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SUBMARINE GEOLOGY PROGRAM, POLAR CONTINENTAL SHELF PROJECT, ISACHSEN, DISTRICT OF FRANKLIN

(Report and 6 figures)

B. R. Pelletier

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By
B.R. Pelletier

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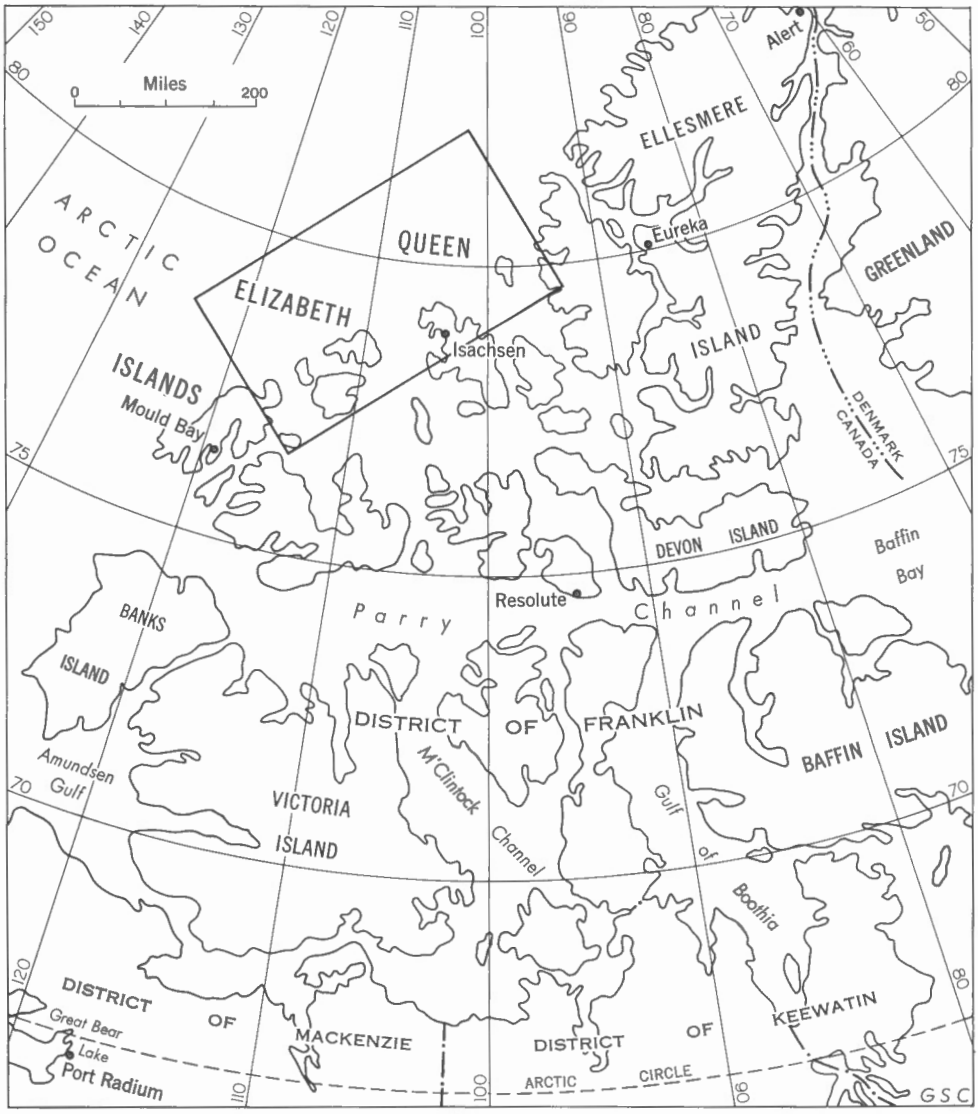

Figure 1. Rectangle indicates study area

SUBMARINE GEOLOGY PROGRAM, POLAR CONTINENTAL SHELF PROJECT, ISACHSEN, DISTRICT OF FRANKLIN

Introduction

The purpose of this report is to describe the organization and working methods of a submarine geology project that commenced in April 1960 in the inshore and offshore waters of the western Queen Elizabeth Islands, District of Franklin (Fig. 1). This project, including the field and laboratory work, was organized by officers of the Geological Survey under the direction of the co-ordinator of the Polar Continental Shelf Project, and was carried out in collaboration with scientists from other federal agencies attached to the shelf project.

The submarine geology program was designed to investigate conditions of sedimentation, the distribution and nature of sediments on the Arctic shelf, and to determine the geological history of these sediments. Fossils were collected in order to establish ecological niches, and eventually to distinguish between indigenous and transported faunas. From such studies it is anticipated that an interpretation of past climatological events can be made. Submarine topography was also studied in order to interpret, partly, the physiographic history of the Arctic continental shelf and adjacent island channels. Tentative interpretations are given later in this report.

A broad sampling program was undertaken to obtain information on the source of the sediments forming the marine deposit, the alteration of this material during sedimentary transport, and its present nature. To trace the various stages of textural and mineralogical alteration, samples were collected from outcrops, river beds, deltas, bottoms of protected bays, island channels and from offshore areas on the continental shelf. All samples were sent to the laboratories of the Geological Survey at Ottawa, for palaeontological, mechanical, petrographic, spectrographic, and X-ray analyses. Some of the results are presented here.

The writer thanks E.F. Roots, co-ordinator, for his assistance on operational problems, and A.E. Collin, oceanographer, who advised, aided, and instructed the writer on the use of bottom-sampling equipment. Special thanks are extended to D.R. Horn who did most of the inshore and inland sampling, and to E.W. Reinhardt who assisted in this work as well as in the transit surveying. The writer is also grateful to E. Chapman for his assistance on the sampling program and to R.W. Mackay for his help in designing and constructing a special apparatus for taking bottom samples in shallow water. Many other workers and scientific teams (surveyors, hydrographers, and the seismic team) provided help and advice.

In Ottawa, the Geological Survey provided facilities and assistance for the following: sedimentological analysis including sieving, pipetting, and the preparation of heavy-mineral mounts—by D.E. Field and R.G. Kelley; geochemical analysis and the preparation of equipment—by G. Bender, J.A. Maxwell and E.M. Cameron; spectrographic analysis—by W.H. Champ and W.F. White; X-ray analysis of clay minerals—by A.P. Sabina and R.J. Trail; palaeontological preparation—by J.E.A. Matte and B.J. Botte; and palaeontological identification and analysis—by F.J.E. Wagner.

References

Collin, A.E.
1961: Oceanographic Activities of the Polar Continental Shelf Project; J. Fish. Research Bd., P.C.S.P. Paper 3-1-2.

Craig, B.G., and Fyles, J.G.
1960: Pleistocene Geology of Arctic Canada; Geol. Surv., Canada, Paper 60-10.

Eaton, R.M.
1961: Borden Island to Meighen Island (Hydrographic Chart Based on Soundings by Polar Continental Shelf Project, with accompanying report); Can. Hydrographic Serv., File F.S. 3072 S.C.

Ericson, D.B., and Wollin, G.
1959: "Micropaleontology and Lithology of Arctic Sediment Cores" in Scientific Studies at Fletcher's Ice Island, T-3 (1952-1955); U.S.A.F. Cambridge Research Centre, Bedford, Mass., Geophys. Research Paper No. 63, vol. 1, pp. 51-58.

Fortier, Y.O., and Morley, L.W.
1956: Geological Unity of the Arctic Islands; Trans. Roy. Soc. Can., vol. 1, ser. 3, Canadian Committee on Oceanography.

Heywood, W.W.
1957: Isachsen Area, Ellef Ringnes Island, District of Franklin, Northwest Territories; Geol. Surv., Canada, Paper 56-8.

Hunkins, K.L., Ewing, M., Heezen, B.C., and Menzies, R.J.
1960: Biological and Geological Observations on the First Photographs of the Arctic Ocean Deep-Sea Floor; Limnology and Oceanography, vol. 5, No. 2, April 1960, pp. 154-161.

Pelletier, B.R.
1960: Submarine Geology Programme, Polar Continental Shelf Project, Isachsen, Northwest Territories; Dept. Mines, Tech. Surv., P.C.S.P. Paper No. 35 (unpublished).

Wagner, F.J.E.
1960: Faunal Study, Polar Continental Shelf Project; Dept. Mines, Tech. Surv., P.C.S.P. Paper No. 36 (unpublished).

Field Program

Sampling stations on land were selected and located with the aid of aerial photographs, a photo-compilation base-map, and a recently completed geological map by W.W. Heywood (1957)[1]. The inshore traverses were laid out by triangulation, and sampling stations on the ice were located by chaining from known points on shore. A logarithmic sampling interval was chosen in order to have maximum sampling near shore where the greatest change in texture, which is commonly exponential with distance from source, was expected; thus, an economy of sampling was effected. Offshore stations across the inter-island channels were located by tellurometer traverses (carried out by F. Hunt and A. Kerr) and stations over the Arctic Ocean by means of a Decca navigational aid.

Transportation to the offshore stations was by aircraft—either the fixed-wing DeHavilland Otter or the rotary-wing (S-55) Sikorsky helicopter. Inshore areas were reached by motor-toboggan before break-up, or by small boats in periods of open water. Inland traverses were carried out mainly by Bell helicopter (G-2 model), or on foot.

To obtain bottom samples, snow was cleared from the ice surface and a hole was made through the ice with specially designed ice-drills—either a plate-like drill 10 inches in diameter with two cutting edges, or a modified earth-auger 6 inches in diameter with a single cutting edge. A Phleger corer was then lowered through the 10-inch hole to the sea floor, dropped under gravity to penetrate the bottom sediments, and returned to the surface by means of a motor-driven winch. A smaller corer designed by R.W. Mackay was used in the inshore areas; it could be lowered through a 6-inch hole and retrieved by a manually operated winch. Depth and temperature of water as well as the nature of the sediment and length of core were recorded for each station. Geological and physiographic observations were noted for the inland samples.

Laboratory Schedules

The samples, upon arrival at the Geological Survey, were processed according to a previously planned laboratory schedule. This schedule, which is shown in the form of a flow sheet (Fig. 2), also indicates the various stages in the laboratory studies wherein the data are analyzed. The schedule as shown in the flow sheet is not rigid and presumably will undergo revision as new fields are investigated and others are abandoned or modified.

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

Results and Conclusions

Most of this information has already been reported (Pelletier, 1960).

Preliminary results of the analyses of 90 samples indicate the occurrence of certain sedimentary trends. In detail, these trends are peculiar to Arctic regions but, in general, they follow well known principles of sedimentation in other aqueous environments.

In fluviatile deposits, three major trends occur. First, a downstream decrease in size takes place. In one river the median diameter of the detritus decreases from 5.5 mm at the headwaters 8.5 miles above the mouth, to 0.7 mm at 7 miles, 0.3 mm at 4 miles, and 0.09 mm at 0.1 mile above the river mouth. Second, the sorting coefficient decreases from 5.0 at the headwaters to 1.4 at the mouth, indicating improved sorting of sediments downstream, although this may not be progressive. Third, heavy minerals (specific gravity greater than 2.89) decrease downstream in total quantity and number of species. For example, in the 0.125 - 0.25 mm class the decrease is from 1.9 per cent and 8 species at the headwaters to 0.64 per cent and 3 dominant species at the mouth. A relationship in the number of species and percentage of the heavy minerals was found according to the distance of sedimentary transport, the average grain size of the sample (which is also partly dependent on sedimentary transport) and, presumably, the nature of the source.

Trends arising from inshore sedimentary transport include the following: 1) the average grain size of sediments decreases with distance from shore; 2) shoreline sediments are generally coarser than those in the mouth of the river that supplied them, probably because minor wave-turbulence at the river mouth during periods of open water carried the finer materials farther out, leaving a residue of coarser material along the shore; 3) the sand content ceases to be an important constituent after about 1/2 mile of offshore sedimentary transport; generally from there on it is less than 10 per cent of the sample; 4) the sediments are generally more poorly sorted as the grain size decreases below an average of 0.2 mm.

Along offshore traverses (see Fig. 3) the following features were observed: 1) the sand content was greatest in sediments from traverses northwest from Ellef Ringnes Island and from those toward mid-channel areas, such as in Sverdrup and Peary Channels, and Prince Gustaf Adolf Sea; and 2), no orderly variation of the median diameters of the detritus nor of sorting coefficients was found.

This summary, for sedimentation in a protected bay, does not explain the high sand content (up to 37 per cent) tens of miles from shore, nor the lack of orderly variation in size and sorting. Because currents are known to exist in the Arctic Ocean[1] and in the inter-island channels which are known to drain Arctic waters in the direction of the Atlantic Ocean, it is suggested that these forces are partly responsible for the apparently anomalous distribution of sand

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[1]Photographic evidence of currents in Arctic waters at lat. 85°53'N and long. 168°42'W is reported by Hunkins et al. (1960).

on the sea floor. Presumably, ice-rafted material originating elsewhere (Ericson and Wollin, 1959) was deposited over the entire area of the continental shelf and channel bottoms, the fine material to some extent was washed away by the currents, and the proportion of sand was thus increased.

X-ray identification of clay minerals was made on samples from all types of traverses. Chlorite, illite and kaolinite groups occur in most samples, but montmorillonite is nowhere found. Differences in ratios of the clay minerals to one another were observed, which tentatively are attributed to original differences in source material. The following are examples. Sediments derived from areas underlain by diabase are deficient in kaolinite, and consist chiefly of chlorite and illite. Some sediments derived from areas underlain by diabase and the Deer Bay formation (shale) consist chiefly of chlorite and illite, others of kaolinite, illite, and chlorite. Similarly, some sediments derived from the Isachsen formation (quartz sandstone mainly) and the Deer Bay formation contain chiefly kaolinite and illite, but little chlorite; others contain chiefly kaolinite, with both chlorite and illite being scarce. This twofold nature of the clay constituents is present apparently because the sources of the parent material are two lithologically different geological formations.

Spectrographic analyses of bottom sediments from inshore waters exhibit variations in certain metallic elements, which again are attributed to the nature of the source material. Sediments derived from the quartz-rich Isachsen formation, for example, contain Si in the 10-to-100-per-cent range, and Al and Fe in the 1-to-10-per-cent range. On the other hand, sediments derived from formations with a lower quartz content contain all three constituents in the 10-to-100-per-cent range. The Na content in the 1-to-10-per-cent range in all samples suggests a lack of chemical weathering at the outcrop, and possibly the absence of diagenesis in the bottom deposits. Fully quantitative chemical analyses, particularly for the oxides, would help to elucidate such chemical problems as weathering, diagenesis, and deposition of non-clastic material.

Fossils from several of the offshore samples examined contain shells that are chalky-white and generally small. The distribution of the dominant species according to depth and distance from shore is currently being studied (see Wagner, 1960) and a comprehensive report is being prepared.

Submarine topographic profiles along the inshore traverses[1] are steep where they cross the bay near Isachsen. The gradient increases from 16 to 20 feet per 100 feet in the first 200 feet or so from shore, and to more than 40 feet per 100 feet beyond that. As a result of these steeper gradients, the bottom of the bay less than a mile from shore is at normal shelf depths (600 feet, or 187 metres, is considered shelf depth by international agreement). Soundings

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[1] Unpublished data after R.D. Horn, E.W. Reinhardt, and B.R. Pelletier.

across the major channels between Borden and Axel Heiberg Islands indicate that within a few miles of land the water is as much as three times deeper than normal shelf depths.

On the other hand, soundings taken northwesterly off the tip of Ellef Ringnes Island (Eaton, 1961; Collin, 1961) show depths of 60 to 90 metres a few kilometres offshore, but depths increase to more than 300 metres about 55 kilometres offshore (Fig. 5). From there to about 90 kilometres along the same northwesterly line from Ellef Ringnes Island, the gradient decreases to form a gently sloping shelf platform at depths exceeding 430 metres. An abrupt decrease or break in the slope at about 90 kilometres offshore may mark the end of a drowned headland and the beginning of the continental shelf proper. At 160 to 175 kilometres offshore, the continental shelf ends, and over a distance of 15 kilometres the continental surface drops abruptly from about 550 metres below sea-level to about 1,200 metres below sea-level.

The profiles across Station Bay, Isachsen, and the channels of at least some of the western Arctic Islands (Fig. 4) appear to represent transverse views of deep troughs that owe their origin partly to glaciation consequent upon an older drainage system, as indicated by Fortier and Morley (1956). The shallower depths off the northwest (and possibly southeast) coasts of the islands suggest drowned headlands, or coastal plains, and shallower soundings in some mid-channel areas suggest submerged ridges that were formerly interfluvial areas (Figs. 4, 5, 6)[1].

Soundings over the continental shelf seaward of the headlands indicate a drowning of perhaps 400 metres. This figure is based partly on the previously defined shelf depth of 187 metres, partly on the marked break in profile at 400 metres, and partly on the position of the northwesterly trending headland and continuous offshore profile with respect to the occurrence of this headland between deep inter-island troughs that also trend northwesterly. The presence of raised beaches several hundred feet above sea-level on several of the Arctic Islands (Craig and Fyles, 1960) also indicates that considerable fluctuation of sea-level has occurred, and suggests that relative movement of sea-level in the order of 400 metres is possible. Four hundred metres (the presumed amount of drowning) subtracted from the actual soundings of 550 to 600 metres over the same area of the shelf, would give 150 to 200 metres—the normal depths of continental shelves.

It is presumed that glaciation occurred when the land was at a higher elevation above sea-level, but that drowning and subsequent sedimentation has obscured the evidence of glaciation. The ice was probably in the form of thin sheets over the interfluvial areas, as shown by the absence of heavy till and the general lack of the constructional and erosional forms produced by glaciation. Over the ancient river channels, ice was in thicker flows or lobes, as

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[1] The possibility of drowned river systems in the western Queen Elizabeth Islands is discussed by Craig and Fyles (1960).

indicated by the steep walls and the longitudinal profile of the channels. The channels indeed rise northwesterly to the drowned sill which, in turn, leads down to the continental shelf (Figs. 5 and 6)[1]. The ice was probably nowhere much more than 1,000 feet thick—at least there is no evidence that it covered any of the presently exposed surfaces, except perhaps the lag or outwash gravel lying on the Beaufort formation on the western parts of the Arctic Coastal Islands.

The erosion of the geological formations on the western Queen Elizabeth Islands has produced a typical 'butte and mesa' topography. This feature is characteristic of erosional forms in regions of rigorous climate due to extreme aridity, extreme cold, or both, in which mechanical disintegration of the land is the chief form of weathering. Much of this erosion could have been accomplished during the Pleistocene or earlier, when a severe climate and the greater elevation of the land before drowning were more conducive to such vigorous erosional forces.

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[1] The channel on the Ellef Ringnes side of Prince Gustaf Adolf Sea is thought to be continuous through the continental shelf (Collin, 1961).

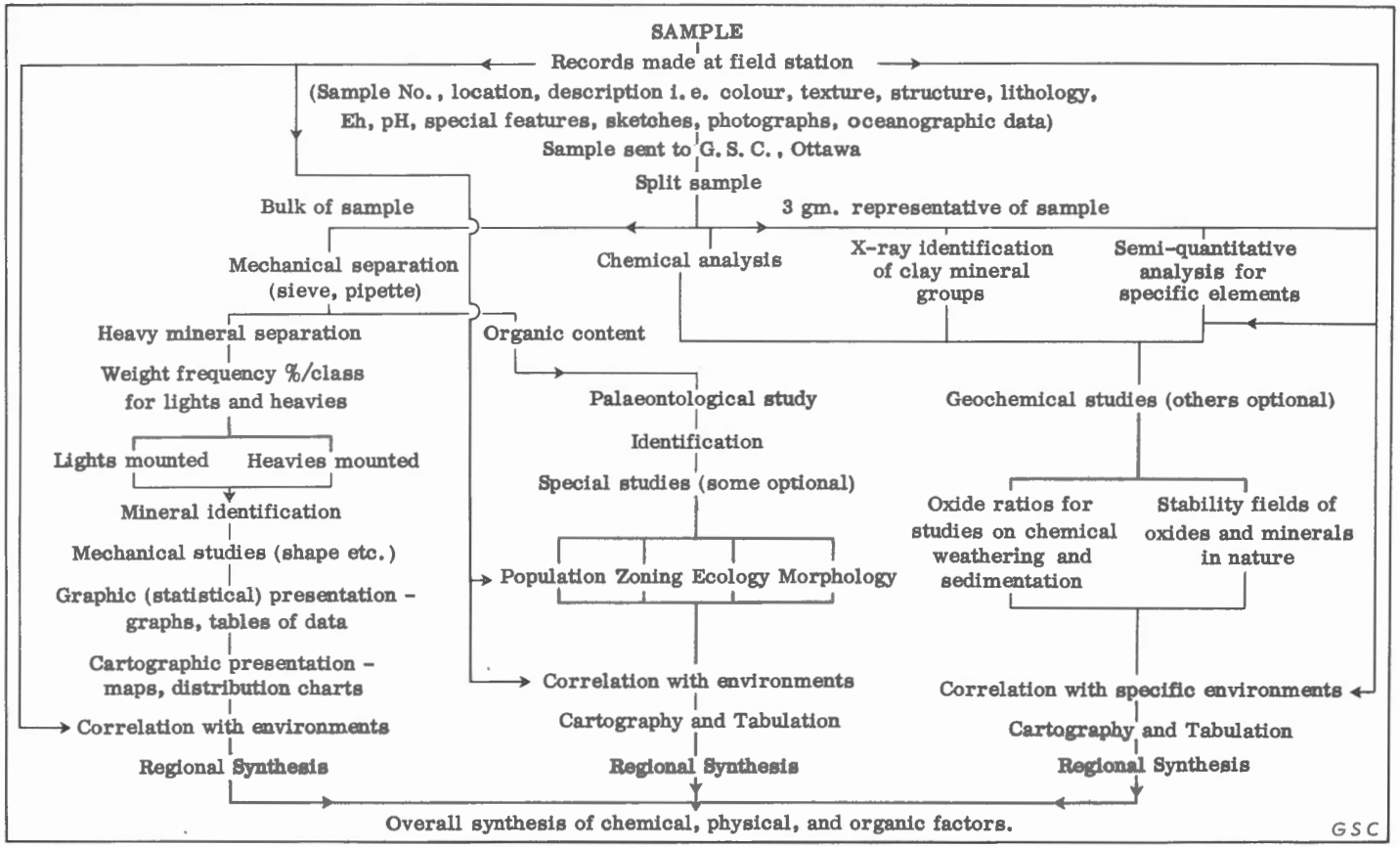

Figure 2. Flow sheet for processing data and samples

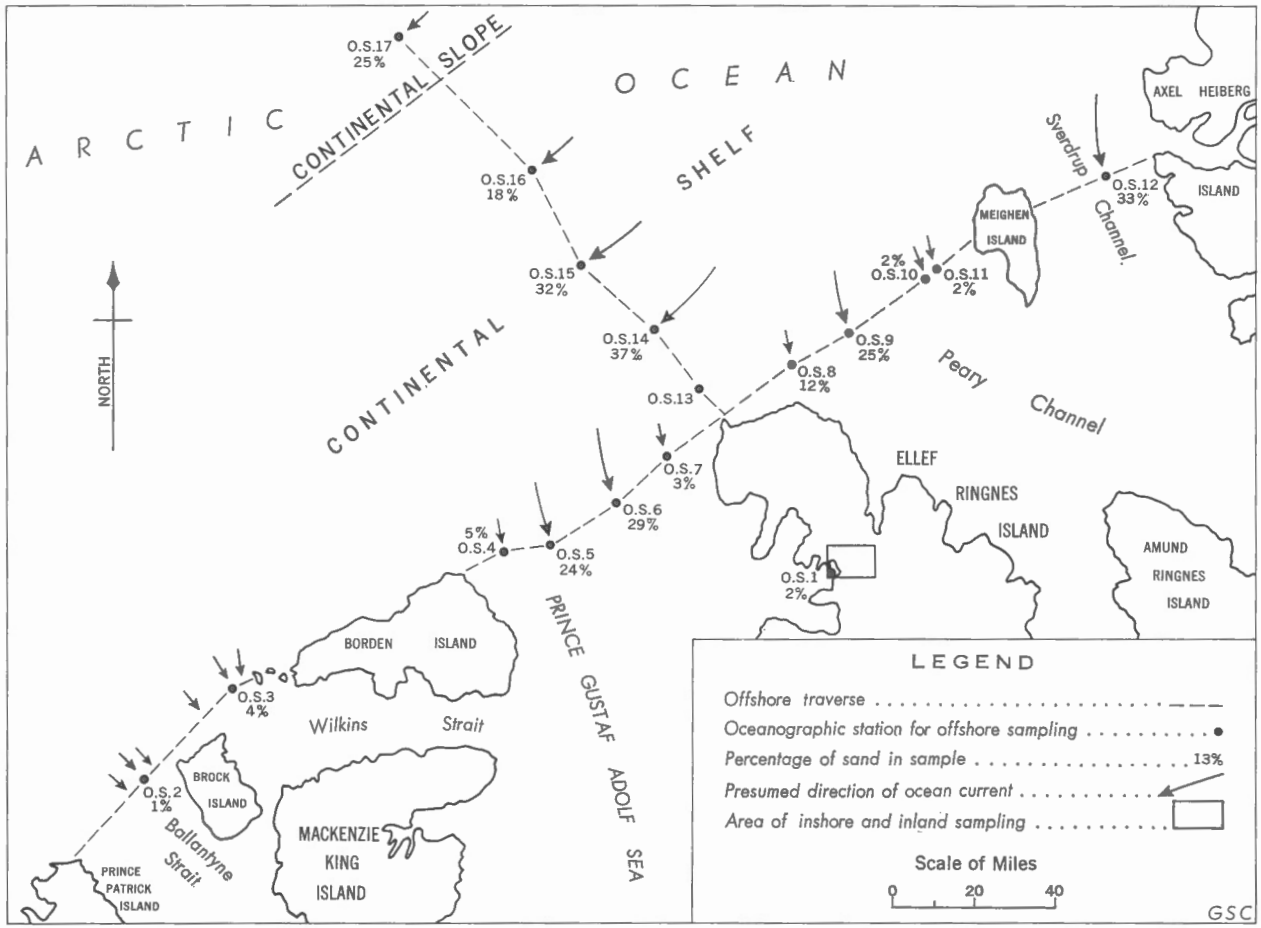

Figure 3. Map showing location of oceanographic stations, and relationship of oceanic currents to sand content of samples

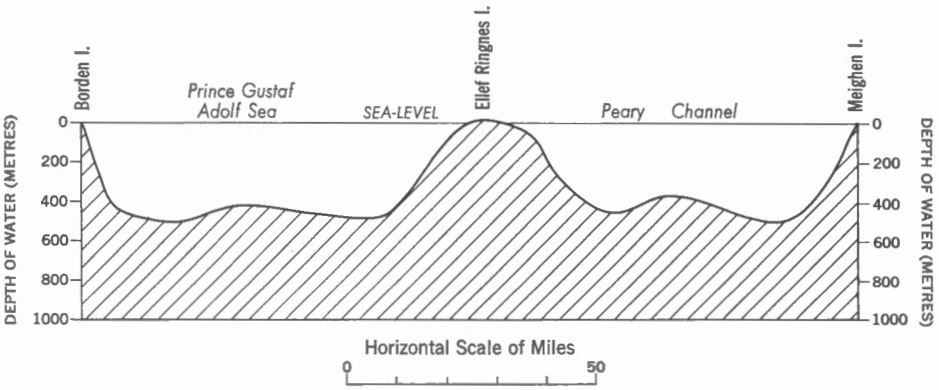

Figure 4. Submarine topographic profile along base-line between Borden and Meighen Islands. Data after R. M. Eaton, R. B. Lawrence, E. L. Sherman and A. E. Collin

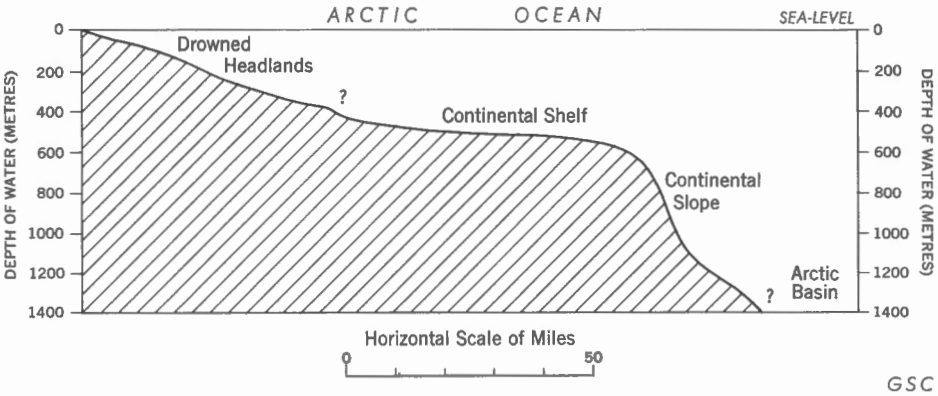

Figure 5. Submarine topographic profile northwesterly from Ellef Ringnes Island across the continental shelf. Data after R. M. Eaton, R. B. Lawrence, E. L. Sherman and A. E. Collin