Bedrock geology beneath Hudson Bay
as interpreted from submarine physiography

by

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(Geological Survey of Canada)

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INTRODUCTION

During a study of Hudson Bay aboard M/V THETA in 1961 undertaken by the Marine Sciences Branch, Department of Mines and Technical Surveys, a contrast was noted in the bottom physiography of various parts of the Bay. The purpose of this report is to present a preliminary interpretation of the bedrock geology underlying Hudson Bay based on physiographic evidence.

Hudson Bay is bordered on the southwest and north by gently dipping Paleozoic sedimentary rocks, and on the east and northwest by Precambrian rocks of the Canadian Shield (Figure 1). Until recently, little had been known about the geology beneath the Bay, and it was generally thought that the Paleozoic rocks extended under the Bay as a thin blanket overlying the crystalline basement rock. Results of a sea magnetometer survey in Hudson Bay during 1961 (Hood, 1964) indicated that this previous interpretation was erroneous. Hood reported a basinal feature in central Hudson Bay containing more than 10,000 feet of sedimentary rocks, which is a much greater thickness than was formerly supposed (Figure 2). This information was of particular interest to the petroleum industry, as the presence of a sedimentary basin under the Bay increased the possibility of oil accumulations. Current economic interest in the bedrock geology of Hudson Bay is sufficient to warrant this preliminary study.

An obvious correlation exists between physiography and geology in the regions bordering Hudson Bay. The Paleozoic area to the southwest of the Bay is called the Hudson Bay Lowlands.
Figure 1. General geology of the Hudson Bay area. (Modified from: Anonymous, 1955)
Figure 2. Interpreted basement contour map of Hudson Bay. Depths given in feet below mean sea level. (After Hood, 1964)
This is a broad plain underlain by almost flat-lying strata and bordered by a low escarpment that marks the boundary between the Paleozoic lowlands and the rolling Precambrian terrain to the south. (Caley and Liberty, 1957). On Southampton Island in northern Hudson Bay the contrast in the physiography between the eastern region of Precambrian crystalline rocks and the region to the west underlain by Paleozoic carbonates is apparent. In a detailed study of the geology and geomorphology of this island, Bird (1953) stated:

"Since the early part of the nineteenth century when Parry entered Duke of York Bay, explorers have been impressed with the contrast on Southampton Island between the broken, often highly scenic uplands of the interior and east coast of Southampton Island, and the flat monotonous lowlands of which the remainder of the island consists. This contrast is present not only on the land but extends out from the shore onto the adjacent continental shelf, and is due essentially to the presence of two widely dissimilar rock types on which geomorphic processes, acting through geological time, have produced the different landscapes we see today."

As it is possible to delineate on the basis of physiography the regions surrounding Hudson Bay that are underlain by Paleozoic rocks, a similar delineation of these rocks in the region beneath the Bay is reasonable.

Fathograms representing approximately 6,500 nautical miles
taken along the lines shown in Figure 3 were studied, and changes in regional topography were plotted. Positions of the cruise lines are based on dead reckoning which was controlled by radar fixes near shore. Information from bottom grab samples, cores, and bottom photographs was considered along with the physiographic data in the interpretation of the bedrock geology of Hudson Bay.
Figure 3. Track of MV THETA in Hudson Bay.
ACKNOWLEDGMENTS

The writers wish to express their gratitude to F. G. Barber, senior scientist on the Hudson Bay cruise, and to Captain C. Maro and the crew of the M/V THETA from which the fathograms were taken. The fathogram of the line extending between Mansel Island and the mainland of Quebec was supplied by our colleague, A. C. Grant, on one of his traverses aboard the launch NEEDLIK. Appreciation is extended to our colleagues L. H. King of the Bedford Institute of Oceanography, and C. V. G. Phipps of the University of Sydney, Australia, who provided many useful suggestions during conversations related to Hudson Bay.

Special thanks are reserved for our technician, T. A. Holler, who arranged and drafted all the illustrations for this report.
DISCUSSION

Section A-A' shown in Figure 4 is a fathogram from Mansel Island to the Quebec mainland. The island is underlain by Paleozoic carbonate rocks, and the land rises from the shore in a series of broad terraces. Continuation of the terrace topography towards the east beneath the Bay is evident in the fathogram, and indicates that this part of the section is underlain by Paleozoic rocks. The Precambrian granite gneiss of the adjacent Quebec mainland is characterized by a rolling topography of hills and valleys. There is a continuation of this topography towards the west under the Bay. The arrow on section A-A' points to an abrupt topographic change and indicates the probable contact between Paleozoic and Precambrian rocks along the section.

A fathogram across the bank in central Hudson Bay is shown in section B-B' of Figure 4. The depth of water over the shallowest portion of this bank is less than 20 fathoms. A comparison of this fathogram with the one off Mansel Island shows that section B-B' has a bottom profile similar to the portion of section A-A' underlain by Paleozoic rocks. Therefore, the central shoal is a broad, east-west arch, underlain by Paleozoic rocks. The features on the flanks of the arch are probably Late Tertiary terraces cut into bedrock and thus are similar to those on Southampton Island described by Bird (1953).

There is a marked contrast between the fathograms of section C-C' between the Belcher Islands and the mainland, and section D-D'
across the mouth of James Bay (Figure 4). Section C-C' is bounded by Precambrian rocks, and shows the rugged profile that is characteristic of Precambrian terrain. Section D-D' is from the Paleozoic lowlands on the west towards the Precambrian uplands on the east. The smooth, gently sloping bottom profile indicates an extension of Paleozoic rocks under James Bay. The probable contact between the Paleozoic and Precambrian is shown by the arrow at the point where the topography becomes irregular. It is unlikely that the contact occurs at the sharp drop present on the eastern portion of the profile, because most of the contacts on land show Precambrian rocks higher than recessive Paleozoic rocks.

Fathograms from the region near the entrance to Hudson Strait were difficult to interpret due to frequent course changes, greater depths, and the possibility of sediment accumulation. The basin between Nottingham Island and Cape Wolstenholme has a smooth, flat bottom with steep sides. The slope of the basin rising towards Mansel Island has a terraced topography typical of Paleozoic regions. The flat bottom of the basin may be the result of infilling by recent marine sediments, however, the topographic evidence supports Hood's (1964) interpretation of this region as a graben underlain by up to 2,500 feet of sedimentary rocks.

A factor to consider in the interpretation of the bathymetry of Hudson Bay is the thickness of overburden, and the extent to
Figure 4.
SELECTED PATHOGRAMS FROM HUDSON BAY

Showing interpretations of bedrock geology based on bottom configuration and relationship to land geology.

Figure 4.
which it has masked the bedrock configuration. In section A-A’ between Mansel Island and mainland Quebec the contrast in the bottom configuration due to a change in bedrock is still evident although bottom samples indicate the region is covered by marine mud. Similarly, the terraces on the flanks of the central shoal, which are characteristic of Paleozoic terrain on land, have not been obliterated by the accumulation of recent marine sediments. The irregularities of section C-C’, off the Belcher Islands, are undoubtedly related to bedrock, but the question arises whether the smooth profile of section D-D’, across the mouth of James Bay, is a reflection of bedrock or has resulted from sediment accumulation. However, it is unlikely that the steep slope near the eastern end of the profile would have been preserved if sediment accumulation was excessive. Also, the bottom rises towards the west in a series of subdued terraces that are probably related to the underlying bedrock.

Evidence from bottom samples, cores, and bottom photographs was used as an aid in physiographic interpretation of the bedrock. Figure 5 shows the distribution of calcium carbonate in the bottom sediments of the bay. The high percentages in the southwest and northern portions of the bay coincide with regions that are bordered and probably underlain by Paleozoic carbonate rocks. Therefore, the high values over the central shoal provide additional evidence that it is underlain by Paleozoic carbonate rocks.

A sediment core taken at Station 84 (Figure 5) penetrated
Figure 5. Calcium carbonate percentages in the bottom sediments of Hudson Bay.
probable glacial till beneath 1 metre of marine mud (Leslie, 1965). The coarse fraction of this till is composed predominantly of carbonate rock particles. As the major constituents of glacial till are usually of local origin, the preponderance of carbonate fragments in the till indicates that it overlies carbonate rocks.

A photograph taken at Station 138 at a depth of 120 metres shows the bottom covered with angular cobbles (Figure 6). These cobbles were at first thought to represent a concentration of ice-rafted material (Leslie, 1964), however, an examination of other photographs taken at this station revealed that the coarse material is much more evenly distributed over the bottom than is usual for ice-rafted sediments. It is more probable that the bottom represents the upper surface of a glacial till which has been only partially covered by subsequent marine deposition. Most of the cobbles have the characteristic tabular shape of carbonate rock fragments, and, as the major constituents of till reflect the underlying bedrock, it is probable that the region is underlain by Paleozoic carbonate rocks.

The distribution of Paleozoic rocks beneath Hudson Bay shown in Figure 7 represents an extension of the land geology based on interpretation of the submarine physiography as previously described. The location of the boundary north of Churchill, shown by the dashed line, was difficult to establish because of many changes in the ship's course, accumulation of sediment from the Churchill River, and complicated land geology which is reflected in the abrupt change in direction of the shoreline. Difficulties
Figure 6. Underwater photographs of the floor of Hudson Bay showing the profuse distribution of blocky, carbonate fragments thought to be Paleozoic in age.
Figure 7. Distribution of Paleozoic rocks beneath Hudson Bay based on interpretation of submarine topography.
were also encountered in determining the boundary between Paleozoic and Precambrian rocks in the region west of the Ottawa Islands and south towards the Belcher Islands. Fathograms in this area show many abrupt changes from flat Paleozoic type terrain to irregular topography typical of the Precambrian. Hood (in press) tried to distinguish the contact west of the Belcher Islands from an east-west sparker record of the sub-bottom profile, but encountered similar complications which he attributed to the presence of Paleozoic outliers.

It is evident from the present study that the configuration of Hudson Bay is directly related to the aerial distribution of Paleozoic rocks. Consideration of this relationship leads to interesting speculation concerning other areas. The presence of Paleozoic rocks on the north and east coasts of Foxe Basin indicates that most of the basin is probably underlain by rocks of similar age. Ungava Bay is bordered by Precambrian rocks, but Akpatok Island in the west-central part of the bay is underlain by Paleozoic rocks. It appears probable that the location and general configuration of Ungava Bay is directly related to the aerial distribution of these younger rocks in a manner similar to that found for Hudson Bay.
CONCLUSIONS

1) Physiographic interpretations of the bedrock geology beneath Hudson Bay indicate that most of the Bay is underlain by Paleozoic rocks.

2) An east-west profile of the bank in central Hudson Bay reveals that this bank is a broad arch underlain by Paleozoic rocks.

3) A fathogram record across the mouth of James Bay indicates that the Paleozoic-Precambrian contact is near the east coast, and therefore Paleozoic rocks occur beneath most of this bay.

4) The location and general configuration of Hudson Bay is directly related to the aerial distribution of Paleozoic rocks. It is probable that rocks of this age also underlie most of Foxe Basin and Ungava Bay.
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