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PHYSIOGRAPHY, TEXTURE, AND BEDFORMS IN KNIK ARM, UPPER COOK INLET, ALASKA DURING JUNE AND JULY, 1980

by

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INTRODUCTION

Knik Arm is located in upper Cook Inlet, and extends from the mouths of the Knik and Matanuska rivers on its northeastern end to the narrows formed by Point MacKenzie and Point Woronzof on its southwestern end (figure 1). The Knik Arm estuary is approximately 50 km long and 6 km wide. It is surrounded by low-lying glacial debris of Pleistocene and Holocene ages (Karlstrom, 1964). The city of Anchorage and its outlying suburban communities are located along the southern shore, and the rural expansion into the Matanuska Valley, including the small village of Knik, flank its northeastern and northern shoreline. The areas to the north and northwest are currently undergoing rapid commercial and industrial expansion, and feasibility studies of several sites are underway for the Knik Arm bridge crossing to link the larger communities on the south shore with the rapidly developing areas to the north and northwest.

This textural study represents baseline data for Knik Arm sediments prior to any major man-made alteration of the upper Inlet region. The setting is macrotidal, with tide ranges in excess of 35 feet (10 meters). A small tidal bore less than 1/3 meter in height accompanies each incoming tide, forming near the limit of the intertidal zone near Goose Bay and the Eagle River mudflats and then moves slowly northeastward up the Arm (figure 2). Larger tidal channels never completely drain, and their depths are unknown. Salinity and water current measurements were not undertaken in the course of this study.

Data presented here on the physiography, texture, and measurement of bedforms were collected during June and July, 1980. Vertical aerial photographs (scale 1:24,000) of Knik Arm were taken on June 9, 1980 near the time of low tide (-0.24 m, - 0.8 ft. mean low water at Anchorage, the nearest tidal station). The photographs were utilized in mapping and sampling the surface sediments in Knik Arm during July, and were the basis for the physiographic map (figure 3).

SAMPLING AND LABORATORY PROCEDURES

The high liquefaction potential of Knik Arm sediment is well-publicized deterrent to foot travel. In addition, most tidal channels never drain, and have unstable banks and bottoms, making them impassable. Therefore, sampling was conducted by helicopter and was limited to areas exposed at low tide. Sampling took place at low tides throughout the month of July. A 80 cm^3 grab sample was collected from the surface sediment at each station, estimates of relative liquefiability and water saturation were made, and the surface bedforms measured and noted. Steps in the textural analysis were: (1) drying at 60°C, (2) weighing, (3) wet-sieving to remove the fraction less than 44 microns, (4) drying, (5) weighing to determine the percent finer than 44 microns, (6) dry-sieving at half-phi intervals, and (7) weighing sieve fractions to an accuracy of 1 mg. The percentage of sand in each sample was then calculated.

TEXTURE OF SEDIMENT

The sediment of Knik Arm shows the highest percentage of sand in the "bulge" formed by the Eagle River mudflats on the south and Goose Bay on the north, and east of this region nearest the large tidal channels (figure 4). The sediment fines upward rapidly to the north and east from the topographically lower portions of the Arm nearest the larger channels to the topographic highs nearest the swamp. The uppermost tidal flat, which presumably is covered only by the highest tides, contains less than 10 percent sand and is grass-covered. The uppermost flat is bordered on the landward side by encroaching swamps.

BEDFORMS

Surface bedforms are typical features over most of the Knik Arm sediments (figure 5, Table 1). They indicate various current regimes of the previous outgoing tide. Bedform data in combination with the textural map, results in interpretation of the sedimentological units of Knik Arm.

Megaripples

The largest bedforms present are assymetric megaripples, which occur at the seaward limit of the intertidal deposit (figure 6). They are composed of sand and gravel. Most of the measurements on these bedforms were only estimated due to the extremely high liquefaction potential of the sediment comprising them, making on-site measurement impossible. The high liquefiability indicates the sediment is well-sorted and highly saturated. The megaripples range in height from approximately 0.5 m to 1.2 m., averaging 0.7 m, and their estimated wavelengths vary from 3.1 m to 6.2 m, averaging 4.7 m. The orientations of the megaripples reflect their formation in the direction of highest current regimes and deepest water of the falling tide preserved in the surface sediment of Knik Arm. Because they are formed in relatively deep water they result from circulation patterns are not as directly affected by bottom morphology as are the smaller-scaled bedforms described here. In a few locations, megaripples record flood tide (flow directions up Knik Arm) orientations, or orientations 180° from the expected ebb tide orientations. These megaripples may be "relict" from the previous flood tide in areas where ebb-tidal currents are not as swift and show the flood tide to be dominant to the ebb tide. Flood-tide dominance has been proven in earlier studies in the Turnagain Arm (Bartsch-Winkler and others, 1975 a,b; Ovenshine and others, 1976), a companion estuary to Knik Arm (figure 1). Alternatively, these flood-oriented megaripples may record eddying of the ebb tide in these locations; i.e., complex ebb-tide circulation patterns.

Straight-crested or sinuous ripple marks

Straight-crested or sinuous ripple marks (Ovenshine and others, 1976) represent the next highest current regime to the megaripples. They are often superimposed on or found associated with megaripples, or in the areas nearest the intertidal channels. Straight-crested ripple marks typically have amplitudes from 3 to 5 cm, and wavelengths of 8 to 15 cm. Although they may also be found higher on the tidal flats in association with lunate-linguoid ripple marks, this type is most typical of the lower flats. Straight-crested ripple marks are characteristically asymmetrical and their orientations reflect small variations in topography of the lower tidal flat. These ripples form in water depths of 0.75 m or more (Ovenshine and others, 1975).

Lunate-linguoid ripple marks

Lunate and linguoid ripple marks (or combinations of both forms) (Ovenshine and others, 1976) are found throughout the tidal flat, and are the most prevalent bedform measured in Knik Arm. Their highest concentration is intermediate between the lowest saturated active mudflat and the upper dry, relatively inactive mudflat. Lunate/linguoid wavelengths are commonly difficult to measure due to their complex morphology, but where measureable have wavelengths ranging from 10 to 25 cm, averaging 15 cm. They have amplitudes ranging from 0.5 cm to 8 cm, averaging 5 cm. Lunate/linguoid ripple marks reflect the moderate to low current regimes of the falling tide in water depths of 0.25 m or less (Ovenshine and others, 1975), and are therefore found superimposed on higher-regime bedforms of the lower flat, and as remnants of higher flow regimes on the lower part of the upper mudflat.

Wind-wave ripple marks

Wind-wave ripple marks, which are small, straight-crested ripple marks, are preserved on the upper mudflat, and result from wind blowing across the last vestiges of outgoing tidewater only a few centimeters deep. Wind-wave ripples are so nearly symmetrical as to be bipolar, and form at right angles to the prevailing wind direction. Such ripples have amplitudes of 1 to 3 cm or less, and wavelengths of 3 to 5 cm.

CONCLUSIONS

Three sedimentary facies may be defined from analysis of the physiography, texture, and bedforms of Knik Arm surface sediment (figure 5).

Lower active mudflat

The lowermost mudflat area is the most dynamic component of Knik Arm, and is probably in motion with each tidal cycle. The mudflat is composed of from 30 to 100 percent water-saturated, well-sorted, and highly liquefiable sand, with minor occurrences of relict (?) gravel. The typical bedforms are megaripples (34 percent), lunate or linguoid ripple marks (49 percent), and straight-crested ripple marks (17 percent). Of the straight-crested and lunate-linguoid ripple marks on the lower active mudflat, straight-crested ripple marks make up 26 percent and lunate/linguoid ripple marks total 76 percent of the readings. Major tidal channels which never empty are the primary drainage features. These are relatively static features which maintained their locations over the duration of the summer of 1980.

Upper active mudflat

The upper active mudflat is intermediate in topographic position between the upper marsh and mudflat area and the lower active mudflat area and is typically composed of less than 30 percent sand. The lower sediment of the upper active mudflat, which is transitional to the upper dry mudflat, is liquefiabile and saturated indicative of the well-sorted property. Small branching drainages which channel water from this area are apparently ephemeral features that are intermediate in scale between the larger main channels of the lower active mudflat and the smaller, more static drainages of the marsh and upper flat area. Many of the drainages of the upper active mudflat shown in the aerial photographs had shifted location by the time that the samples were collected one month later.

There are no megaripple occurrences in this facies of Knik Arm; the typical bedforms include straight-crested ripples (17 percent), lunate-linguoid ripple marks (76 percent), and wind-wave ripple marks (7 percent). When comparing the number of occurrences of straight-crested and lunate-linguoid ripples for the upper active mudflat, straight-crested ripple marks comprise 19 percent and lunate-linguoid ripple marks comprise 81 percent. Therefore, although lunate-linguoid ripple marks are the most typical bedform found in Knik Arm, their relative abundance increases on the upper active mudflat. Conversely, the occurrence of straight-crested ripples relative to lunate-linguoid ripples increases on the lower active mudflat. These facts support the conclusion that straight-crested ripple marks are formed in swifter currents and deeper water than are lunate-linguoid ripple marks.

Marsh and upper dry mudflat

The upper mudflat area is commonly grass- or moss-covered and is relatively featureless (figure 5). The sediment is composed predominantly of silt; sand percentages are less than 10 percent and average less than 3 percent. The mudflat is dry at low tide and the sediment is commonly honeycombed with alveolar structures (entrapped air voids). Mudcracks are a notable feature of the upper mudflat and marsh, and can be attributed to the fine grain size and to low water content in these sediments. Drainage features which are finer and more permanent than the lower facies described are characteristic of the upper mudflat, where the patterns are the result of downslope flow of shallow surface and interstitial water in relatively fine-grained sediment. As such, these drainages define the highest topographic area of the upper mudflat. Circular or ring-shaped patches of grass are present in some locations (figure 7). The origin of these grass circles is unknown, but perhaps they represent freshwater "pipes" into the more brackish regions of the upper mudflat. If so, the grass circles may indicate that the freshwater swamp areas are encroaching into the intertidal region; i.e., the sediment in these areas is building up or prograding into the supratidal regions. The upper reaches of Turnagain Arm (near the abandoned village of Portage), as well as the upper reaches of Knik Arm, suffered tectonic subsidence and sediment consolidation during the great Alaskan earthquake of 1964. Studies in upper Turnagain Arm indicate that the sediment level has been building up from this earthquake-caused subsidence and that currently trees and shrubs killed by saltwater incursion resulting from the subsidence are regenerating (Bartsch-Winkler and Garrow, 1982). It would not be logical to assume that a similar process of progradation is occurring in Upper Knik Arm.

Figure 2. Tidal bores occur daily in Knik Arm. In this picture, taken near Knik, the bore is less than 0.5 m high, and arrives about 3 hours past low tide at Anchorage, the nearest tidal station about 26 km to the south. Note the two people in the bottom center of the photo for scale.

Figure 6. Gravel and sand megaripples commonly have floodtide orientations and pebble imbrications. The megaripples are part of the active lower mudflat, and are located north of the mouth of the Eagle River.

Figure 7. Circular and doughnut-shaped patches of grass are found on the outer reaches of the upper dry mudflat and marsh area (location shown in figure 5).

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