10. COASTAL MORPHOLOGY AND TERRAIN STUDIES, KIVITOO PENINSULA, BAFFIN ISLAND

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A brief visit was made in 1975 to the Kivitoo Peninsula, on the east coast of Baffin Island, (Fig. 10.1), to examine landform modification under periglacial conditions. Field studies were continued in summer 1976 and were concentrated on the geomorphic processes active along the coast and on the role of snow in terrain development.

Shoreline Investigations

The dynamics and rates of shoreline modification in arctic environments are inadequately known both in construction of theoretical models and in their application to resource development. In Canada there is a fundamental contrast between western Arctic shores, where massive ground ice and fine unconsolidated sediments are major components of marine cliffs and depositional beach forms are widespread, and the eastern Arctic, where cliffs and talus slopes are characteristic and coarse sediments dominate the beaches. Special elements in coastal processes in the eastern Arctic include the presence of an ice foot, low energy wave conditions for a large part of the year due to sea ice, and great seasonal variability of the shore environment depending on the distribution of sea ice (McCann, 1973).

The coasts of the eastern Arctic adjacent to the Labrador Sea, Davis Strait, and Baffin Bay are developed in rocks of the Canadian Shield and are dominated by high cliffs and rock forelands; coastal lowlands are few. A conspicuous exception to the general pattern is on either side of Home Bay, Baffin Island, where low forelands, separated by fiord troughs, are covered with marine, glacial, and fluvioglacial deposits (Andrews et al., 1975; Feyling-Hanssen, 1976).

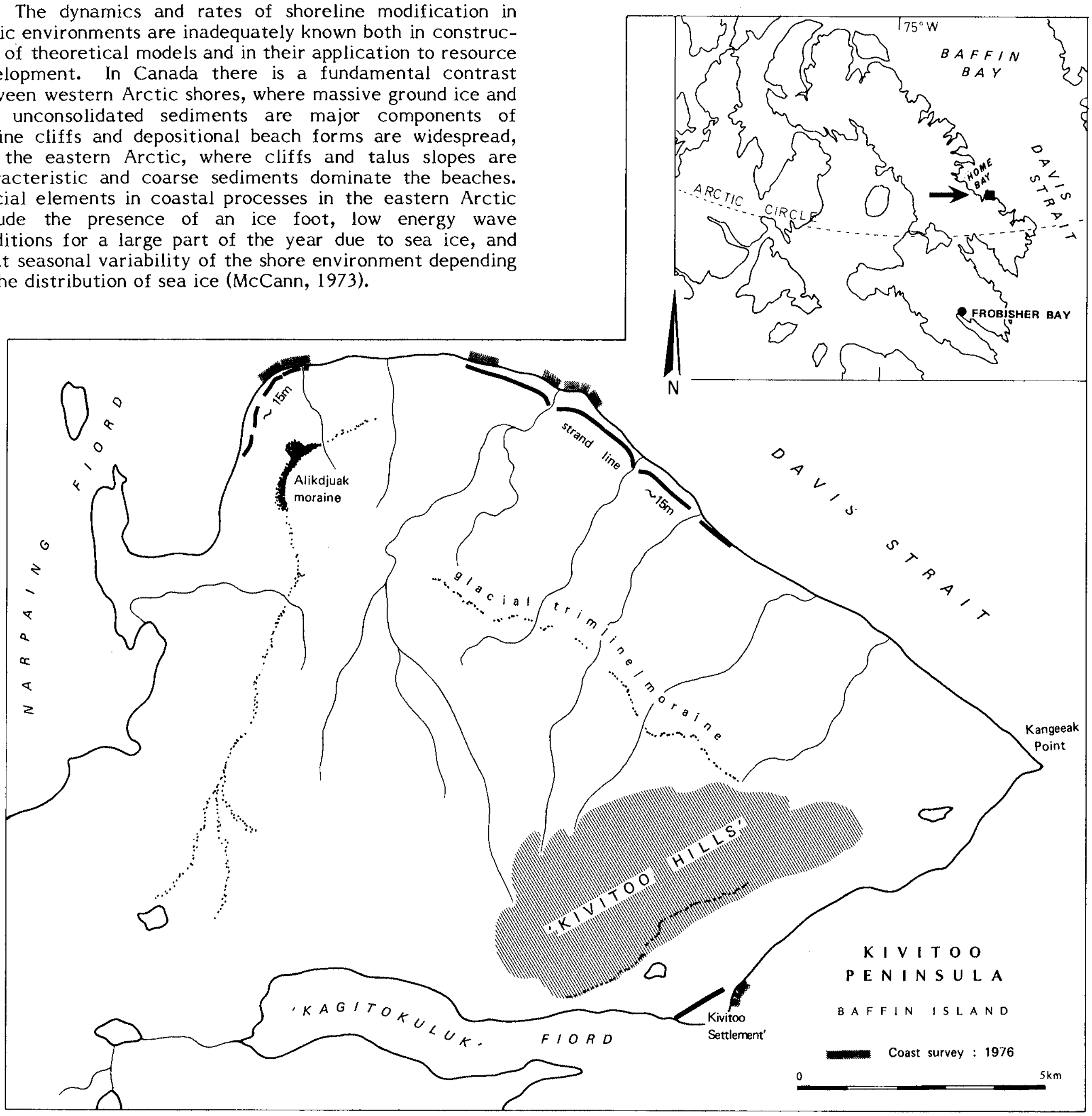

Figure 10.1. Location map.

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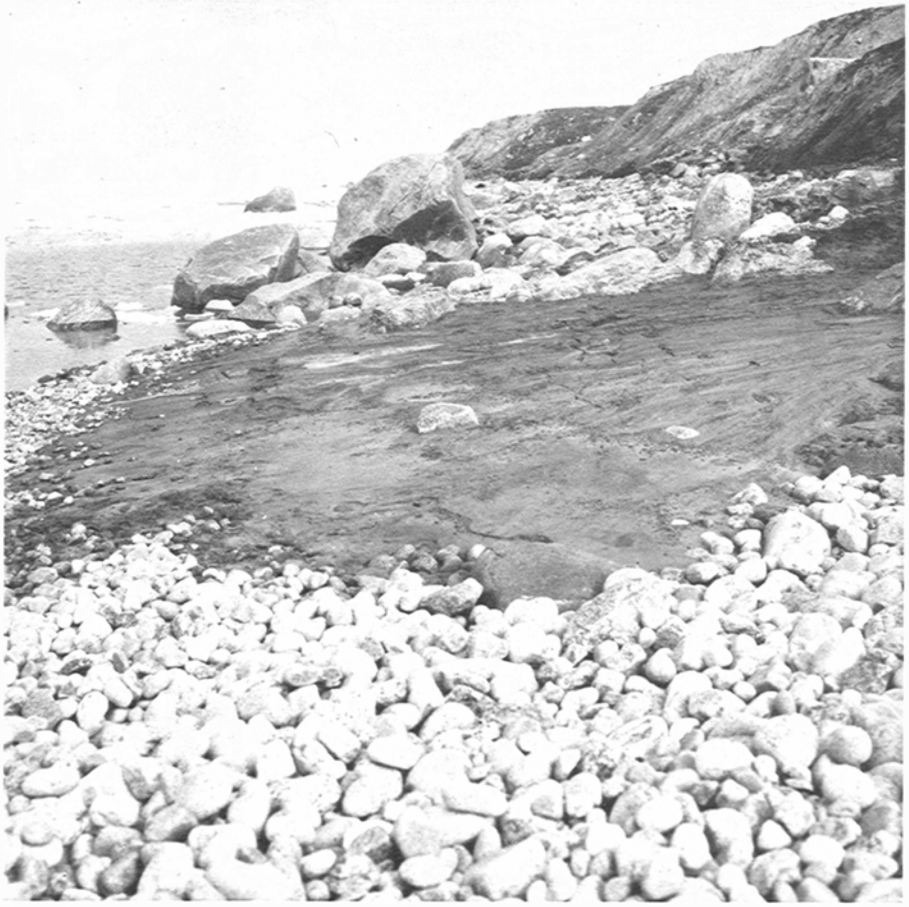

Figure 10.2. Beach and gullied cliff, Kivitoo Peninsula, August 1976. A small fan, developed from a mudflow on the cliff face, temporarily buries part of the beach.

During low sea level phases in the late Quaternary, the forelands apparently extended eastwards as part of the relatively wide, and today, shallow, continental shelf (Løken and Hodgson, 1971) and to some degree were glacier free. The forelands are surrounded in part by cliffs eroded in unconsolidated sediments. The cliffs at present are retreating rapidly as indicated (in the case of the Kivitoo area) by the destruction of prehistoric Eskimo house sites.

Coastal Morphology – The Cliffs

Kivitoo Peninsula, the foreland on the southeast side of Home Bay (Fig. 10.1), is ringed by cliffs from near the former Kivitoo settlement at the entrance of Kagitokuluk Fiord for 27 km to Narpaing Fiord. The cliffs vary in height, increasing from 5 to 8 m in the vicinity of Kangeeak Point to more than 20 m at the northwest corner of the peninsula. They are developed in a variety of unconsolidated materials including sorted sands, silts and clays, pebbles, cobbles, and boulders. Bedding commonly is obscured along the cliff face; where visible it is generally horizontal with local tilting and minor faulting and occasional conspicuous unconformities. Andrews et al. (1975) have identified several units in the sediments and interpreted them as a succession of glacial (till) and elevated interglacial/interstadial marine beds dating back to the last interglacial or earlier. No massive ground ice, either in the form of wedges or horizontal sheets, has been observed in the cliffs.

In detail, the morphology of the cliff face is highly varied. At some localities, usually where the cliff is formed in mixed, coarse sediments with a sandy matrix, the face is a single linear slope, from crest to beach, unbroken by gullies or slump features and with an angle of 38 to 44 degrees. At other localities the slope angle is more variable (range 30 to more than 65 degrees, major grouping ~39 degrees). The face morphology is less uniform, and it is broken by gullies and earthflow features. The base of the cliff is steepened in places but is nowhere vertical or (wave) notched. In some areas gullies are spaced uniformly along the cliff and apparently are developed by moisture from the cliff face. Elsewhere gullies are associated with surface fissures developed in an elevated marine terrace to the rear of the cliff. The fissures, which are 10 to 50 cm deep, extend to the crest of the cliff where a gully starts; in one sector of 13 consecutive gullies, 12 were linked to fissures. Gully erosion results from water led off the terrace in the fissure during the spring and from large boulders that are concentrated in the fissures and that slide down the cliff face as retreat occurs. Moisture seepage in late summer along the cliff face also is associated with earthflows, mudflows, and rivulet erosion.

Markers and cliff crest lines, surveyed in 1976, eventually will enable the rate of cliff retreat to be determined; preliminary observations indicate retreat of approximately 0.5 to 1.0 m per year in the most vulnerable sectors by a combination of 1) concentrated debris slides initiated by falling boulders; 2) sheet debris slides where desiccation and removal of the sand matrix by gravity and wind leaves larger particles unsupported; and 3) earthflows and mudflows located in gullies.

The active transfer season for debris across the cliff face reaches a maximum of about 125 days in the north and northwest of the peninsula. Snowbanks bury the cliff face for much of the summer in the eastern parts of the peninsula; in the vicinity of Kangeeak Point some snowbanks are quasi-permanent. The distribution of late-surviving snowbanks is associated with extreme shallow offshore conditions; in these cases the banks are resting on an ice foot which is not easily removed by wave action. Further examination will reveal the relationship of the snow to the cliff and particularly whether they are frozen together at the interface. Northeast of the former Kivitoo settlement, where late snowbanks are widespread, melting snow saturates the cliff face as the ground thaws, and small mudflows are common in the latter part of the summer.

The Beach

A beach separates the base of the cliff from the sea, and it is unusual for waves to reach the foot of the cliff. Beaches have an average width above the high tide mark of 10 m and a variable slope averaging 5 degrees; the normal tidal range at spring is 1.5 m. The composition of the beach differs from sector to sector with a uniform grade size predominating at some sites and a mixture at others. The dominant beach materials are commonly cobbles (subrounded to rounded) with small boulders (subrounded) and a few large subangular boulders (more than 1.5 m diameter) (Fig. 10.2). Sand is rarely present on the beach although it forms a high proportion of the cliff material. Inspection offshore shows that sand is widely distributed 1 m and more below low water (or 1.75 m below sea level), and therefore it must be transferred rapidly across the beach from the cliff to deeper water.

The beach profile is normally straight with a berm restricted to the widest beaches (at the northwest end) and to wide gaps (valleys) in the cliffs. At a few points, double (stepped) berms were observed suggesting that the profile may be in a dynamic state and is combed down and then built up at different periods. Except for two small fans no unreworked cliff material was found on the beaches below the berm.

There is little direct evidence in the beach profile of the action of sea ice; apart from the morphologically graded nature of the profile and the rounding of the finer material, there is little evidence of sediment transfer, especially in the form of longshore drifting. Large boulders accumulate at or just below low water, a process that is suggestive of the growth of incipient boulder barricades; large boulders also are concentrated at the headlands. It was not evident, however, to what degree headlands are preserved by the presence of boulders offshore, providing protection against ice and wave action.

It is suggested (Fig. 10.3) that longshore movement is minimal, and it follows that the dynamic transfer of debris off the beach, enabling cliff retreat to continue at a high rate, must be found in movement of sediments to inshore and offshore zones.

Wave Action on the Beach

Two processes associated with waves and sea ice are responsible for redistributing sediments on the beach. Wave action clearly is restricted by sea ice conditions. Fast ice and close pack ice are present until late June and do not permit inshore wave activity. Conditions in the open sea period, which prevail from then until late October, are highly variable from year to year. When heavy pack ice is present throughout the summer (e.g., 1973), it is unlikely that any significant wave action occurs on the outer coast of the Kivitoo Peninsula. In contrast, during a season in which there is little pack ice either inshore or in Davis Strait (e.g., 1975), long swell waves generated in the open ocean arrive for days at a time, and beach material is in constant motion in the surf. Even under these conditions much of the wave energy is dissipated in the shallow offshore waters before reaching the beach. This is particularly evident in the vicinity of Kangeeak Point where the water may be less than 5 m deep for more than 1 km offshore.

A 'normal' season falls between these extremes and resembles the 1976 season when pack ice was present off the coast throughout July and August. For the first part of the summer the sea was open, and ice remained off the coast giving clear water near the beach; however, there was little wave action. In the second month the ice cover was up to 4/10 within 5 km of the shore, and waves were effectively dampened.

The roundness of cobbles and fine beach material may be explained by their original roundness in the cliff beds and by the action of surf spread over a long period. The transfer of cliff debris from the rear of the beach is explained less easily, as grading to the local profile occurs for all material except the largest boulders within the period of an annual cycle. To analyze this, conditions prior to breakup, and particularly the role of the ice foot, will have to be examined.

The peninsula is drained by several streams which rise in the Kivitoo Hills and flow to the northeast. For the upper and middle part of their courses the streams flow in shallow depressions and shallow channels on the surface of the plateau. Near the sea the streams become entrenched into the foreland, the valley sides are steep (more than 25 degrees), and the channels are choked with coarse sediment including large boulders. Although the watersheds are small (the largest is 38 km^2 and the majority are less than 10 km^2), stream competency and capacity are temporarily high during the spring runoff when the snowpack over the entire foreland melts essentially at the same time. The stream load is derived primarily from the sides of the lower, entrenched valleys where the erosional processes closely resemble those acting on the marine cliffs. The coarse component of the load that reaches the sea is deposited as an underwater boulder delta off the stream mouth. The deltas are small in terms of the material eroded to form the valleys, and it is assumed that the finer material becomes incorporated in the sea bed directly offshore.

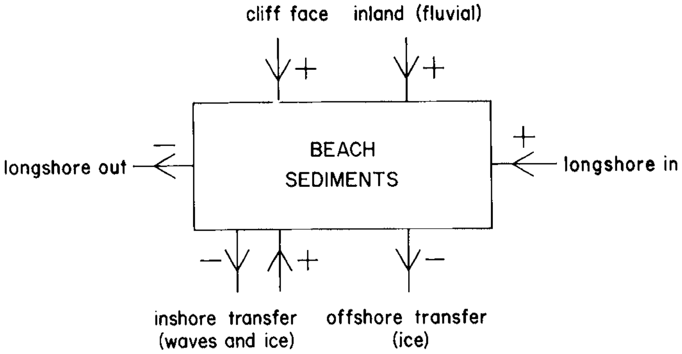

Figure 10.3. A model of beach sediment transfer.

It is proposed in continuing studies to concentrate on the properties of the cliff sediments, the relationship between permafrost and soil moisture distribution near the cliff face, the initial protective and subsequent sediment transport role of the ice foot, and the frequency of exceptional environmental events especially the incidence of storms on open beaches.

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