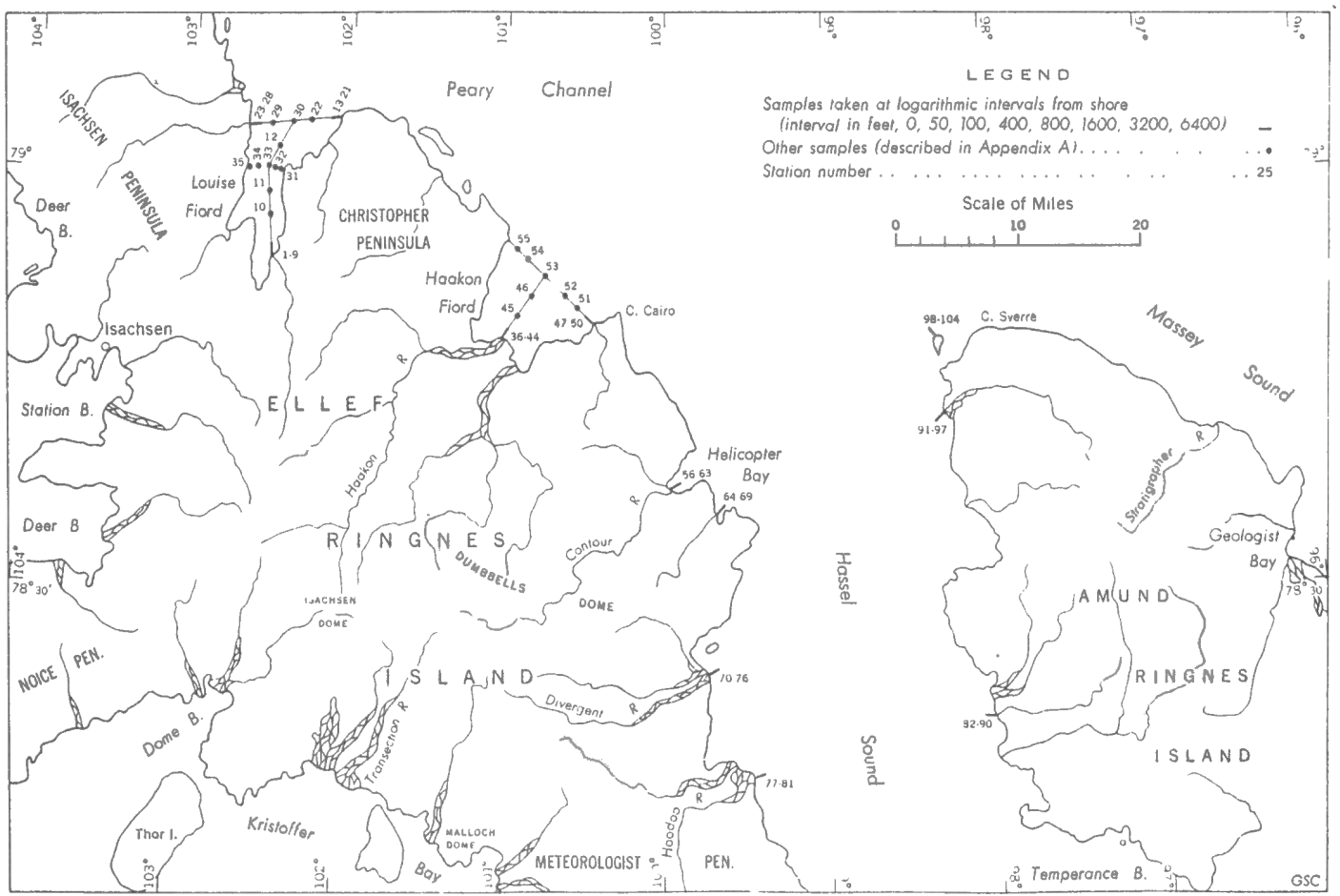

Figure 4. Locations of in-shore sample stations, Ellef Ringnes, and Amund Ringnes Islands, Sverdrup Islands area

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