The Geology of the Igloolik Island Area, and Sea Level Changes

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SCIENCE INSTITUTE
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FOREWORD

This Report is the second in Scientific Report Series and the first to focus on Foxe Basin. The Report continues our aim of providing scientific information in a style and language that can be understood by the general reader in the Northwest Territories.

The author, Ms. Lynda Dredge, is a geologist with the Terrain Science Division of the Geological Survey of Canada. She works out of the Survey's headquarters in Ottawa, Ontario. Ms. Dredge has a Master of Science degree from McGill University and a Doctorate in Environmental Studies from Waterloo University.

For several years she has been working on the regional geological mapping of the Melville Peninsula and the studying the changes in sea level which resulted from the disappearance of the ice sheets associated with the last ice age. Ms. Dredge has also undertaken research on the permafrost conditions in the Hudson Bay lowlands and sea level changes in the Gulf of St. Lawrence.

The Institute would like to express it's appreciation to Ms. Dredge for the considerable effort involved in preparing this report, and to the Geological Survey of Canada for allowing its publication.

The Science Institute welcomes any comments that readers may have on this Report. Suggestions for new reports are of particular interest. The offer to author additional topics would be especially appreciated!

Copies of this Report may be obtained by writing the Institute at the address on the title page.

David Sherstone
Director, Scientific Services
Yellowknife, November, 199

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INTRODUCTION:
The ups and downs of Igloolik Island

Most of the geologic features on Igloolik Island and in the Hall Beach area developed during four main events in the earth's history: ancient marine floodings, glaciation, emergence of the land from the sea after ice ages, and the present day cold-climate.

Igloolik's geological heritage is tied to the sea. As early as 500 million years ago, what is now the island was part of an ancient sea bottom. Several times in the ancient past, it rose from the sea, only to be submerged again. The history of these very early events can be read in the rocks.

More recently, during the Ice Ages of the last 2 million years, the island and all nearby areas were covered by a massive ice sheet, perhaps 1 km thick. This ice sheet covered most of Canada. During the Ice Ages, glaciers and ice sheets grew and melted away a number of times. Each time the ice sheets grew, the tremendous weight of the ice depressed the crust of the earth beneath it (in the same way that finger-pressure on an inflated balloon will distort the balloon's surface). Each time the ice sheets melted the crust slowly rebounded to its original shape. At Igloolik, the weight of the ice depressed the crust about 150m, so that the whole island was below sea level. After the last of the ice sheets melted, the crust slowly rebounded, until Igloolik Island finally emerged from the sea. The earth materials on top of the bedrock tell the story of this passage of glaciers, and the final emergence of the island from the sea.

Between glaciations, Igloolik experienced climates similar to, or slightly warmer than, present. The present environment is probably an interglacial period, between the last ice age and the one to come.

The first people arrived on the Island about 4000 years ago. They built their habitations along the coast, but their sites are now about 45 m above sea level. The location of the early habitations reflects continuing rise of the island from the sea, and changing coastal shapes.

Topography

Igloolik Island lies in the northwestern part of Foxe Basin near the entrance to Fury and Hecla Strait (Fig. 1). The island, which is 18 km long, consists of prominent, rocky, flat-topped hills, called buttes, joined by lowland plains where a low bedrock outcrop is partly covered by old, raised beaches. The highest butte, on which the airport is situated, reaches an elevation of 56m above the present sea level. The cemetery butte north of the settlement is 51m, and the smaller butte on the eastern part of the island 33m, above sea level. These high areas step down to the sea in a series of cliffs and smaller scarps. Bedrock lies near the surface throughout the island, but glacial deposits, raised beaches and scree (rock rubble on slopes) cover the bedrock in many places.

Bedrock

Bedrock is visible along the cliffs above the Hamlet of Igloolik. It consists of the horizontally layered rocks that were originally marine muds. The main rock unit is dolomite, which is make up of calcium magnesium carbonate. This type of rock forms most of the cliffs and underlies the lowlands. The second rock unit is limestone (calcium carbonate) and this type of rock lies on top of the dolomite and forms the uppermost part of the buttes. Both units contain fossils which are known to have lived between 500 million and 450 million years ago. Some of these fossils, Brachiopods (marine shellfish with asymmetric shells), cephalopods (molluscs), coral, bryozoans (colonial moss animals), and algae were collected from localities 3 and 4, Figure 2. Between the two rock units is a churned up layer and pebbly zone (locality 1 and 2, Fig. 2). The main dolomite unit was deposited in a lagoon or shallow sea. Later, the island emerged from the sea, and the pebble and sandy churned-up layers were deposited as a result of erosion of the land during that time. The overlying, younger limestone was later deposited in an open, deep sea at a later time, when the sea covered most of northeastern Canada, including all of Melville Peninsula and Igloolik Island.

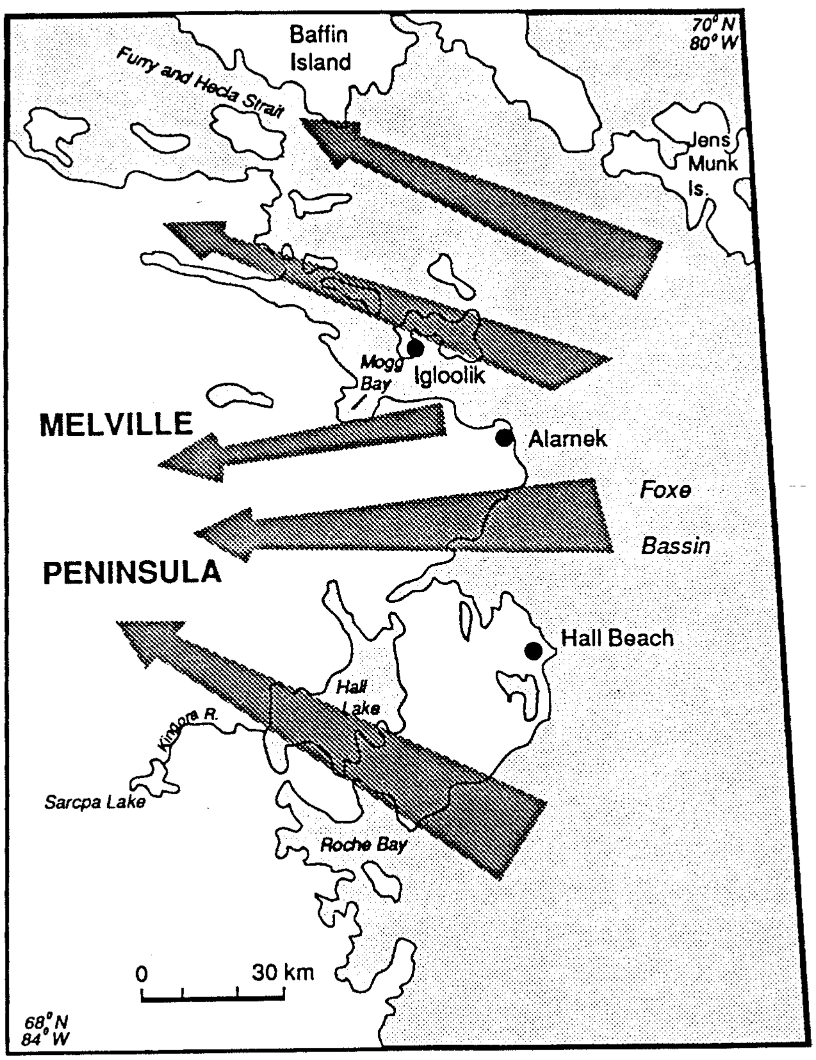


Fig. 1. Location map. Arrows show the pattern of glacier movement across the peninsula.

Glacial deposits and features

A thin layer of gritty, pebbly debris (called till) was laid down by the glaciers that crossed the region. This till covers much of the bedrock on the lowland areas of both eastern and western Igloolik Island and eastern Melville Peninsula. These deposits have been modified by the action of the seas since their deposition. The original, unmodified till can be seen along the wall of the reservoir pit near the Igloolik airport, sandwiched between surface marine deposits and the bedrock. It is a grey or tan coloured, pebbly, gritty silt. The grain sizes of the finer part of the till are about 5% granules, 30% sand, 45% silt, and 20% clay. This till is made from local rocks that were ground up underneath the glaciers but not moved far and from material that has been glacially eroded and transported from sources as distant as 250 km away. Sixty to 80% of the fine material is ground up limestone and dolomite. Most boulders in the till are dolomite and limestone, but sandstone, quartzite, shale and granite boulders have also been transported onto the Island. Some of the stones in the till are covered by scratches (striations) made by the rubbing together of grit and rock fragments in the base of the glacier.

Landforms showing the direction of glacier movement are rare in the Igloolik area because recent frost action has shattered the original glaciated bedrock surfaces; however, glacial scratches (striations) on bedrock have been preserved on the northwest part of the island. The orientation of these striations indicates that the glaciers flowed towards the northwest. These striations fit into a regional pattern,

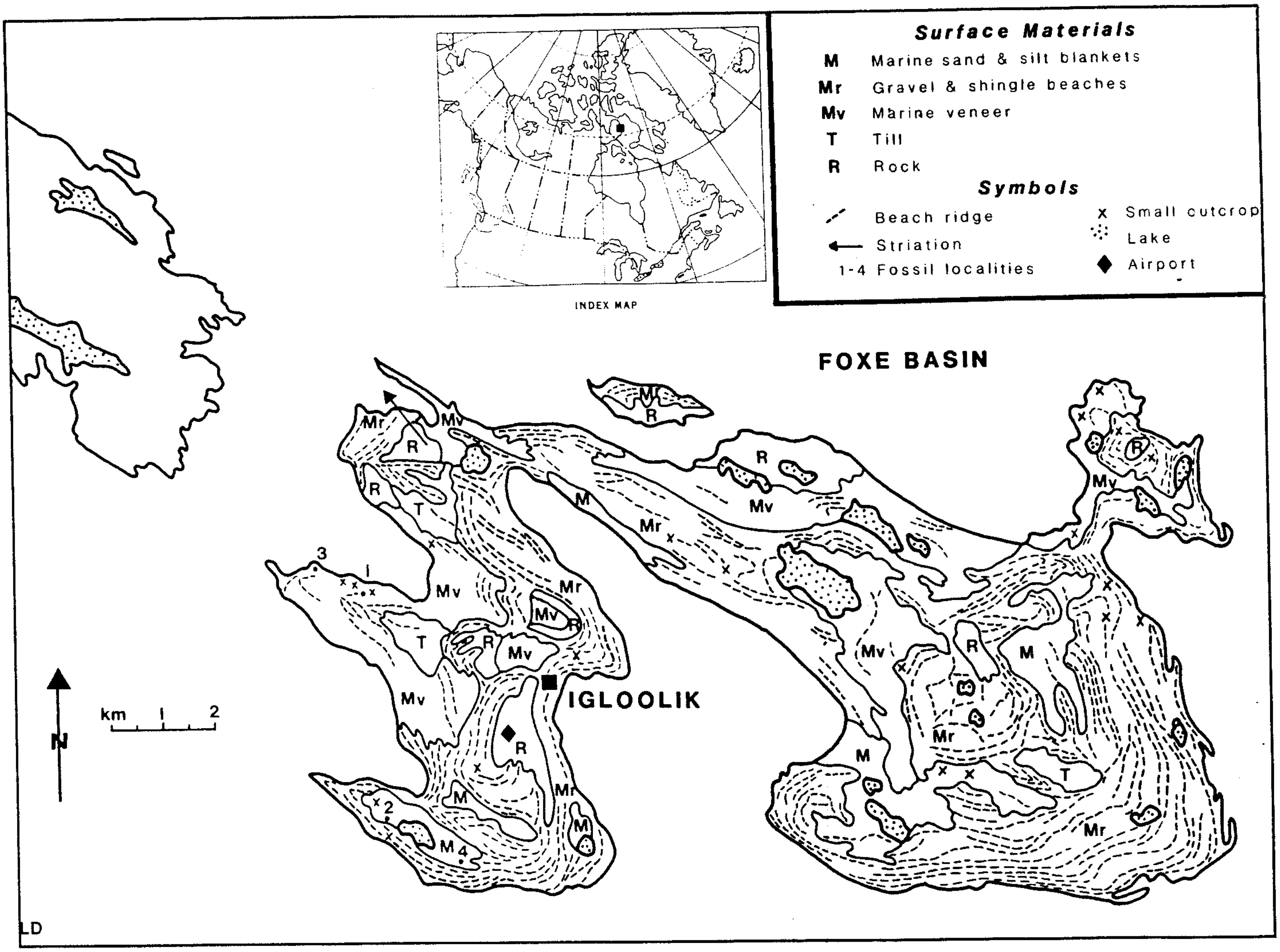


Fig. 2. Geology, Igloolik Island.

which indicates that glacier ice flowed outwards from a centre in Foxe Basin, crossed Melville Peninsula, and streamed through Fury and Hecla Strait (Fig. 1). The predominance of limestone and dolomite boulders in the till supports this ice flow interpretation, because these rock types underlie most of Foxe Basin. The quartzite and granite found in the till do not fit this ice-flow model. The source of these rock types is on Baffin Island, north of Igloolik, or on Melville Peninsula. These erratics were probably transported by an earlier ice mass which was centred to the north or west, and subsequently picked up by the Foxe ice mass.

Marine deposits and sea level change

Raised beaches, lying well above and away from the present shoreline, abound on Igloolik Island, and form concentric rings around the bedrock buttes (Fig. 2 and 3). The character of these raised beaches changes from place to place. In some areas they are composed of well-sorted, pebble-sized gravel; in others, where the rock outcrop is nearby, platy, shingle beaches prevail. Much of the beach material appears to have been derived from the adjacent buttes of limestone and dolomite, which were probably much bigger in the past. However, granite and quartzite boulders are also scattered across the beach ridges. These may have come from glacial deposits underlying the beaches or they may have been transported by sea ice rather than by glacier ice. Blankets of marine sand and silt cover small areas of the island (Fig. 2). The beach material can be used as a source of sand and gravel, but there are some problems: firstly, they contain a substantial amount of very fine material, and secondly, most raised beach deposits are only about 1m thick.

The raised beaches on Igloolik Island and adjacent parts of the mainland indicate that the entire island was covered by the sea immediately following the last deglaciation, when the earth's crust was still depressed from the weight of the glacier load. The land has continuously risen and emerged since that time. The ages of fossil marine shells that lived in the sea when it covered most of the island have been measured by the carbon-14 method.

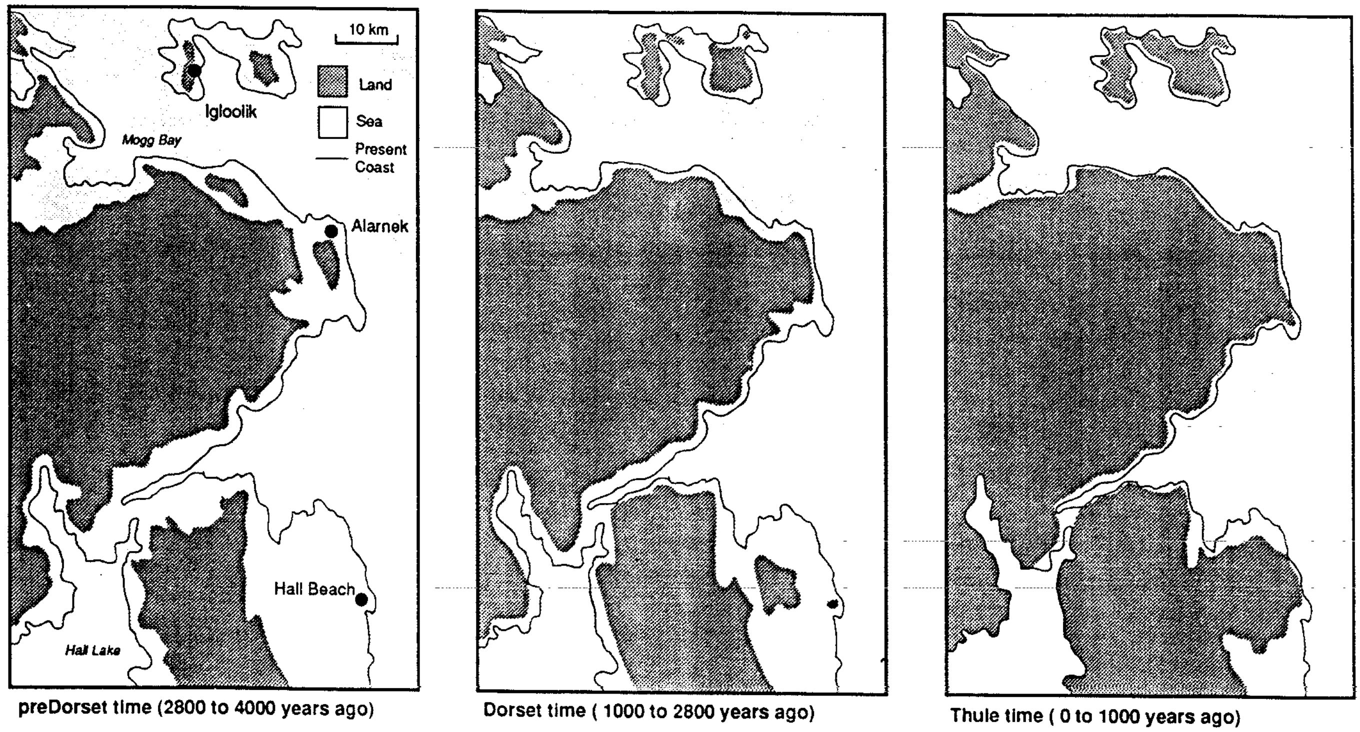
South of Parry Bay on Melville Peninsula dated shells indicated that the glacier disappeared from Foxe Basin about 6900 years ago. The land has uplifted 146m since that time, which means that the 6900 year old shoreline is now marked by a beach ridge that lies 146m above to-day's sea level. West of Hall Beach, this same beach lies about 60 km inland from the modern coast. By obtaining carbon-14 dates on marine shells at different elevations, it is possible to reconstruct the style and rate of emergence.

A curve showing the changes of sea level since deglaciation at Hall Lake - Kingora River is shown in Fig. 4A. Carbon-14 dates on ivory and antler from ancient habitation sites show the relationships between people and the sea, and another sea level curve can be constructed for Igloolik based on this data (Fig. 4B). The dated ivory and antler come from house ruins on raised beaches on Igloolik Island and Arlagnuk Point, which is 30 km southeast of Igloolik. The Igloolik site belongs to the pre-Dorset culture, while those at Arlagnuk are Dorset and Thule (Table 1). Because the sites represent coastal hunting communities, the oldest dates from these sites should give approximate ages for sea levels at their respective elevations.

The pattern of emergence shown on Fig. 4B, constructed from the archaeological data, appears to be similar to that in the Hall Beach area, which was based on dates from marine shells on raised beaches, and on bone and tissue from a whale found underneath a raised beach. The timing and rate of emergence here differs from that at Kingora River. The rate of present emergence at Hall Beach and Igloolik appears to be about 70 cm every hundred years, while that at Kingora River is only about 45 cm per hundred years. The more rapid emergence at Igloolik and Hall Beach indicates that these localities are closer to the centre of late Foxe Basin glacial unloading.

Figure 5 shows the shape of the coastline on northeastern Melville Peninsula and Igloolik Island in pre-Dorset, Dorset and Thule times, the three main Inuit cultural periods recognized in the area. These maps are constructed from the sea level emergence curves, dated archaeological sites, and topographic maps with a 10m contour interval. The area looked substantially different in pre-Dorset times when Igloolik was two small separate islands. The area around Hall Beach was under water; the lowlands and lakes west and northwest of Mogg Bay were connected to the sea, and Hall Lake was an open strait that separated the mainland from a large offshore island. The local name for Hall Lake, Tasiujaq, means 'that which is like a

Fig. 3. Air photo of western Igloolik Island, showing the settlement, bedrock scarps, raised beaches, and areas of frost-shattered rock (FSR). NAPL A-24206-4,5, 1975. Scale 1: 24 000.



Areas of land and sea in preDorset, Dorset, and Thule times. The present coastline is shown for reference.

Fig. 5. Configuration of northeastern Melville Peninsula in pre-Dorset, Dorset and Thule times. The present coastline (thin lines) is shown for reference.

lake', and is commonly used for enclosed arms of the sea (Mathiassen, 1933, p. 73). Mathiassen suggested that this and names for other features around the lake, indicate that while Eskimos had been living in the area, the lake had been an arm of the sea. According to the sea level curve and coastline reconstructions, Hall Lake was part of the sea until about 1000 years ago.

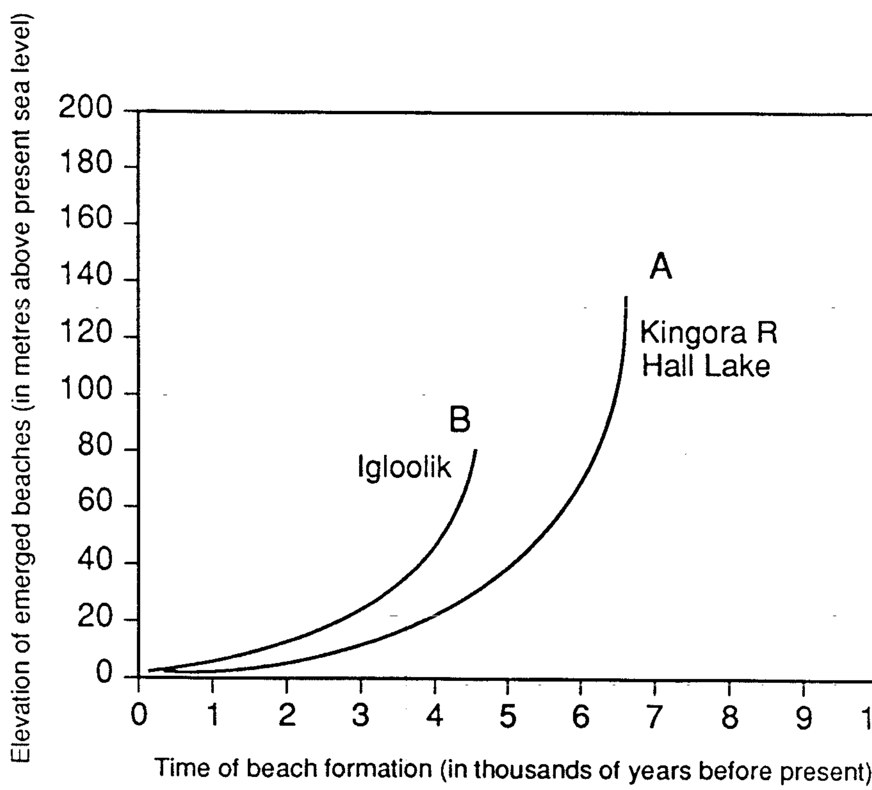
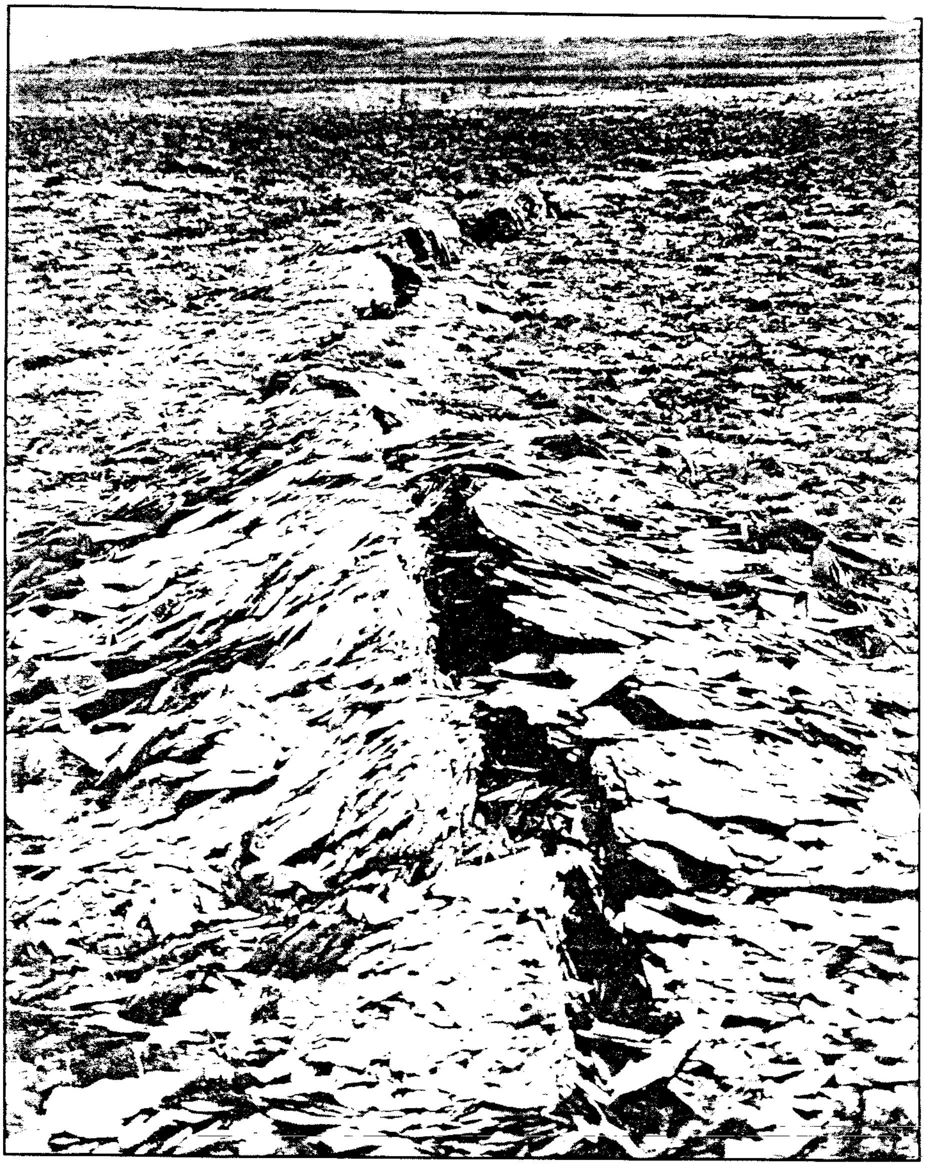


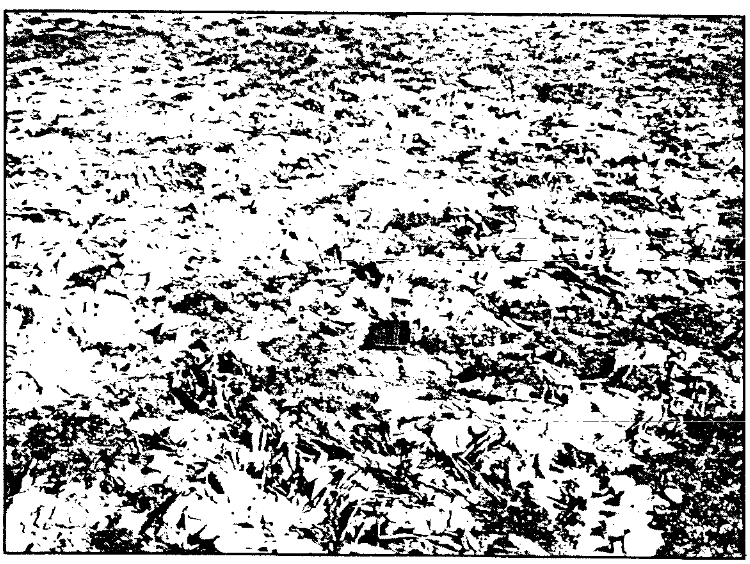
Fig. 4. Sea level curves and postglacial emergence at Hall Lake - Kingora River and at Igloolik. The curves show how the land emerged over time. For instance, the beach which was formed at sea level 4000 years ago is now found at 20m above sea level near the Kingora River, and about 45m above the present sea level at Igloolik.

Geologic processes in the present environment

The upper 50 - 100cm of the ground thaws each summer, and most weathering processes happen in this surface layer. Below this layer, to a depth of about 400m, the ground remains frozen year-round.

Churning of the upper metre of the soil by frost action and frost heave of bedrock are the principal geomorphic processes presently operating. Mudboils are small circular soil forms that result from the thawing of ice in the soil during the summer, and the churning, or sorting, of materials by frost action. In some mudboils, the gravel fragments are turned up on end (Fig. 6). Frost heave is severe, as indicated by the abundance of broken rock. Heaving begins where water seeps along horizontal layers in the bedrock, or along vertical fractures (Fig. 7). When freezing occurs, platy bedrock fragments are split off and thrust upwards or sideways by the direct effects of the expansion of water as it changes to ice, or as a result of excessive pore water pressure created below the icy layers. Examples of these processes can be seen near the airport, where thrusting is occurring along a network of bedrock joints (Fig. 3 and 7). Broken bedrock slabs litter the entire surface, and form a scree slope along the cliff face to the east.





Left: Fig. 6. Mudboils north of Igloolik, showing upturned shale and limestone pebbles.

Above: Fig. 7. Broken bedrock surface of flaggy dolomite at Igloolik airport, created by frost shattering along fractures.

Table 1: Radiocarbon dates from archaeological sites

SITE	ELEVATION	MATERIAL	14C. AGE	LABORATORY NUMBER
Alarnek				
Dorset	22	ivory	2910.±129	P-213
Dorset	22	antler	2404.±137	P-212
Thule	2-6	?	1100.	
Kaleruserk (Igloolik)				
Pre-Dorset	52	ivory	3958.±168	P-207
Pre-Dorset	52	antler	3560.±123	P-208
Pre-Dorset	51	ivory	3906.±133	P-209
Pre-Dorset	51	antler	3700.±300	K-505
Hall Beach				
–	7	shells	1020.±130	GSC-691
–	8	whale	1130.±60	GSC-3850

after Dredge, 1991

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