RECENT CHANGES IN THE SHORELINE NEAR POINT BARROW, ALASKA†

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THE tundra of the Point Barrow area is part of the coastal plain that forms the northern section of the Arctic Slope of Alaska. Like all typical coastal plains, it is underlain by poorly consolidated materials. It differs from more southerly coastal plains chiefly in the presence of ground ice throughout its extent, and in such geomorphic features as innumerable lakes and swamps, soil polygons, and other phenomena caused by permafrost. Many abandoned beach ridges, spits, and other shore features in an excellent state of preservation are to be found at various distances from the present shoreline, testifying to a relatively recent general emergence. The region discussed in this paper is shown on Fig. 1, which is based on Charts 9445 and 9495 issued by the U.S. Coast and Geodetic Survey.

Several segments of coast may be distinguished in the vicinity of Point Barrow. For some 50 miles southwest from Barrow village the shore of the Arctic Ocean is composed of low cliffs or bluffs 25 to 70 feet high, cut in poorly consolidated sand and clay. These bluffs are nicked by numerous small hanging gullies, and are broken by several small stream valleys, most of which show signs of slight drowning. From Barrow village to the base of the sand spit that leads to Point Barrow the shore is low and gravelly, and is backed by low, grassy tundra. From the base of the sand spit northwards the coast is a low, narrow sand-and-gravel bar except at the point itself, where it widens and carries many sand dunes, some of which are 16 feet or more in altitude. Beyond the tip of Point Barrow the spit continues in a southeasterly direction for 2½ miles to Eluitkak Pass, separating Elson Lagoon from the Arctic Ocean. From Eluitkak Pass to Christie Point, Elson Lagoon is protected from the ocean by the Plover Islands, a series of low barrier beaches broken by many inlets. The south shore of Elson Lagoon, from the base of the Point Barrow sand spit to Christie Point, is somewhat like the shore southwest of Barrow village. It is composed for the most part of low cliffs or bluffs cut in unconsolidated materials and broken by one small and one fair-sized estuary. These cliffs are nowhere more than about 20 feet high and are usually much lower.

Although protected from wave action by sea ice for at least half the year, these various coastal segments are being eroded rapidly and at a few places it has been possible to measure the rate of shoreline retreat.

Leffingwell[1] gives a generalized description of the arctic coastline of Alaska, and discusses in some detail its development, recent changes, and rate

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[1]Leffingwell, E. de K. 1919. 'The Canning River region, northern Alaska'. *U.S. Geol. Survey Prof. Pap.* 109, pp. 169–71.

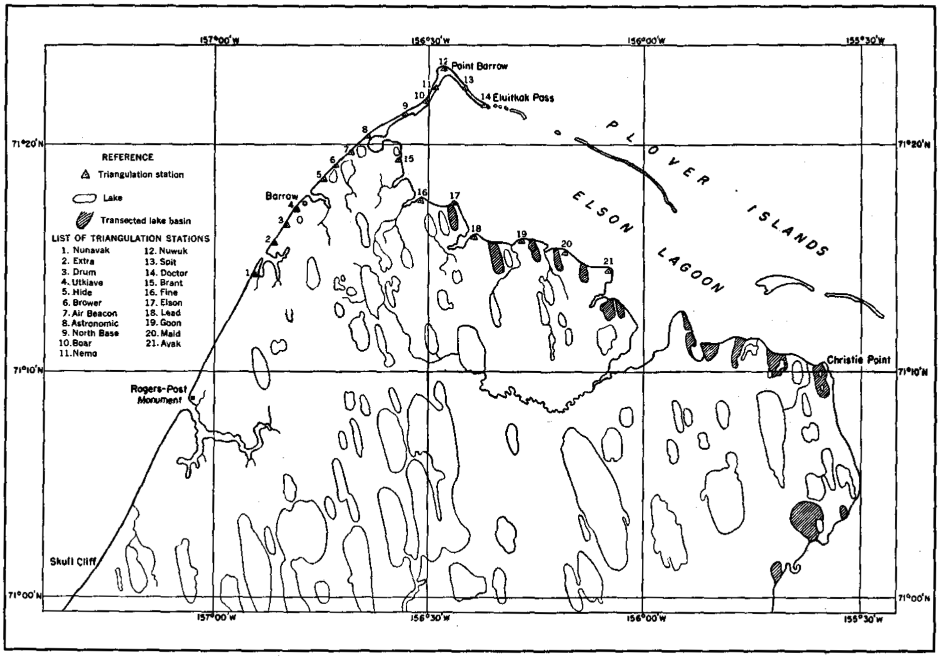

Fig. 1. Sketch-map of Point Barrow area. None of the numerous swamps and only a few of the lakes and streams are shown. Redrawn from charts 9445 and 9495 issued by the U.S. Coast and Geodetic Survey.

of erosion. Although most of his specific descriptions apply to an area well to the east of Point Barrow, his conclusions can probably be extended to the Barrow region. According to his determinations Flaxman Island had been cut back "at least half a mile" between 1826 and 1914. The sharp point of land extending "a mile or so" into Smith Bay in 1837, to which the name Cape Simpson was given at that time, had been cut back so far since 1853 that it was "now impossible to locate the place where the name was applied." A lake near Point Drew, said to be 4 miles from the coast in 1837, was only 2 miles from it in 1914. Leffingwell estimates a rate of 30 feet per year for the retreat of the shoreline at Brownlow Point, east of Flaxman Island, between 1901 and 1907 and a rate of 100 feet per year for Cape Simpson and Point Drew. He further states that: "An average retreat of 10 feet for all the cliffs on the north shore is estimated for the summer of 1911, but as scarcely any retreat occurred between 1911 and 1914, the average retreat must have been less than 4 feet."

Evidence of retreat of the shoreline

Skull Cliff to Barrow village—The fresh appearance of the cliffs along this segment of the coast, cut as they are in very non-resistant material, the recurrent landslides and slumps down the face of the bluffs, and the innumerable small hanging gullies which notch the crest of the bluffs, all attest to a rapid retreat. Although there are several U.S. Coast and Geodetic Survey triangulation stations along this stretch of coast,[1] measurements were made at only four of them. These measurements indicate that the rate of retreat between 1945 and 1951 was too slight to be determined quantitatively, although fresh slumps in the immediate vicinity of each of the stations visited indicated that some retreat was taking place.

Barrow village to base of sand spit—There are several small ponds or lagoons along this stretch of coast, each of which is separated from the Arctic Ocean by a beach bar. At least two of these lagoons are almost certainly small estuaries, while the others seem to be tundra lake basins which have been cut into by the retreating shore. If actually transected lake basins, these small lagoons offer proof of a recent, although by no means necessarily a present-day, retreat of the shore.

In October 1949 measurements were made at three triangulation stations along this segment of coast, and indicated that during the period 1945–9 the shore had been built out an average distance of about 27 feet. Measurements made in the summer of 1951 seemed to show that this advance had been replaced by a retreat which averaged 17 feet during the period 1949–51. This particular bit of beach has been greatly disturbed by dredging for gravel and by the maintenance of a road along its inner margin, so that these figures cannot be taken as representative of natural changes in configuration.

Base of the sand spit to Point Barrow—Measurements made at such of the 1945 triangulation stations as could be recovered indicate an average retreat along this coastal segment of about 16 feet during the period 1945–9. Measurements taken in 1950 and 1951 indicate an average retreat of about 24 feet in the period 1949–51. At 'Nuwuk'[2] the evidence of rapid retreat is especially striking (Fig. 3). The abandoned native village of the same name, which formerly occupied most of the area immediately surrounding the station site, is being rapidly eaten away by the retreat of the bluff and in October 1949 the remains of four old pit dwellings, then partially collapsed and filled with solid ice, were exposed in cross section in the face of the bluff. In 1951 these four dwellings had been completely eroded away, and several more exposed.

Point Barrow to Eluitkak Pass—Only one of the 1945 triangulation stations in this area was recovered, and it was in process of being destroyed by wave action in October 1949 (Fig. 2). The 1945 records are not clear in regard to this station: on one interpretation the shore must have retreated 86 or 87 feet during the period 1945–9, while according to an alternative interpretation the retreat was not much over 60 feet. This station was not revisited in 1950 or 1951.

[1]U.S.C. & G.S., (planographed publication) "Alaska No. 80: description of triangulation stations, vicinity of Point Barrow", no date, and similar publication "Alaska No. 84: descriptions of triangulation stations, Barrow to Wainwright, Alaska." Additional information was obtained by personal communications from Lt. Cmdr. Robert A. Earle, U.S.C. & G.S.

[2]Nuwuk, the Eskimo name for the abandoned village near the tip of Point Barrow and for the point itself, is usually translated as "used to be a point (of land)." Thus it would seem that the native inhabitants of this locality recognized that rapid erosion was taking place.

Fig. 2. Triangulation station 'Doctor', at the extreme end of the sand spit projecting southeast from Point Barrow, being undermined by wave action. 20 October 1949. This station was recorded as being 85 feet from the shoreline in September 1945.

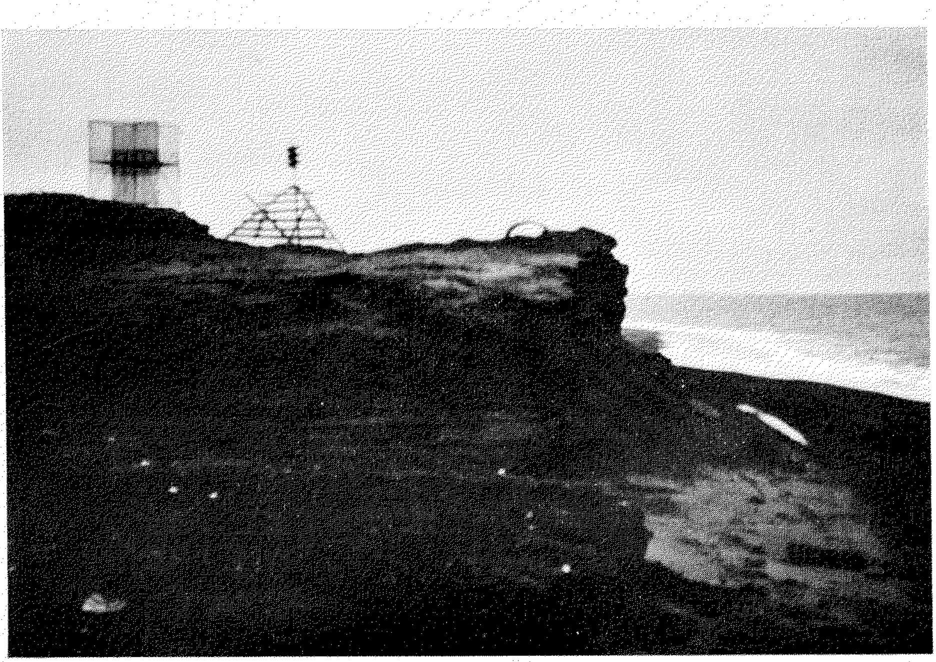

Fig. 3. Bluff at the tip of Point Barrow composed of dune sand cemented by interstitial ice. Pit dwellings are exposed in the seaward face of this bluff. Triangulation station is 'Nuwuk'. 13 September 1949.

Plover Islands—While several triangulation stations were established on these islands in 1945, most of them have since been destroyed by wave or ice action, and it was not considered worth while to visit them.

South shore of Elson Lagoon—Although most of Elson Lagoon is quite shallow, with a rather uniform depth of 8 to 10 feet, and is cut off from the Arctic Ocean by the Plover Islands, its south shore is undergoing rapid erosion. The innumerable small hanging gullies and the many fresh slumps at the foot of the low bluffs give evidence of rapid retreat. There are many transected lake basins, some of which are shown on Chart No. 9495 of the U.S.C. & G.S. (Point Barrow to Smith Bay), and many more not shown on this chart may be seen from the air. Although numerous triangulation stations were established along this shore in 1945, in almost no case is the distance to the water line given in the available records. Some of these stations were visited in 1949, 1950, and 1951, and the measurements made at these times are presented as a part of Table 1.

Table I. Measurements made at triangulation stations.

Station	*Distance to shoreline (feet)*				*Change (feet)*	*Annual change (feet)*	*Measured from**
	Sept. 1945	*Oct. 1949*	*July–Aug. 1950*	*July 1951*			
Nunavak	165 (approx.)	–	170	–	+ 5 ('45–'50)	+ 0.9	bluff
Extra	165 (approx.)	–	150	–	−15 ('45–'50)	− 3.0	bluff
Drum	262 (approx.)	–	–	267	– ('45–'51)	–	bluff
Utkiave	265	265	265	265	– ('45–'51)	0.0	bluff
Hide	180	231	225	226	+46 ('45–'51)	+ 7.9	water
Brower	150	151	150	125	−25 ('45–'51)	− 4.3	water
Air Beacon	400	431	397	411	+11 ('45–'51)	+ 1.9	water
Astronomic	–	237	231	214	−23 ('49–'51)	−13.1	water
North Base	170	135	149	95	−75 ('45–'51)	−12.8	water
Boar	110	124	121	94	−16 ('45–'51)	− 2.7	water
Nemo	–	249	252	238	−11 ('49–'51)	− 6.3	water
Nuwuk	50	22	17	7.5	−42.5('45–'51)	− 7.1	bluff
Doctor	85	25	(destroyed)	–	−60 ('45–'49)	−14.7	water
Brant	600	485	–	481	− 4 ('49–'51)	− 2.3	water
Elson	–	150 (Jan. '50)	–	141.5	− 8.5('50–'51)	− 5.7	bluff
Lead	–	3.5	–	−5 (est.)	− 8.5('49–'51)	− 4.9	bluff
Goon	–	44 (Jan. '50)	–	34	−10 ('50–'51)	− 6.7	bluff

*"Bluff" indicates measurements to top of bluff; "water" indicates measurements to water line at time station was visited.

Physical processes involved in the erosion

Where cliffs are distinct, as between Skull Cliff and Barrow village, undercutting at the foot, followed by slumping and landsliding down the face of the bluff, seems to be the chief erosive process at work. This process is aided and accelerated by the presence of a great deal of ground ice, which, when it melts, not only greatly reduces the coherency of the cliff face, but also

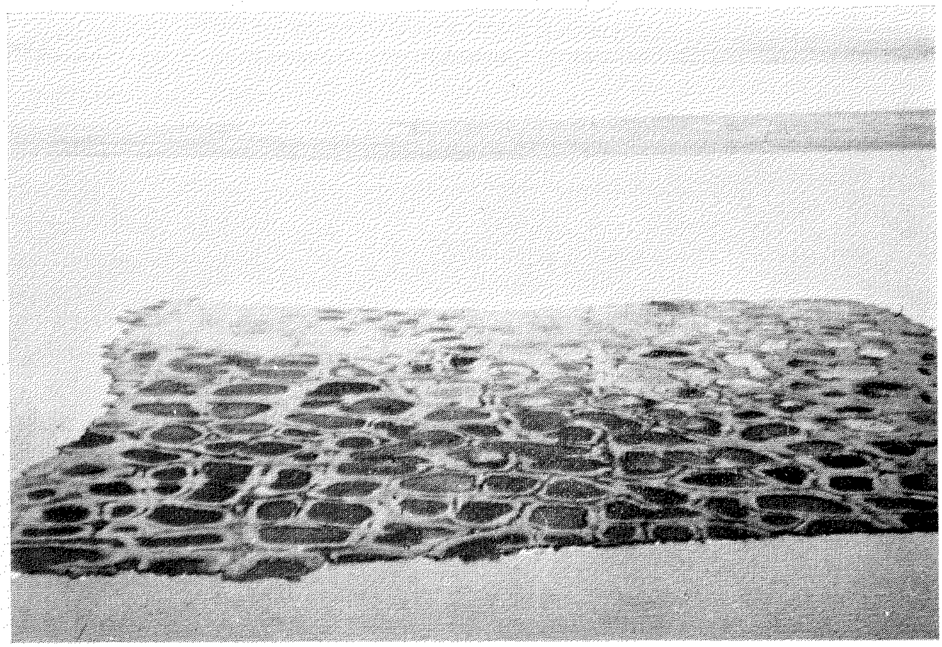

Fig. 4. Island of polygonal ground near Dease Inlet. Note the details of the shoreline following the ice wedges. All polygons shown are of the "low-centred" type. 24 July 1950.

Fig. 5. Breakdown of bluff along ice wedges near triangulation station 'Goon'. Note ice exposed just beneath the seated figure.

lubricates the mass of unstable material. Polygonal ground, where at all well developed, creates a tendency for the cliff faces to break off along the lines of ice wedges that bound the polygons (Fig. 4), so that whole polygons, or large parts of them, fall as a unit, leaving nearly vertical walls of ice to mark their former positions. Figure 5 shows a breakdown of the bluff near triangulation station 'Goon'.

The effects of polygonal ground on cliff erosion are well illustrated in the low bluffs along the south shore of Elson Lagoon. Breakdown of these cliffs is controlled almost wholly by the presence of the vertical ice wedges that bound the soil polygons. After a part of the cliff breaks away along one of these wedges and falls to the beach, it disintegrates further and its materials are distributed by wave and current action.

The sand spit that connects Point Barrow with the mainland shows only the ordinary erosional processes at work. Although poorly developed soil polygons are present in the sand and gravel, they do not seem to influence shore processes to any appreciable extent. At the point itself sand and gravel bluffs about 15 or 16 feet high are rendered sufficiently coherent by interstitial ground ice to maintain vertical faces toward the beach. Slow melting of some of this interstitial ice in the face of the bluffs during the warmer months loosens the sand and gravel, which slump and gradually build up a talus slope that, after a protracted spell of warm weather not accompanied by storm waves, may almost completely conceal the face of the bluff. Occasionally a large block of the cliff face falls away and piles up on the beach, having split off along one of the ice wedges that bound the soil polygons back of the bluff. This material is removed from the beach by wave action during the next period of rough water, and the whole process is ready to repeat itself.

Nowhere could any direct erosion by sea ice be distinguished as such although at times the sea ice pushes well up on the beaches and, more rarely, completely over-rides them. The chief effect of the sea ice seems to be protective rather than destructive, since no wave or current action is possible while the ice still forms a firm mass along the beach, as it does for at least half of each year. Also, when a major ice shove occurs, as happens in this neighbourhood at least once in every 4 or 5 years,[1] it brings with it considerable quantities of sand and gravel, which are deposited when the ice melts, thus helping to build up the beach rather than to cut it back. Remnants of two such ice shoves, both of which occurred during the winter of 1949–50, were visible along the beaches in August 1951. At that time they existed in the form of low mounds of ice, up to 8 or 10 feet in height, completely mantled by sand and gravel except where wave erosion along their seaward side had exposed the underlying ice.

Floating ice, which is present even during the warmer months, also helps to protect the beaches from direct wave action, as it has a strong inhibiting effect on wave development; the waves expend a large proportion of their energy on this floating ice offshore, and are greatly reduced before reaching the beaches. Even when no floating ice can be seen from the shore the polar

[1]Information supplied by Mr. Tom Brower of Barrow.

pack may be only a few miles beyond the horizon, and the fetch of open water available for the development of waves is correspondingly reduced. All this tends to minimize effective wave action so that, judging from personal observations extending over three summers and from information gleaned from other people, it seems that only once or twice in any one summer is the wave development likely to be sufficient to produce much active surf along this coast.

Tidal effects in the neighbourhood of Barrow are almost non-existent; the average rise and fall of the tide at Barrow is only about 6 inches.[1] So feeble a tide seems to have no discernible effect on shoreline processes. Variations in barometric pressure and movements of the surface water in response to offshore and onshore winds have greater influence than the tides on the local sea level, but even these are insufficient to produce appreciable effects.

Elson Lagoon is not only very shallow, but it is also only 5 to 10 miles wide; and it is protected from ocean waves by the Plover Islands. These islands prevent the development of large storm waves in the lagoon. Moreover, because of its sheltered position, and perhaps also because of its shallowness, the lagoon freezes over earlier than the open ocean and the ice tends to persist longer in the spring. Yet some of the most striking evidence of rapid shoreline retreat was observed along the south shore of Elson Lagoon.

In view of these considerations, it seems certain that the observed rapid changes in shoreline configuration, particularly at such sites as 'Nuwuk' and along the low bluffs of the south shore of Elson Lagoon, are due not to a vigorous attack by the sea but rather to the presence of a great deal of ground ice, which renders the land particularly susceptible even to feeble attacks.

The chief role of waves and currents is not that of direct erosion except during rare summer storms. Yet, while almost completely ineffective throughout the greater part of each year, waves and currents are sufficiently active to remove the incoherent thawed material that slumps and accumulates at the foot of the bluffs, thus ensuring that fresh surfaces are repeatedly exposed to thawing action during the warmer months.

The observations recorded in this paper were made while the writer was at the Arctic Research Laboratory at Barrow engaged in a geothermal project sponsored jointly by the U.S. Geological Survey and the Office of Naval Research.

[1] *U.S. Coast Pilot*, 'Alaska', Pt. II, 5th (1947) ed., p. 594.