

THE EFFECTS OF ICE-PUSH ON ARCTIC BEACHES

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ABSTRACT. Pack ice along the northern Alaskan coast is commonly pushed on to the beaches where it striates, planes, gouges, and, after melting, leaves deposits in the form of mounds or ridges. These ice-pushed ridges are commonly 2 feet high but may reach 15 feet. The deposits probably do not form more than 10 percent of the beach material above sea level; 1 to 2 percent is typical.

During the summers of 1954 to 1959 and the winter of 1956-57. Schalk observed the effects of ice-push during studies of the Alaskan coast between Point Lay and Tangent Point. Hume joined him in 1959. Since then, Hume has been studying sedimentation near Barrow, Alaska, and has continued ice observations.

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In the past, several geologists and explorers have reported on ice-push effects. The most often mentioned include McClintock (1856), Armstrong (1857), Leffingwell (1919), Stefansson (1921), and Johansen who was quoted by Kindle (1924). More recently, Washburn (1947), Rex and Taylor (1953), and Nichols (1953, 1961), have mentioned the phenomenon. All of these reports have tended to be descriptive with few, if any, actual measurements. The authors felt such measurements should be made. In particular, the amount of sediment added to the beaches by the ice should be determined.

The coast which was studied lies between 250 and 350 miles north of the Arctic Circle (fig. 1). Approximately nine months of the year, the Arctic Ocean is frozen. During the other three months, the ice near the coast melts, breaks into floes, and drifts away from shore to varying degrees. Occasionally, the wind or currents may force the ice, either loose pack ice or solid winter ice, up on the beach. This may happen at any time of the year. The ice may move over the beaches as more or less unbroken, smooth sheets, or it may buckle and break up into blocks. Regardless of the method of motion, the ice usually gouges some beach material, pushes it up on the beach, and deposits it.

In 1961, Hume observed the effects of an almost ideal case of smooth, gliding ice movement near the old Eskimo village of Nuwuk on Point Barrow (fig. 2; pl. 1-A). The ice advanced up to 140 feet over a low, sandy beach with a width that approached 400 feet. In its advance, the ice planed off and striated the beach. At the terminus, an almost continuous line of low mounds was left by the ice-push. At the flanks of the sheet, the ice buckled, possibly because the beach slopes were steeper.

Buckling of the ice seems more common than smooth flow. When this happens, the buckling usually causes gouging, transportation, and deposition of the

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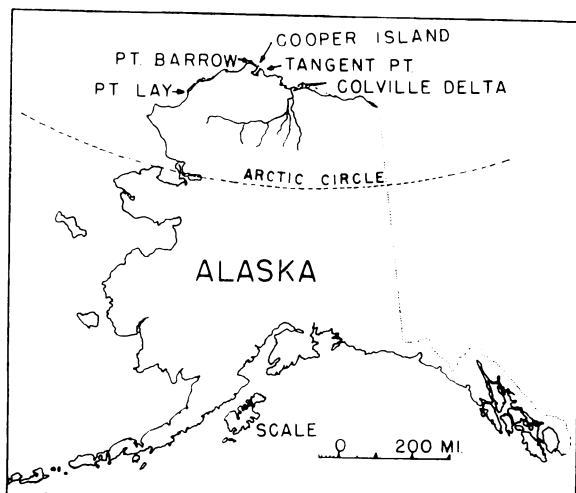


Fig. 1. Location map.

beach sediments in irregular mounds or ridges which have been called ice-push, ice-pushed, or ice-shoved mounds or ridges. Buckled ice can reach considerable heights. Between Tangent Point and Point Lay, 20 or 30 feet would be considered a high ice ridge. The gravel ridges themselves are not nearly as high. The lateral extent of the ice-pushed ridges also varies considerably.

During the spring and early summer of 1960, three individual ice-pushed ridges were left along the beach at Barrow. The youngest, nearest the shoreline, was the highest and most extensive (pl. 1-B). It extended along approximately two-thirds of the coast between Point Barrow and Barrow Village, 8 miles to the southwest. Normally, the ice melts and the gravel is left, first as a veneer over the melting ice, finally as a low, irregular, discontinuous ridge of sand and gravel a few feet high which is usually destroyed by waves. In this case, the melting proceeded slowly under the insulating gravel, and the remnants of some of the mounds, still containing some ice, were recognizable one year later.

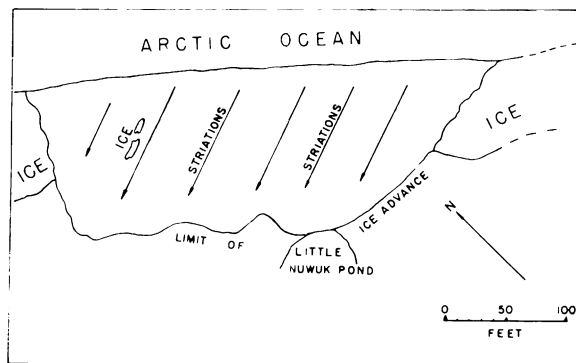
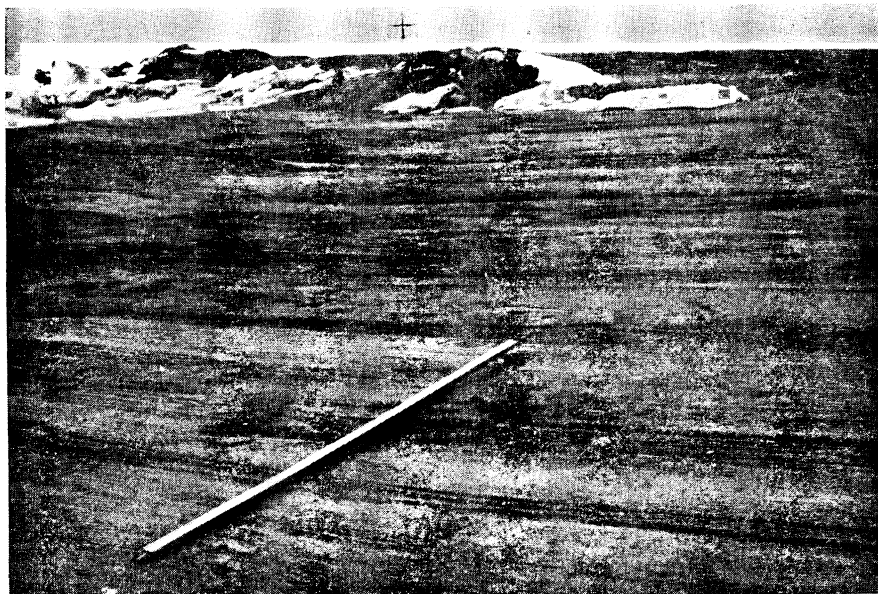
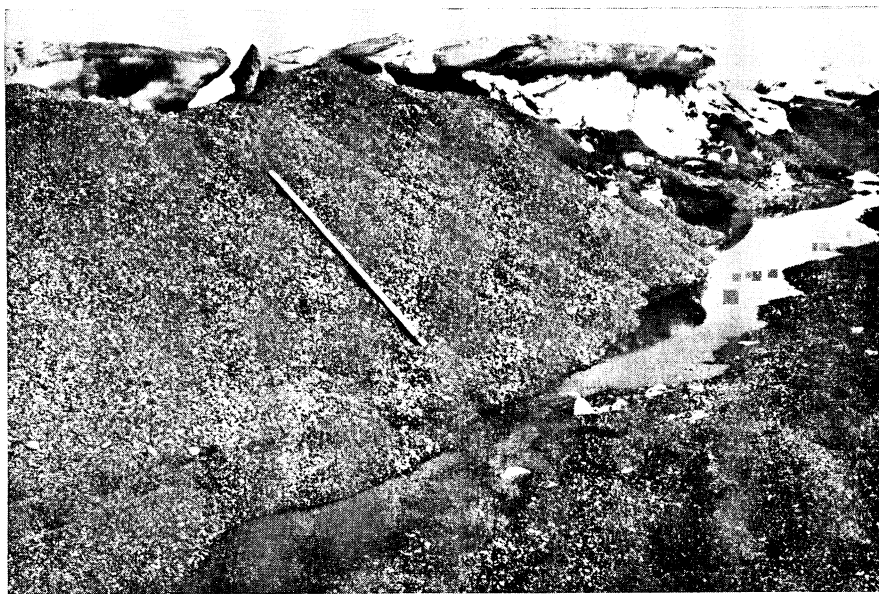


Fig. 2. Striated area, Point Barrow, Alaska.

PLATE 1



A. Striated area, Point Barrow, Alaska, July 5, 1961. 12 foot rod. Point Barrow radar reflector in background.

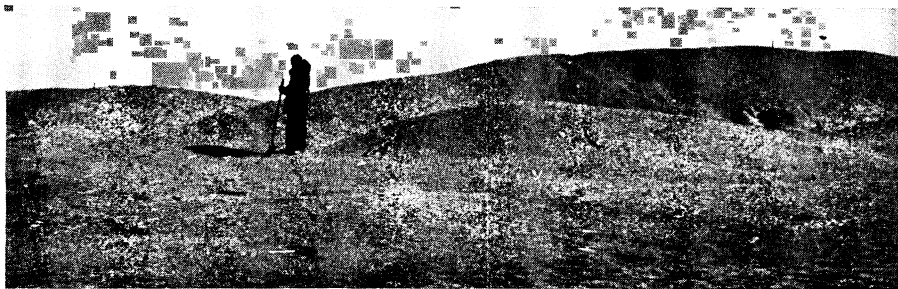


B. Ice-push near the Arctic Research Laboratory, Barrow, Alaska, July 10, 1960. 7 foot rod.

PLATE 2



A. Ice-pushed mounds near the Arctic Research Laboratory, Barrow, Alaska, June 30, 1961.



B. Ice-pushed mounds, Cooper Island, Alaska. August 21, 1959.

In order to obtain exact measurements of the size and quantity of the deposits left by the ice, two examples were chosen, one on the beach in front of the Arctic Research Laboratory, 3 miles toward the Point from Barrow Village, the other on Cooper Island about 25 miles east of Barrow (pl. 2, A and B). The first case was chosen because it was thought to be typical, the second because it was the largest known to the authors along that part of the Alaskan coast.

Five profiles (fig. 3) from the 1961 ridge system at Barrow were made at 20 foot intervals after some melting had occurred. The profiles were surveyed with transit and stadia rod, depth to the ice core being determined by a steel probe. The ridges were typical in the sense of size and position. The one selected for measurement extended inland approximately 25 feet, had a height of about 6 feet above sealevel, and was about 1000 feet long. It was one of a series of ridges (new) again extending along two-thirds of the coast between Barrow Village and Point Barrow. Two samples of the ice core were taken and found to be about 20 percent sediment by volume. After complete melting the ice-pushed debris would have formed an irregular ridge about two feet high.

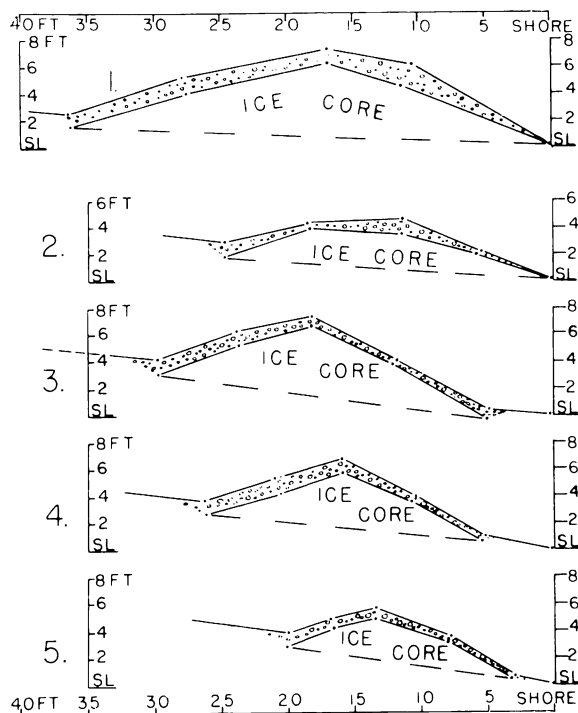


Fig. 3. Profiles of ice-pushed mounds near the Arctic Research Laboratory, Barrow, Alaska, June 29, 1961.

As these deposits were near the shoreline, they probably would have been destroyed by waves later in the summer. In this particular case they were excavated for fill before melting was complete.

Three profiles were made using the same method at Cooper Island (fig. 4). Inclement weather prohibited more field work. The profiles were made at intervals of about 275 feet across areas of extensive ice-pushed ridges. *No ice core was present.* The mounds were about 5 feet high, 30 feet wide, and individual ridges extended for several hundred feet parallel to the beach. The complex of ridges extended for approximately one mile parallel to the ocean shore, the side from which the ice came. These older mounds were found from 110 to 340 feet inland. Younger, smaller mounds were present along the shore. The amount of sediment added to the island by ice, in the area of extreme ice-push, was about 10 percent of the mass above sea level. This compared with about 3 percent for similar beach areas near Barrow.

Unfortunately it could not be determined definitely whether the older mounds had been pushed inland or left inland by prograding of the beach. The presence of scattered tufts of grass on the ice-push ridges suggested that the ridges were several years old, probably 10 or more. If the ridges had been formed prior to prograding, it was thought that they must have been a great deal older than 10 years to allow time for beach advance. In this case, the

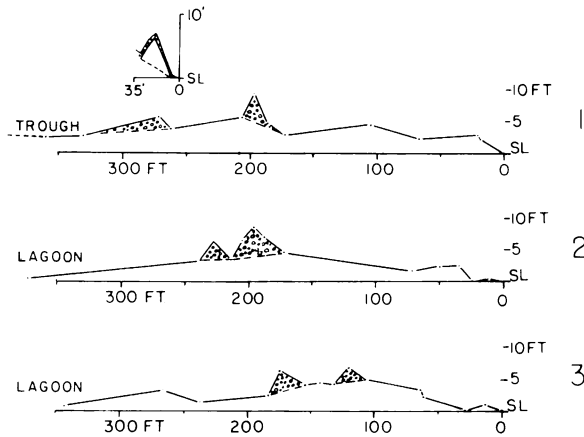


Fig. 4. Profiles of ice-pushed mounds, Cooper Island, Alaska, September 5, 1961. The insert is profile 3 of figure 3.

grass cover would have been more complete and would have resembled that between the ridges and the present high tide mark. It was therefore felt that the ridges had probably formed after most, if not all, of the beach growth and that the ice in this area had been pushed inland over the beach for several hundred feet. The presence of ice wedges in the beach and their absence in the ridges supported this conclusion. Striations, if they had ever existed, had been destroyed.

Ice-push seems to be a common phenomenon along the northern Alaskan coast. Point Barrow, lying athwart a major direction of ice movement, seems to be subjected to great ice action. The old Eskimo village of Nuwuk on the tip of Point Barrow was reported to have been abandoned because ice overrode it. Cooper Island also seems to be an area of extreme ice-push because of its proximity to a major pass in the barrier islands. Normally, the ice-pushed ridges and mounds will not be preserved. However, if the ice action terminates well inland or at sufficient elevation, the mounds may be preserved. Prograding of the beach may also protect the deposits. Ice-pushed mounds and ridges, when found, should be examined carefully for an ice core. A core might conceivably last for several years, depending on summer temperatures.

The Cooper Island ridges, without an ice core, were the largest found by the authors. David M. Hopkins (personal communication, 1962), however, has seen ice-pushed ridges 12 to 15 feet high on the north-central shore of Selawik Lake, Seward Peninsula, Alaska. As these ridges had grass growing on them, they were several years old and could not have had an ice core. These ridges were part of an extensive system of ice-pushed features occurring around approximately one-half of Selawik Lake.

Most of the Alaskan coast north of the Arctic Circle is probably subject to ice action at one time or another. During any one year, it is doubtful if more than 5 percent of the coast is attacked, however. Certain areas, such as Barrow, Cooper Island, and Selawik Lake, are for various reasons subject to

much more intensive ice action. Barrow and Cooper Island, for instance, receive ice-push deposits over the majority of the beach almost every year. In most cases, the deposits are temporary and are destroyed by the first storm waves, especially if the storm results in a higher than normal tide. (Normal tide range at Barrow is less than one foot; a storm in October, 1954, probably the worst in over a hundred years, pushed up a storm tide of at least 9 feet at Barrow.) In some areas, namely Barrow and Cooper Island, the deposits may persist because wave erosion is retarded by the presence during most of the year of pack ice. In some cases, also, the ice may push sediment even beyond the reach of major storm waves. However, even in areas where ice-push is pronounced, it is doubtful if the deposits ever amount to more than 10 percent of the sediment above sea level. Probably a more typical figure for ice-push deposits along this section of the Alaska coast would be 1 or 2 percent.

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