

Fig. 1. Map of part of northwestern Alaska showing location of area studied. Lines perpendicular to the beach mark points referred to by illustrations of corresponding numbers.

# MARINE PLATFORM OF PROBABLE SANGAMON AGE, AND ASSOCIATED TERRACE DEPOSITS, CAPE THOMPSON AREA, NORTHWESTERN ALASKA<sup>1</sup>

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## Introduction

**A** COASTAL TERRACE adjoins the northwest coast of Alaska almost continuously from Point Hope to the Noatak River, a distance of more than 100 miles (Fig. 1 insert). This terrace, in general, fronts a line of old sea cliffs that terminate a prominent upland erosion surface (Collier 1902 and 1906, Smith 1930).

Detailed field studies in 1958 over a section of the terrace 20 miles long have shown it to be complex, consisting of a marine platform that is veneered to various depths by marine deposits of a type which indicate shallow-water deposition, and by beach deposits which underlie a thick colluvial cover that forms the terrace. The surface of the colluvial cover is so sharply defined as to suggest that it too is a result of marine planation, but field observations disprove this.

The old sea cliffs remain as a series of faceted ridges and headlands that in places are 900 ft. high. The inner edge of the marine platform at the base of the sea cliff is exposed at scattered points along the coast. Several small streams have incised through the terrace to expose complete cross sections of the terrace and marine platform.

The difference in altitude between the marine platform and the terrace surface is as much as 110 ft. The areal extent of the terrace coincides with that of the marine platform and, as a result of several factors some of which may be unique to polar regions or climates, the configuration of the terrace surface is in part inherited from the marine platform. It is believed that similar features may exist elsewhere along the Arctic coastlines, and that they may have been described as simple marine terraces in the absence of detailed ground examination. Such a description might lead to erroneous conclusions regarding the height of the ancient sea responsible for the

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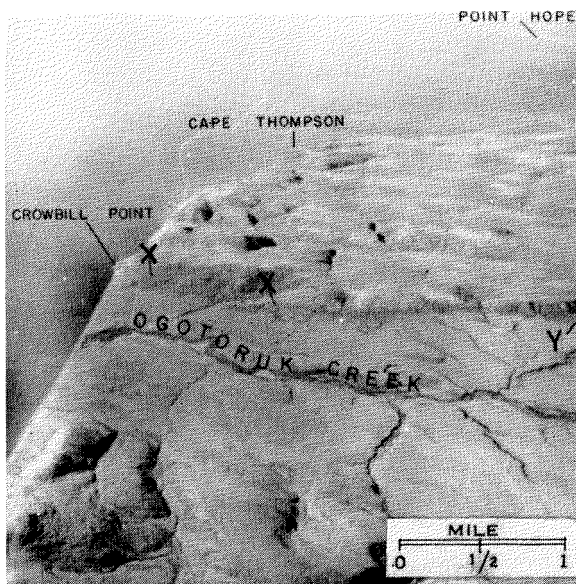
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terrace. The primary purposes of this paper are to establish the true height of the sea level responsible for the marine platform, and to show that a disparity of as much as 120 ft. could exist between estimates of sea level, depending upon whether measurements are related to the cliff-base shoreline of the marine platform or to the upper terrace level, and to call attention to other features that could be of marine origin. The importance of measurements on the ground at the inner edge of the marine-platform shoreline angle is emphasized, thus supporting statements by Johnson (1944, p. 801).

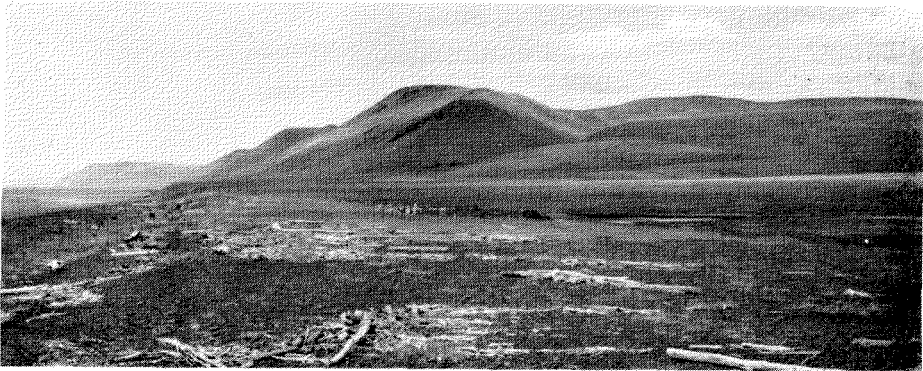
The conclusions and ideas herein expressed are based upon data collected and observations made by the authors during a season's detailed work in 1958; and on additional observations made during the period 1959-62. The field data were collected during work done on behalf of the U.S. Atomic Energy Commission to evaluate the potential sites selected for a proposed test excavation by nuclear energy.

In a paper that in part discusses the terrace described in this report, Hopkins (1959, p. 1520) correlated the sea cliffs of the terrace with a late Pliocene or early Pleistocene marine strandline, which he considered to be the initial shoreline of the Bering and Chukchi Seas. After the results of the field studies made by the authors in 1958 were made available to Hopkins, the terrace later was assigned a Sangamon age (Hopkins and MacNeil, 1960). As no field data or source are given for the new age assignment, this paper will provide factual data for our original assignment of a Sangamon age to the terrace.



**Fig. 2.** View westward showing Ogotoruk Creek valley, Cape Thompson, and Point Hope in far distance. Remnants of the terrace and marine platform are preserved between Ogotoruk Creek and Cape Thompson. X's and Y mark spots where marine (?) gravels were found in Ogotoruk Creek valley above levels of the marine platform described.

(Photo.: U.S. Air Force)



**Fig. 3.** View westward along marine-truncated mountain spurs between Kisimilok Creek and Ogotoruk Creek. Note smooth upstream continuation of colluvial surface at base of mountains (Crowbill Point is in distant background). Old sea cliffs are eroded and considerably reduced in slope angle. Note concordant, flat summits of mountains which record an ancient erosion surface that could be a result of either marine planation or of subaerial erosion.

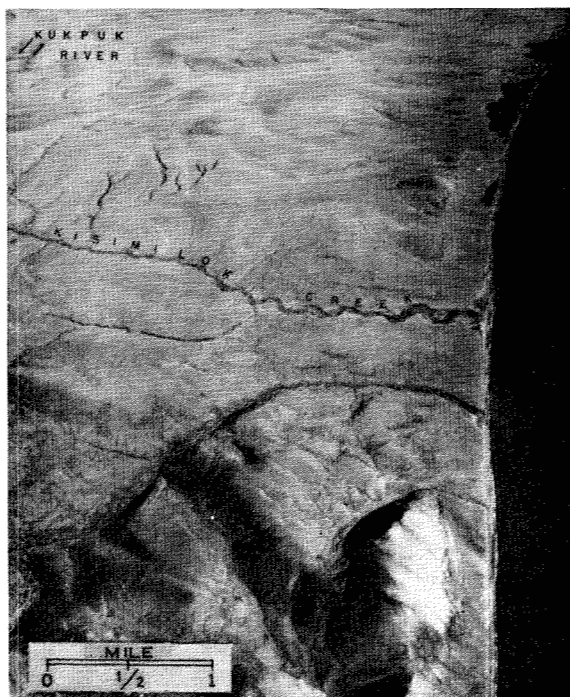
### Definitions

The geomorphic features herein described consist of two distinct but related features: (1) an upper terrace-like surface that represents the depositional surface of unconsolidated nonmarine sediments, and (2) an underlying marine platform, planed across bedrock, exposed locally in stream cuts and in modern sea cliffs. In the following discussion we call the upper surface the "terrace" and the lower surface the "marine platform," as suggested by Russell (1933). Marine and nonmarine deposits on the marine platform will be referred to as "terrace deposits."

### Terrace and marine platform

#### General description

Although the terrace is a conspicuous feature for at least 100 miles, field data were collected at intervals along a section of coastline about 20 miles long east of Cape Thompson (Figs. 1, 2, 3, 4). In this area the terrace is almost continuous but is best shown east of Ogotoruk Creek. There it forms a prominent bench at an altitude ranging from 60 to 140 ft. above mean sea level along the truncated fronts of mountains that rise to an altitude of about 800 ft. (Figs. 2 and 3). Farther east the topography is subdued and the terrace, although readily visible, is lower and is interrupted by stream valleys and by deltas (Fig. 4). In lowland areas, shallow lakes of fresh or brackish water that are impounded behind barrier bars cover parts of the terrace. Along the modern sea cliffs west of Ogotoruk Creek (Fig. 2), the terrace is preserved only as isolated remnants in stream valleys or in areas of low relief.



(Photo.: U.S. Air Force)

**Fig. 4.** View eastward showing continuation of terrace east from Kisimilok Creek. Lakes behind beach ridges lie on colluvium that buries old marine platform. Note linear scars at base of ridges in foreground. Scale on map: along creek.

In the broad valleys of Ogotoruk Creek and Kisimilok Creek the terrace merges with the valley floor and is not discernible. Moreover, well-developed solifluction lobes, stream terraces, and probable marine terraces older than the marine platform complicate the recognition of the terrace and underlying marine platform. An ancient baymouth bar at an altitude of 34 ft. extends westward from Ogotoruk Creek. This bar is apparently contemporary with the sea that cut the marine platform.

The modern sea is eroding the terrace deposits and the underlying marine platform, so that in places only remnants of the platform remain. East of Ogotoruk Creek valley, the terrace is continuous and ranges in width from a few hundred feet to about a mile. The marine platform, where it is exposed along the modern sea cliffs, ranges in height from 6 to 18 ft. above the present sea. This range in altitude is not due to deformation of the platform, but to the different positions of the exposed parts of the platform relative to the old shoreline.

#### **Exposures west of Cape Thompson**

The marine platform is well exposed where stripped by storm waves at a point about 1.5 miles west of Cape Thompson (Fig. 5). The platform is planed across vertical beds of quartzite and sandstone. The exposed part of the marine platform lies well seaward of the old shoreline. The platform now stands about 21 ft. above sea level.

The terrace here is about half a mile wide. The old sea cliffs are recognizable, but the inner margin of the platform is not exposed. The terrace deposits consist of marine gravels that contain shell fragments, and a thinner cover of colluvium which probably thickens toward the old sea cliffs.

### Exposures between Cape Thompson and Ogotoruk Creek

Remnants of the terrace occur at several places at the base of the steep headlands between Cape Thompson and the valley of Ogotoruk Creek. The marine platform is exposed continuously for a distance of more than a mile (Fig. 6), and other small remnants are exposed at scattered places along the Ogotoruk Creek-Cape Thompson section of the coast, which is about 7 miles long. The marine platform in this section is underlain by siltstone, chert, and limestone. The terrace deposits differ from place to place. Marine deposits, which consist of clean sand and gravel with shell fragments, and which overlie the marine platform wherever it is exposed, here attain a thickness of 18 ft. Colluvium covers the beach deposits and is from 1 to 120 ft. thick, its thickness increasing with an increase in adjacent relief and an increase in size of the local source area. Fig. 8 shows the relations determined by measurement at a point where a log in the ancient beach was found by K. O. Emery. This section is within 50 ft. of the base of the old sea cliff. The log was determined by carbon<sup>14</sup> technique to be more than 38,000 years old. (Isotopes, Inc., Report #1440, sample 58-AKd-C183).



**Fig. 5.** Marine platform at western edge of area examined. Rocks are micaceous quartzites and sandstones. Modern storm beach level, shown in background, is at approximately the same altitude as old marine platform. Overlying terrace deposits consist of marine gravels thinly covered with colluvium.



**Fig. 6.** Marine platform (at level of arrow) exposed in headlands east of Cape Thompson. Rocks upon which platform is formed are chert and limestone of Triassic age (at right) and shale and siltstone of Jurassic or Cretaceous age. Note apparent rise of marine platform to the west. This rise is due to increasing nearness to the inner margin of the platform.

### Exposures in Ogotoruk Creek valley

Both the marine platform and the terrace are obscure in Ogotoruk Creek valley. Ogotoruk Creek valley was a bay less than 2 miles wide that extended inland about 1 mile during the final cutting of the marine platform. Distinct wave-cut cliffs are not preserved in Ogotoruk Creek valley at the surface although marine deposits are exposed in cuts along Ogotoruk Creek and its tributaries.

In a small stream on the west side of Ogotoruk Creek valley, beach gravel overlain by colluvium is exposed continuously from the modern beach to 700 ft. inland (A in Fig. 7), where the top of the beach gravel is at an altitude of about 40 ft. and the colluvium is 10 ft. thick. Here, a remnant of the old bedrock sea cliff sloping steeply seaward is exposed, and the marine platform is inferred, therefore, to lie beneath the beach gravels.

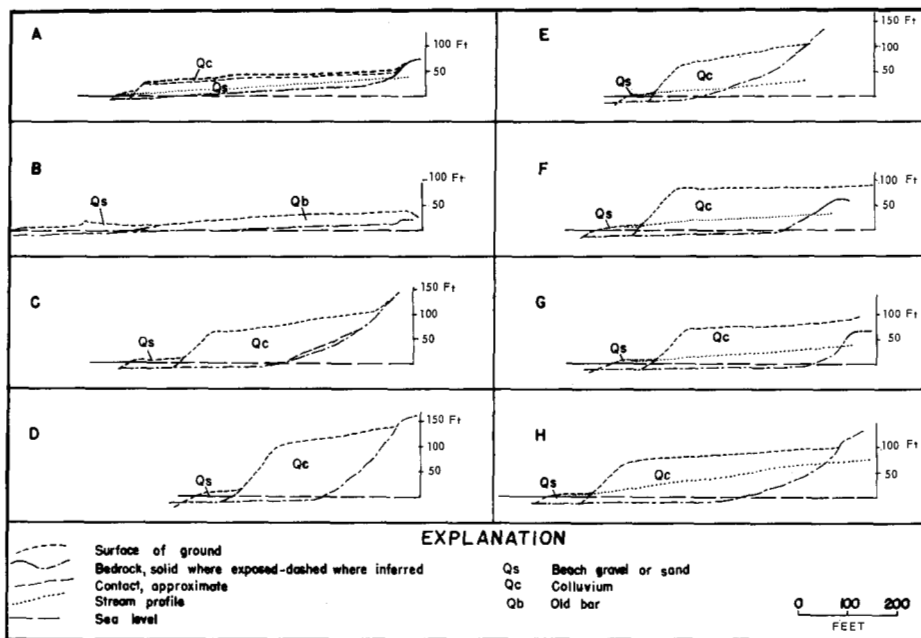
In the valley of Ogotoruk Creek, an old baymouth bar, which extends halfway across the valley from the western side a few hundred feet landward of the modern strand line, is the best evidence of the level of the sea which cut the marine platform. The bar surface is at an altitude of 34 ft. at Ogotoruk Creek and to the west it rises gently to an altitude of 42 ft. where it is covered by colluvium. The bar is composed of rounded to subrounded rock clasts in a silt and clay matrix. Where Ogotoruk Creek has eroded through the bar, bedrock is exposed at an altitude of 17 ft. above sea level (Fig. 7, B). The bedrock could be a remnant of a low sea cliff, or it could be a stream-cut feature. Even though the bedrock may be stream-cut, its position indicates that the marine platform stood at least 17 ft. above sea level at this location. Any down-cutting of this bedrock by the present creek would succeed the removal of the old bar over or around the bedrock

being eroded. We consider the bedrock beneath the bar to be the marine platform at or near the inner margin.

At Nome, 260 miles south of Ogotoruk Creek on the Bering Sea, Hopkins, MacNeil and Leopold (1960, p. 52) described an ancient barrier beach of Sangamon age that is 40 ft. above sea level. The beach deposits overlie a planed surface cut in till at an altitude of 27 ft. The baymouth bar in Ogotoruk Creek valley, described in this report, is considered to be correlative with the barrier beach at Nome and lies at an equivalent altitude above sea level.

### Exposures east of Ogotoruk Creek

The terrace extends virtually unbroken for several miles eastward from Ogotoruk Creek valley. Several small streams have eroded through the terrace, exposing excellent sections from the terrace surface to the marine platform (Fig. 9). The marine and nonmarine terrace deposits attain their maximum thickness in this area, and the terrace surface attains a height of 120 to 140 ft. Several sections measured in this area are shown on Fig. 7, C-H.



**Fig. 7.** Profiles across terrace and marine platform showing relations of bedrock, marine gravel, and colluvium. Location of profiles shown on Fig. 1. Profiles based on pace and compass traverses. Location as follows: A. Along small stream at west side of the valley of Ogotoruk Creek; B. Near Ogotoruk Creek from modern beach to old baymouth bar; C. Across terrace at point 1.4 miles east of Ogotoruk Creek; D. Across terrace at point 250 yards west of first stream cut east of Ogotoruk Creek; E. On west side of a creek valley 2.2 miles east of Ogotoruk Creek; F. In bed of stream 2.5 miles east of Ogotoruk Creek; G. In bed of stream 3 miles east of Ogotoruk Creek; H. In bed of stream 3.4 miles east of Ogotoruk Creek.



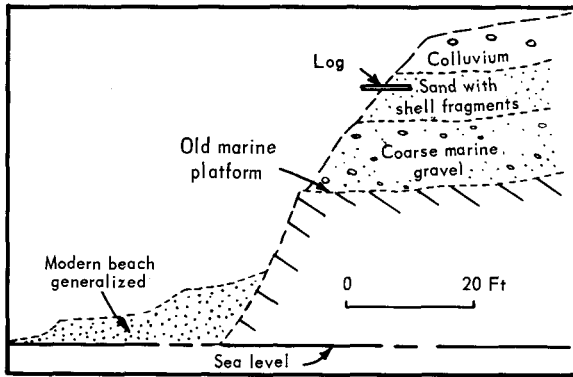


Fig. 8. Cross section of marine platform and terrace deposits at a point 3 miles west of Ogotoruk Creek.

The terrace deposits consist almost entirely of colluvium composed of angular fragments of graywacke and siltstone in a matrix of clay and silt, which amount to less than 16 per cent by weight of the colluvium. The tabular clasts tend to lie flat, imparting a crude fabric to the colluvium; however, observed stratification is very crude and is confined to the basal part of the terrace deposits near streams.

Detritus from the old sea cliffs is accumulating as what might be termed "colluvial fans" on the terrace surface, so that the upper surface of the terrace is somewhat more irregular than west of Ogotoruk valley. Turf cover on the terrace is moderate to sparse. Linear scars, plainly visible on Fig. 4, coincide roughly with the landward edge of the inner margin of the platform. They are discussed later in this paper.

Beach gravels no more than a few feet thick veneer the marine platform where it is exposed in the valley of a small stream (Fig. 9). No shell fragments were found in the beach deposits, but the high percentage of rounded and polished chert fragments of foreign derivation is considered conclusive evidence that the gravels are marine. The modern sea cliffs are eroded into perennially frozen terrace deposits and stand at relatively steep angles (Fig. 7). No ancient marine gravels are exposed in the modern sea cliffs that are cut in the colluvial terrace deposits, this lack indicating that the old beach gravel was either thin in this area or was almost removed by post-Sangamon erosion.

The terrace deposits, examined in exposures farther east, consist of colluvium. The marine platform is buried. The terrace, however, is still a very striking geomorphic feature (Fig. 4).

In summary, from our detailed study of the marine platform and terrace along 20 miles of coastline we have concluded the following:

1. The marine platform is bevelled across rocks of widely different lithology. Altitude differences measured are minor and are explainable by the position of the measuring point with respect to the old shoreline.

2. Beach deposits, which are clearly recognizable wherever the marine platform is exposed, range in thickness from about a foot to a little more than 20 ft.

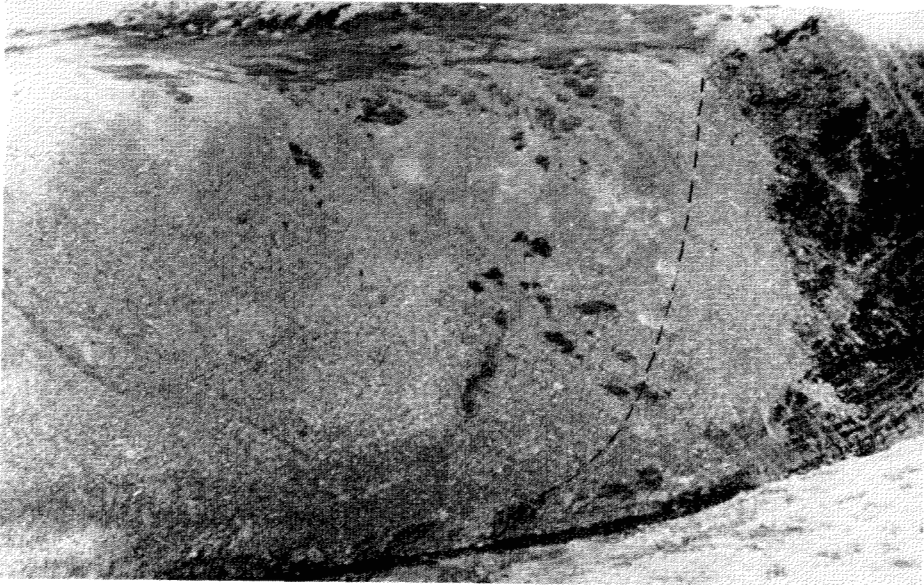
3. The beach deposits are buried beneath colluvium that has no apparent internal unconformities, soil horizons, or relict beach gravels, and is as much as 120 ft. thick.

4. In Ogotoruk Creek valley, an old baymouth bar was formed by the same ancient sea that carved the marine platform.

5. The upper surface of the terrace faithfully reproduces the old marine platform, but reveals no dependable evidence of either the height of the sea which carved the platform or of the amount of warping of the terrace. The height of the sea during the formation of the marine features discussed was between the altitude of the old baymouth bar (34 ft.), and the maximum height of the marine platform where exposed seaward of the shoreline angle, or about 21 ft.

#### Age of the marine platform

The marine platform was cut when sea level was 25 to 40 ft. higher than it is at present. This range is necessary because of our inability to assess the depth of water over the marine platform at points near the old shoreline, because of the altitude of the log shown on Fig. 8 with respect to the ancient sea level, and because we cannot determine the relative height of sea water and the surface of the old baymouth bar. Baymouth bars rise above sea level to varying heights, logs are buried in beach gravels well above sea level, and the depth to bottom is a function of the distance to shore and the lithology of the bedrock over which a marine platform is



**Fig. 9.** Marine platform and terrace deposits at mouth of stream midway between Ogotoruk Creek and Kisimilok Creek. Beach gravels are confined to thin zone on marine platform. Bulk of unconsolidated material is colluvium. Top of marine platform is dashed where obscured by slope wash. Note higher terrace which may represent an older marine terrace, a stream terrace, or a storm-wave feature.

carved. Bedrock immediately seaward of the modern beach in this area generally lies at a depth of 18 to 20 ft. (Scholl and Sainsbury 1961). If 18 ft. is added to the 24 ft. altitude of the marine platform shown in Fig. 8, the minimum sea level was approximately 42 ft. above the present sea.

The maximum altitude of the marine gravels of the ancient baymouth bar across Ogotoruk Creek valley is 42 ft. and is within 1 ft. of the observed altitude (43 ft.) of the marine part of the terrace deposits shown on Fig. 8. The altitude of the log indicated on Fig. 8 is 40 ft. We observed in Ogotoruk Creek valley that during severe storms (1958) the present sea is depositing beach gravel and driftwood to an altitude of about 15 ft. This evidence and that provided by the log indicate that the sea level which planed the marine platform could have been as low as 25 ft. above the present level of the sea.

The marine platform and marine gravels record the last high stand of sea level recognized in coastal areas near Cape Thompson; the sea evidently stood between about 28 and 40 ft. above its present level at a time more than 38,000 years ago. Unless the coastline was tectonically uplifted, which seems improbable in the light of our data, this age would correlate with the level of the sea in Sangamon time. Therefore, we consider the 28 to 40 ft. shoreline near Cape Thompson also to be of Sangamon age. As no stratigraphic breaks were observed in the colluvium that overlies the terrace deposits, it is assumed that colluvium has accumulated continuously since sea level retreated from the ancient shoreline and that the colluvium is probably of Wisconsin and Recent age.

### Warping of marine platform

The relatively constant height of the marine platform over a distance of 20 miles shows that no major warping of the platform has occurred. Measurements precise enough to detect any minor warping of the marine platform are difficult to obtain, principally because most of the exposures are near the ancient sea cliff or shoreline angle where the slope of the marine platform is changing rapidly. Also, warping of about 5 to 10 ft. along the 20 miles of coast examined would not be identifiable in the exposures that are available to us. Warping of about 20 ft., however, would have been detected.

### Origin and preservation of terrace

The morphology of the terrace is so similar to that of a marine platform, with only slight modification, as to be the *prima facie* evidence of marine erosion. The marine origin of the platform cut over bedrock is evident. The origin of the upper terrace surface is more obscure. The facts which seem to rule out a marine origin for the upper terrace are:

1. Absence of marine gravels on or immediately beneath the vegetation or surface of the terrace deposits.
2. Angularity, clay matrix, and obvious local derivation of all but the lowest part of the terrace deposits.

3. Absence of associated sea cliffs comparable to those along the present coast, or along old sea cliffs buried by colluvium at a height corresponding to a sea stand that could have carved the terrace surface.

4. Absence of any surface planed on bedrock at a height comparable to the terrace.

5. Absence of bars or spits in main river valleys at altitudes comparable to those of the terrace surface.

The terrace, therefore, is believed to be a depositional feature that has inherited its areal extent from the underlying marine platform. The morphology of the terrace is more difficult to explain. Several factors which are unique to polar regions have contributed to the preservation of the sharp slope break, generally marked by a line of linear scars at the contact of the colluvium with the old sea cliffs. This break is so sharp that it suggests that recent faults cut the colluvium (Fig. 4). The important factors that have contributed to the preservation of this slope break are shown diagrammatically on Fig. 10, and are as follows:

1. General year-round protection of the slope break by snowbanks that accumulate on the seaward (and downwind) side of the break. During spring and early summer, slope wash and talus are transferred across the slope break (Fig. 10, A-B). At two places this process was active enough to create a back-slope angle.

2. Differential thrust with an outward component caused by seasonal frost acting against the rock of the ancient sea cliff (Fig. 10, C-D). Solifluction and slope creep would tend to give similar effects.

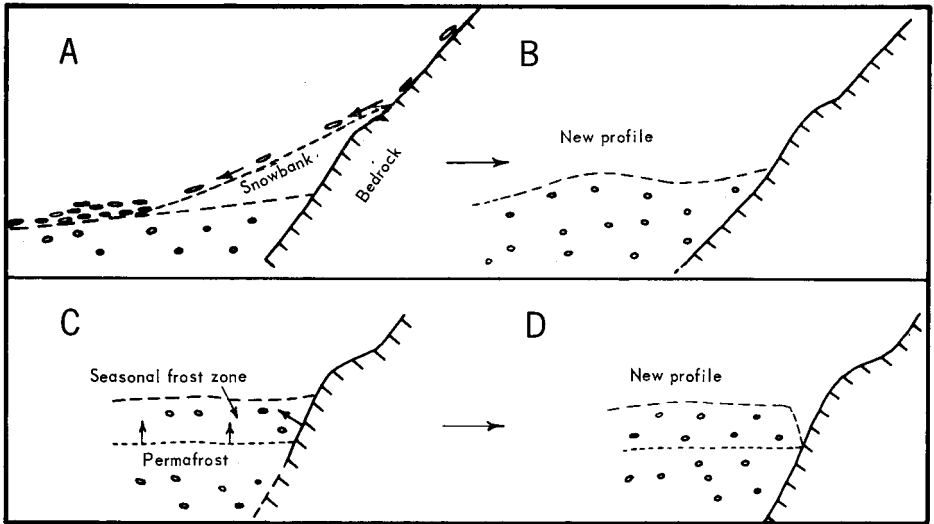
3. Compaction of the colluvium, thus tending to preserve the sharp contact line between colluvium and bedrock.

#### **Evidence for higher marine levels**

The marine platform and terrace associated with the Sangamon shoreline constitute the only obvious and well-established marine features in the area, although evidence suggests that there were still higher positions of sea level.

Isolated flat benches cut over bedrock form a distinctive part of the topography of Ogotoruk Creek valley (Fig. 11). Many are devoid of vegetation or soil and consist of frost-riven bedrock. Scattered rounded pebbles, generally of mechanically and chemically resistant black chert or siliceous siltstone, can be seen on several of these benches but no shell fragments have been found.

At the west side of the valley of Ogotoruk Creek, near the present shoreline, two round granite cobbles were found at an altitude of 140 ft. in a small gully below a bedrock platform backed by a sharp cliff suggestive of a sea cliff. The rock platform is at an altitude of 150 ft. and contains numerous well-rounded cobbles and pebbles of graywacke, chert, and limestone. The graywacke could not have come from the slope above, for the bedrock there consists entirely of limestone, chert, and argillite, and the nearest source of granite cobbles lies at least 50 miles east of the drainage basin of Ogotoruk



**Fig. 10.** Diagrammatic drawing to illustrate two processes that have contributed to preservation of sharp slope break and linear scars in tundra of old sea cliffs. A and B illustrate role of snowbanks in preservation of slope break. C and D illustrate role of frost heaving in active frost zone in preservation of scars at contact of bedrock and colluvium. Same results would probably be achieved by solifluction.

Creek. The modern beach contains granite cobbles derived from the same source areas, probably by ice rafting. At an altitude of 200 ft. in the same general area, a bedrock platform cut across shale and siltstone has numerous rounded cobbles and pebbles of weathered graywacke, dark argillite and chert. These two areas are shown by the left-hand X in Fig. 2.

Pebbles having foreign lithology lie scattered on a rock bench at a second point about 1.5 miles north of the point just described (right-hand X, Fig. 2, and X, Fig. 11) at an altitude of about 210 ft. A pebble of diabase collected here represents a lithology completely foreign to this part of western Alaska. The back slope of the rock bench rises steeply for several feet, again suggestive of a wave-cut cliff further modified by erosion.

Large deposits of gravel and sand, in places more than 50 ft. thick, occur from altitudes of 150 to 350 ft. along the base of the limestone ridge forming the west side of Ogotoruk Creek valley. The southernmost exposure of the gravel is at the point Y on Fig. 2. The deposits extend north for several miles, forming a thick apron at the base of the limestone ridge. They were studied by Campbell in 1959.

The deposits generally are thin and evenly stratified. Gravel, 85 per cent of which ranges in size from 1 mm. to 15 mm., predominates over the irregularly interbedded layers of fine to medium-grained sand. The deposits are relatively free of interstitial silt and clay. The sand contains a high percentage of quartz and chert, but the coarser sand contains fragments of quartzite, chert, and schistose rocks which are common lithologic types in

the gravels. Graywacke and cherty limestone are the chief constituents of the gravel.

The pebbles in the gravel are round to subround, whereas the sand grains range from well rounded to very angular. The deposits certainly were transported and deposited by water, but whether the environment was marine or fluvial is not certain. However, the sand from the present beach near the valley of Ogotoruk Creek is very similar to the sand in the gravel deposits, both lithologically and in appearance of grains, except that no shell fragments have been found in the high-level gravel deposits.

Campbell has also mapped extensive gravel deposits in the area south of the confluence of the Kukpuk and Ipewik Rivers (Z, Fig. 1). These deposits range in altitude from 125 ft. to 475 ft. and locally are as high as 550 ft. The gravels are much coarser and not as well sorted as the gravels along the west flank of Ogotoruk Creek. Small cobble-size debris was noted.

The gravel deposits can be explained without difficulty if they are marine in origin. If they are assumed to be stream deposited, major difficulties are encountered in explaining their position and distribution. In addition, a major stream flowing northward would be required, and the drainage area of the stream would lie offshore. If the gravels were explained as a result of diversion of the Kukpuk River (Fig. 1) to the south (other than by ice), it is extremely difficult to visualize how the Kukpuk River would return to its present course which is transverse to the strike of the resistant limestone west of Ogotoruk Creek valley.

On the western Seward Peninsula, some 200 miles south of the area discussed in this report, Sainsbury has found pebbles and cobbles foreign to the area resting upon discontinuous terraces and bedrock benches similar



**Fig. 11.** View west across Ogotoruk Creek valley showing flat topography of highest erosion level, and numerous isolated terrace levels generally cut on bedrock. X marks spot where diabase pebble was found on bench.

to those in Ogotoruk valley. On the Seward Peninsula, the benches were cut by streams that flowed along the margins of glaciers, and the source areas can be located by the train of rock of foreign derivation. Although no one has yet suggested that an extensive ice sheet covered the Ogotoruk-Cape Thompson area, the high-level gravels described in this report could be explained as a result of ice blocking of the drainages, and temporary diversion of streams.

West of the area studied in detail, as indicated on Fig. 1, an extensive marine-planned lowland area is well exposed along the sea cliffs north and west of Point Hope. The lowland area extends northward for 25 miles and inland for a maximum of 12 miles. This planned lowland rises from an average altitude of 25 ft. along the coast to an average of 100 ft. inland, with local altitudes of 115 to 120 ft.

Figs. 2, 3, and 11 illustrate the relative flatness of the tops of the hills west of Ogotoruk Creek, which are underlain by the Mississippian Lisburne Group. This upper surface is a distinctive feature of this part of northwestern Alaska. The surface lies generally between 750 and 850 ft. above sea level and has isolated hills rising to an altitude of 980 ft. Hopkins (1959, p. 1520) referred to the surface as "a rolling upland that evidently represents an ancient erosion surface, now deeply dissected by valleys graded to sea level". He also believed that the ancient sea cliffs, which are described in this paper as the Sangamon sea cliffs and which terminate this erosion surface, represent the outline of the original marine basin, of earliest Pleistocene age, of the Bering and Chukchi Seas (Hopkins 1959, p. 1520). The scope of this paper does not permit a discussion of the origin and development of the land and marine topography of northwestern Alaska. Our studies, however, have shown that the sea cliffs near Cape Thompson, which were assumed by Hopkins to be of late Pliocene or early Pleistocene age, are probably of Sangamon age.

Evidence that marine action extended considerably landward of the "original basin" of the Chukchi Sea, as postulated by Hopkins, has been found in the valley of Ogotoruk Creek. The clearness of the marine record increases with decreasing altitude and presumably decreasing age. We suggest that all these features could have been formed by marine erosion as salt water withdrew from an ancient marine basin of pre-Pleistocene age resulting from crustal uplift prior to Pleistocene time. The Chukchi and Bering Seas at that time would have been considerably larger and deeper than at present. We hope that this paper will lead other geologists to record field relations bearing on the question of higher levels of marine erosion, which can only be resolved by considerably more field work.

#### Acknowledgements

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