DEPARTMENT OF THE INTERIOR
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Introduction

The Kobuk Sand Dunes and the investigated part of the Kobuk Lowland are located in the Ambler River, Shungnak, Selawik and Baird Mountains quadrangles (1:250,000) between the northern footslopes of the Waring Mountains and the southern footslopes of the Baird Mountains (north of the map area) and between the confluence of the Kobuk and Ambler Rivers and Kavet Creek. These active sand dunes are located in two main areas, (1) the Great Kobuk Sand Dunes occupy an area of 62 km^2 in the southwestern corner of the Ambler River (A-6) quadrangle (1:63,360) and southeastern part of the Baird Mountains (A-1) quadrangle (1:63,360) 50 km west of the village of Ambler, and (2) the Little Kobuk Sand Dunes occupy 8 km^2 in the southern part of the Ambler River (A-5) quadrangle (1:63,360). These active dunes form only a small part of a 650 km^2 area of eolian sand deposits as mapped by Fernald (1964).

Vegetation in the area consists of boreal forest (white and black spruce, white birch and aspen), wet tundra (sedges and dwarf shrubs), and dry tundra characterized by low matlike plants and scattered clumps of shrubs (Fernald, 1964, p. K 4). The central part of the Kobuk Valley lies within the zone of continuous permafrost and the area has a mean annual air temperature of approximately - 6° C (Ferrians, 1965). Depth to permafrost varies from 15 to 30 cm in muskeg areas to greater than 0.5 m in areas of coarse grained sediments (Hamilton, 1984). "Hundreds of thaw lakes and innumerable ice-wedge polygons occur over large parts of the valley" (Fernald, 1964, p. K2). Geologic maps of the area by Patton and others (1968), Pessel and Brosgé (1977), Mayfield and Tailleur (1978) were used to obtain information regarding the bedrock geology. The surficial mapping by Fernald (1964, scale 1:250,000) and Hamilton (1984, scale 1:250,000) provided most of the information used in the photo-interpretation of the study area.

The famous archaeological site of Onion Portage is located in the upper central part of the investigated area on the upstream side of a meander loop just north of the Kobuk River. This locality and Epiguruk Bluff are two areas where detailed stratigraphic information is available (Ashley and others, 1984; Hamilton, 1970; Schweger, 1976, 1982).

This map (approximate scale 1:63,360) is primarily based on the interpretation of twenty-five false color infrared aerial photographs [3]. Brief field observations were made in both the Great and Little Kobuk Sand Dunes during the summer of 1981. The four major map units - eolian sand deposits, fluvial deposits, undifferentiated surficial deposits, and bedrock - which form the basis for our map, have been distinguished mainly by means of surface configuration and color. In conformity with the photo-interpretation map of the Nogahabara Sand Dunes and part of the Koyukuk Lowland (Koster and others, 1984) these units have been indicated by their inferred lithology. Each major map unit has been subdivided into various geomorphological units. The eolian units (Qs) have been listed according to their inferred degree of stabilization, whereas the fluvial units (Qf) have been listed in order of local relative age. Eolian landforms are recognized on the airphotos by: 1) topography and geomorphic form, (2) color differences, (3) degree of fluvial dissection and of modification by thermokarst activity. Fluvial landforms are separated on the basis of: 1) color differences, 2) topography, 3) degree of modification of point bars by thermokarst activity, 4) presence or absence of oxbow lakes or abandoned channels, and 5) cross-cutting relationships. Areas of undifferentiated surficial deposits (Qu) are separated into relief map units on the basis of topography. Landforms characterized by steep slopes and/or great differences in height, and whether they are isolated or not, are mapped as being developed on bedrock (K). Where recognized, individual landforms of fluvial, eolian and periglacial origin are indicated by a special symbol on the map.

Eolian Sand Deposits

Based on topographic expression, the eolian landforms have been indicated as dune fields, sand sheets, or canoe-shaped blowouts. Using color differences on the photographs these eolian landforms have been subdivided further into nine units, reflecting their degree of stabilization.

Active dune fields (unit Qs_9) consist of actively drifting sand free of vegetation that appears white to light-blue on the photographs. The largest active dune field - the Great Kobuk Sand Dunes - forms a NW-SE oriented body of sand which, lying at an elevation of 50 to 170 m above sea level, covers an area of about 62 km^2. To the southwest and south, the Great Kobuk Sand Dunes are bordered by Kavet Creek and Niaktuvik Creek respectively. Both creeks have been crowded against the footslopes of the Waring Mountains by active dunes which have partly climbed the steep mountain slopes. The western edge of the active dunes is sharply defined by a distinct escarpment. Ahnewetut Creek has maintained its narrow course through the active dune field, despite the large bodies of sand that still migrate across the valley during winter when the creek is frozen. All three creeks carry silt in suspension and sand as a bed load (U.S. Department of the Interior, 1974). At the base of the active dune front several springs, forming amphitheater-like depressions, drain the dune field towards Kavet Creek. The main part of the active dunes consists of N-S to NW-SE oriented transverse dune ridges, locally alternating with elongated, relatively flat interdune areas that at places are covered by low vegetation. At a few places, the huge transverse dune ridges have developed into barchan-like dunes with edges pointing south-west. The dune ridges reach heights of 40 to 50 m. Most dune crests can be followed for a few kilometers and are uniform in spacing, between 200 and 300 meters. There seems to be a clear relationship between dune height, width and crest to crest spacing of the transverse dune ridges. Some relatively short secondary longitudinal dunes cross dune ridges at right angles. To the northwest, the active dunes are mainly made up of small transverse dunes having parallel crests oriented about SW-NE and spaced about 150 m apart. Wind direction responsible for the migration of the various dune forms varies from northeast to southeast (Fernald, 1964).

Only preliminary results of the grain size distribution and mineralogy of the eolian sands are available (Cox and Lawrence, 1983; Fernald, 1964; Galloway and Koster, 1984; Galloway and others, 1985); more detailed analyses are being made. Mechanical analysis of twenty sand samples from the Great Kobuk Sand Dunes shows that the midpoint on the cumulative frequency curve ranges from 1.84 phi, medium sand,to 3.0 phi, fine sand, (Galloway and Koster, 1984).

The other major area of active dunes, the Little Kobuk Sand Dunes, is 50 to 80 m above sea level and covers an area of about 8 km^2. The dunes are drained by a large spring at their northwestern end pointing towards Tunutuk Creek. The Little Kobuk dunes are a parabola-shaped, NW-SE oriented body of sand situated on the downwind side of a large, complex canoe-shaped blowout. Transverse dune ridges, as high as 10 m, cross the field in NE-SW direction. The dune crests are also parallel in orientation NE-SW and are uniformly spaced about 125 m apart. The relatively narrow, southeastern part of the Little Kobuk dunes consists of U-shaped and parabolic dunes with edges pointing in SE direction. In view of the orientation and morphology, both the Little Kobuk dunes as well as individual dunes are moving northwestward.

Areas in which dunes have different degrees of stabilization: moderately stabilized dune fields (Qs_8), predominantly stabilized dune fields (Qs_7), and completely stabilized dune fields (Qs_6), cover about 100 km^2 to the north and east of the Little Kobuk Sand Dunes. The dune fields have been subdivided based on color differences the presence or absence of thaw lakes and their degree of dissection by streams. According to Fernald (1964, p. K 18) dune types within the area covered by the units described above are "...all of the phytogenic class in which vegetation plays an active role. They range from small single dunes to large complex patterns, all basically parabolic or U-shaped. Cliff-head dunes are present on low terraces where streams have dissected the sand." Hamilton (1984) has mapped this unit as sand deposits and inactive dune sand. The sand deposits consist of moderately sorted fine to medium sand and "...forms broad sheets across the Kobuk valley and Ambler lowland..." (Hamilton, 1984). Inactive dune sand consists of medium to fine sand which "...forms extensive fields of forested parabolic dunes south of the Kobuk River, southwest corner of the map." (Hamilton, 1984)

Moderately stabilized dune fields (Qs_8) appear spotted white-red on the false-color infrared photographs suggesting stabilization is still incomplete. The scattered white dots are interpreted as drifting sand. The pink-red mottling with small white dots on the photographs shown as predominantly stabilized dune fields (Qs_7) suggests stabilization by a sparse vegetation cover. Completely stabilized dune fields (Qs_6) have a dense vegetation cover as suggested by the dark red color on the photographs. All three geomorphological units have an irregular topography. Trends of transverse dune ridges could be recognized on the aerial photographs most clearly in the completely stabilized dune field (Qs 6). Here the relatively steep northwest to west facing slopes of the dunes suggest deposition by southeast to east winds. The dune fields are intersected by canoe-shaped blowouts and longitudinal dunes, showing a strong WNW-ESE trend.

Areas interpreted as covered by predominantly to completely stabilized sand sheets (Qs_5 and Qs_4) occur mainly in a zone as wide as 6 km, bordering the northeastern side of the Great Kobuk Sand Dunes. These sand sheets display, in comparison with the dune fields, lesser relief and a finer texture on the photographs. Crest lines of individual, irregular-shaped dunes could be followed on the photographs over a distance of a few kilometers. Locally recognized were rosette-like dunes comparable with those distinguished in the vicinity of the Nogahabara Sand Dunes (Koster and others, 1984). Predominantly stabilized sand sheets (Qs_5) exhibit a fine, pink-red mottling on the photographs that suggests stabilization by a sparse vegetation cover. As noted for other eolian units the scattered white dots are interpreted as drifting sand. The red-grey mottling displayed on the photographs in unit Qs_4 (completely stabilized sand sheets) probably reflects a dense vegetation cover. In addition, a comparable sand sheet covers a relatively small area surrounding a bedrock hill southeast of the Little Kobuk Sand Dunes. Apart from some SE-NW oriented active longitudinal dunes (white color) along its outer limit, the surface is rather smooth. The sand sheet appears mainly reddish-green on the photographs, suggesting stabilization by low, matlike plants. The sand sheets have been dissected by stream erosion, whereas modification by thaw lakes is minor.

Stabilized canoe-shaped blowouts (Qs_3 - Qs_2 - Qs_1) are scattered among the stabilized dune fields and border part of the two active dune fields. Fernald (1964) described these forms as large, complex blowouts which are characterized by canoe-shaped troughs bordered laterally by long arcuate ridges. We call these units "canoe-shaped blowouts." The longitudinal ridges are made up of a series of many U-shaped dunes. Locally, parabolic dune-heads have developed on their leeward side. The dune ridges associated with these blowouts resemble the "Cree Lake-type dune ridges" investigated by David (1981) in northern Saskatchewan. Similar forms, also described as elongate parabolic dunes, hairpin dunes or winddrift dunes occur in coastal regions (Pye, 1982, 1983). The bottom of the blowouts consists of relatively dry, sand-covered areas (light-blue color on the photographs) as well as of relatively wet areas (dark greyish-blue). Only the largest active dune patches within the blowouts have been mapped separately. Within the blowout that borders the Little Kobuk Sand Dunes to the southeast, the long arcuate ridges are connected with active dune ridges running parallel to the dune field. It appears that there is a close relation between the canoe-shaped blowout and the active dune field, in that the Little Kobuk Sand Dunes form a large, compound parabolic dune-head. Based on dimension and shape, a distinction has been made between simple and complex canoe-shaped blowouts. The simple, canoe-shaped blowouts are elongated and sharply outlined by long arcuated ridges. Locally they have been dissected, more or less at right angles, by fluvial erosion. The complex canoe-shaped blowouts are made up of a large series of longitudinal ridges and cover a larger area. Their outline is more irregular and they are strongly modified by both fluvial erosion and exhibit some thermokarst topography. The amount of white spots, which at several places could be recognized as active U-shaped and parabolic dunes, forms the basis on which moderately stabilized blowouts (Qs_3 and Qs_2) are separated from completely stabilized blowouts (Qs_1). Generally, canoe-shaped blowouts are characterized by light pink to light greyish-blue colors on the photographs. The extremely uniform orientation of the blowouts (NW-SE) and of the longitudinal ridges (WNW-ESE) together with their internal morphology indicate formation by east to southeasterly winds.

Fluvial Deposits

In the central Kobuk Valley, at an elevation of about 10 to 30 m, the Kobuk River has formed a meander plain that ranges in width from about 1 to 7 km (Fernald, 1964). At most places, the meander plain is bounded by a well developed terrace scarp 10 to 30 m high. Within the meander plain we have identified four river and point bar systems, which are arranged according to local relative age and appear to be basically equivalent to the systems distinguished along the Koyukuk River by Weber and Péwé (1970) and Koster and others (1984). As is the case with the Koyukuk River, the Kobuk River flood plain is a classic example of a flood plain developed by strongly meandering rivers under periglacial conditions (Péwé, 1975, p. 68). Due to strong channel migration point bar systems are still actively expanding. The effects of erosion on perenially frozen stream banks is discussed in detail by Lawson (1983) and Walker (1983). The large and steep escarpment of Epiguruk Bluff, located in the central part of the map, is a result of thermo-erosion during flooding and subsidence resulting from thaw of frozen bank materials. The stratigraphic history of this exposure indicates periods of extensive alluviation during the late Pleistocene glaciations as well as periods of downcutting, which brought the Kobuk River to near its present level in early Holocene time (Schweger, 1982; Ashley and others, 1984). The Kobuk River deposits consist principally of sand and lesser amounts of silt and gravel and some organic debris (Fernald, 1964). Along the downstream course of the Ambler River only the three youngest fluvial systems were recognized.

Modern river bars (Qf_6) appear white and light blue in color on the photographs. They are free of vegetation, indicating that channel changes are still occurring. Very strong north winds blowing from out of the mountain valleys of the Brooks Range are known to remove great quantities of sand from these river bars and other unvegetated parts of the meander plain (Schweger, 1976).

The youngest point bar system (Qf 5) is characterized by point bars which appear fresh showing little or no evidence of erosion by thaw lakes. Drainage is not integraded. This unit appears red on the photographs and as noted by Fernald (1964) the point bars are covered with a dense forest of spruce.

As in the flood plain of the Koyukuk River (Koster and others, 1984), the younger point bar system (Qf_4) represents several generations of points bars suggesting a complex history. It consists of point bars and abandoned channels, both modified by thaw lakes and occasionally by small blowouts. Thaw lakes are locally abundant, but drainage is still not integrated. This unit appears greenish-grey on the photographs, indicative of a tundra vegetation.

The older point bar system (Qf_3) includes oxbow lakes, abandoned channels, thaw lakes and remnants of point bars. In some areas this unit displays a rather coarse and grey colored, angular pattern, suggesting the presence of ice-wedge polygons. The remaining area shows a pink color. Integration of drainage between thaw lakes and the degree of modification of the point bars suggest this unit has been abandoned for a relatively long time. A summary of late Pleistocene alluviation for the map area, based on studies at Epiguruk Bluff is given by Hamilton and others (1984).

Two additional fluvial units have been recognized in the map area. A triangular-shaped area limited by the Kobuk River on the north, Niaktuvik Creek on the southeast and partly by Ahnewetut Creek on the west, has been recognized as a fluvial terrace (Qf_2) based on the presence of, (1) small abandoned meandering channels, which are abundant, (2) a rather smooth surface, and (3) the absence of recognizable eolian landforms. The surface is strongly intersected by large thaw lakes, often with remarkably angular outlines. Patterned ground features were observed in several drained thaw lake basins. Smaller, comparable areas are present along the downstream courses of the Ambler River and Jade Creek and along the eastern part of the Kobuk River in the study area. This unit appears mainly pink on the aerial photographs. For the central Kobuk valley, Fernald (1964, p. K29) states, "The thaw lakes in general show various stages of development. Some are being enlarged completely around their margins, but others are being filled where thawing and caving is no longer active." Fernald (1964) has mapped this unit as "terrace and fan alluvium." Hamilton (1984) has mapped parts of this unit as younger and older sand deposits which stand 10 to 20 m and 30 to 50 m above modern stream levels.

The main tributaries of the Kobuk River have formed long and narrow fluvial plains (Qf_1), which appear red-colored on the photographs, suggesting the presence of a dense and healthy vegetation. Streams to small to permit further subdivisions or designate separately also form part of this unit. These streams are strongly meandering and are commonly bordered by small oxbow lakes and abandoned channels. Parts of the Mishuk, Nakochelkik and Kopehsuit Creeks show a beaded drainage, characterized by a series of small pools which are connected by short watercourses. Ahnewetut Creek has maintained its narrow braided course through the active Great Kobuk Sand Dunes. Braiding of the creek may be related to the heavy bed load of "dune" sand it carries.

Undifferentiated Surficial Deposits

Units for which no distinct landforms of eolian or fluvial origin could be identified have been mapped as undifferentiated surficial deposits (Qu). Accoeding to Fernald (1964) these surficial deposits included eolian, alluvial sand and drift deposits. Hamilton (1984) has mapped part of this area as younger and older sand deposits. The younger sand deposits were "...deposited as broad sheets across Kobuk valley and Ambler lowland by slow-moving streams...(Hamilton, 1984)." The older sand deposits "...filled the Kobuk valley and lower courses of its tributaries...(Hamilton, 1984)." Large relatively flat areas on both sides of the Kobuk River with a rather irregular topography, affected as they are by fluvial erosion and exhibiting a thermokarst topography, form unit Qu_4. Thaw lakes show highly irregular outlines. Evidence of eolian morphology is completely absent.

An equally large area, relatively flat to gently sloping, locally with an indistinct dune morphology is indicated as unit Qu_3. East of the Little Kobuk Sand Dunes, this unit extends towards the flood plain of the Kobuk River, where it is bounded by a terrace scarp. In this area low, irregular-shaped bedrock hills protrude locally. The more or less smooth surface is intersected by numerous thaw lakes and strongly dissected by fluvial erosion. Patterned ground features were observed in several drained thaw lake basins. Thaw lakes in both units have been emptied or partly emptied where an outlet to a lower level has been established. Drained thaw lake basins are noted on the map. Locally, small U-shaped, parabolic or irregular-shaped dunes line the main streams or drained thaw lakes. The generally white color of these dunes indicate the presence of actively drifting sand. Moreover, some stabilized, longitudinal dunes were recognized within this unit. Dune morphology indicates former transport directions to the west. Fernald (1964) has mapped the areas described above as dune sand and to a smaller extent as terrace and fan alluvium.

Areas with undulating relief (Qu_2) occur north of the Kobuk River, and on both sides of the Ambler River. This area is characterized by an undulating topography and is dissected both by streams and gelifluction stripes. Thaw lakes are almost absent. Striking is the rosette-like pattern shown by the dense vegetation cover. On Fernald's map (1964) a part of this unit is shown as till and outwash gravel and sand. At various places distinct, gently sloping colluvial footslopes (Qu_2) occur especially along the Waring Mountains; the footslopes are underlain at shallow depth by bedrock.

Several linear features visible on the aerial photographs can be traced for several kilometers. These rectilinear escarpments occur in the undifferentiated surficial deposits (Qu) except for one lineament just northwest of Onion Portage which is developed in an older point bar system. Origin of these linear features is uncertain, but may be structural in origin. All but one of these features are found along the contact between undifferentiated surficial deposits and fluvial deposits. Drainage patterns along the linear escarpments is very angular. Patton and others (1968) have noted several faults occuring in bedrock north of the map area but do not show the presence of any faults or linear features in the surficial deposits for the map area. Likewise, Hamilton (1984) and Fernald (1964) show no linear features (escarpments) as being present in the southwestern part of the Ambler River quadrangle.

Bedrock

The mountainous area (K_1) south of the Kobuk River forms part of the Waring Mountains. Bedrock is quartz conglomerate, sandstone, mudstone, and igneous pebble-conglomerate of Cretaceous age (Patton and others, 1968; Mayfield and Tailleur, 1978). Here the main drainage divide[4] is at 630 m above sea level. East of this area isolated bedrock hills (K_2) occur, reaching elevations of about 170 m. With the exception of some crests in the Waring Mountain, where a grey color on the photographs indicates outcrops of bare rock, the slopes are mainly covered by a dense white spruce forest (Fernald, 1964) which appears red in color. Hamilton (1984) has mapped parts of this area as sand aprons which consist of fine to very fine sand forming "...smoothly sloping, wedge-like, tundra-covered deposits that extend to heights of 100 to 250 m against flanks of uplands bordering Kobuk valley..." Gelifluction stripes are common features in the mountains area. North of the Kobuk River unit K_1 includes part of the southern footslopes of the Jade Mountains.

Discussion

The Kobuk Lowland was subjected to several phases of glaciation during the Pleistocene (Fernald, 1964; Hamilton, 1984). The glacial periods provided conditions most favorable to the formation of dunes. Extensive glaciolacustrine sediments provided the source material for the eolian sands that cover much of the Kobuk Valley floor (Hamilton, 1984). Indications that widespread dune building occurred during the late Pleistocene glaciation have been found by Ashley and others (1984) and Koster and Galloway (1984). Subsequent alluviation in the central Kobuk Valley was controlled primarily by high rates of influx of eolian sediments from the nearby sand sea (Ashley and others, 1984; Schweger, 1982).

Based on topographic position, dune morphology and degree of dune modification, fluvial dissection, and thermokarst activity, at least four periods of eolian activity can be recognized. Predominantly and completely stabilized sand sheets (Qs_5 and Qs_4) and relatively flat to gently sloping areas with local dune morphology (Qu_3) probably represent the remnants of the oldest eolian phase, which have been preserved. The moderately to completely stabilized dune fields (Qs_8 - Qs_6) are of a second phase. It is unclear whether the differences in degree of stabilization can be ascribed to differences in depositional age or to differences in degree of reactivation. The canoe-shaped blowout dunes (Qs_3 - Qs_1) undoubtedly represent an even younger phase of eolian activity. These spectacular forms certainly merit further attention because they have not yet been fully described in the literature on eolian deposits (Niessen and others, 1984). The active dune fields (Qs_9) are the fourth and most recent phase of eolian activity. The Great and Little Kobuk Sand Dunes may have been active since the early Holocene. The dune sand in the Great Kobuk Sand Dunes is supplied from earlier eolian units. Recent as well as paleowind directions responsible for dune formation appear to vary from southeast to southwest, as is also the case in the Koyukuk Lowland (Koster and others, 1984). In the active dune fields, however, secondary slip faces on the dunes develop during the summer months due to westerly winds (U.S. Department of the Interior, 1974; Koster and Galloway, 1984). Hamilton (1984) and Fernald (1964) have recognized two major phases of sand and silt deposition which occurred during the late Pleistocene. The oldest phase, the Itkillik glaciation (called the Ambler glaciation by Fernald, 1964), "...filled the Kobuk valley and lower courses of its tributaries as proglacial deposits of fluvial and eolian origin (Hamilton, 1984)." During the Walker Lake glaciation sand was "...deposited as broad sheets across Kobuk Valley and Ambler lowland by slow-moving streams that recieved heavy sand loads of glacial and eolian origin...(Hamilton, 1984)." Hamilton (1984) also notes that the sand aprons, part of our unit K_1, were "...deposited by wind from areas of bare sand (active dunes and flood plains) along the valley floor during Itkillik and Walker Lake glaciations."

The Holocene flood plain history of the Kobuk River is divided into four units that clearly resemble those of the Koyukuk River (Weber and Péwé, 1970; Koster and others, 1984).

Because of their areal extent, spectacular geomorphology and rarity in cold-climate regions, the active Great and Little Kobuk Sand Dunes and adjacent stabilized dunes form a very important landscape element in the Kobuk Valley National Monument.

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FOOTNOTES

[1] University of Amsterdam, Physical Geography and Soil Science Laboratory, The Netherlands.

[2] U.S. Geological Survey, Menlo Park, CA., U.S.A. 94025

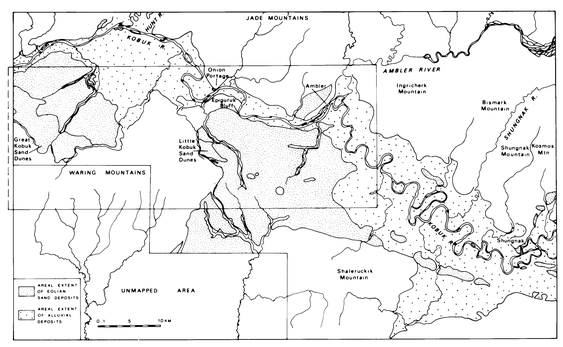
[3] Aerial photographs used for this study: false-color infrared -
NASA-JSC 386, July 78 Alaska CIR 69 roll 15, photographs 130-142
NASA-JSC 386, July 78 Alaska CIR 69 roll 29, photographs 275-286.

[4] divide (stream): The line of separation, or ridge, summit, or narrow tract of high ground, marking the boundary between two adjacent drainage basins or dividing the surface waters that flow naturally in one direction from those that flow in the opposite direction (Syn: drainage divide)(Gary and others, 1972).

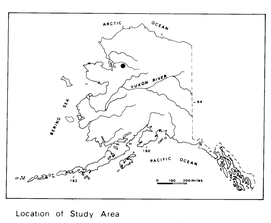
DESCRIPTION OF MAP UNITS

LITHOLOGICAL UNITS	GEOMORPHOLOGICAL UNITS	
EOLIAN SAND DEPOSITS	Qs9	ACTIVE DUNEFIELDS
	Qs8	MODERATELY STABILIZED DUNEFIELDS
	Qs7	PREDOMINANTLY STABILIZED DUNEFIELDS
	Qs6	COMPLETELY STABILIZED DUNEFIELDS
	Qs5	PREDOMINANTLY STABILIZED SANDSHEETS
	Qs4	COMPLETELY STABILIZED SANDSHEETS
	Qs3	SIMPLE, MODERATELY STABILIZED CANOE-SHAPED BLOWOUTS
	Qs2	COMPLEX, MODERATELY STABILIZED CANOE-SHAPED BLOWOUTS
	Qs1	SIMPLE, COMPLETELY STABILIZED CANOE-SHAPED BLOWOUTS
FLUVIAL DEPOSITS	Qf6	MODERN RIVER BARS
	Qf5	YOUNGEST POINT BAR SYSTEM
	Qf4	YOUNGER POINT BAR SYSTEM
	Qf3	OLDER POINT BAR SYSTEM
	Qf2	FLUVIAL TERRACES
	Qf1	FLUVIAL PLAINS OF MAIN TRIBUTARIES
UNDIFFERENTIATED SURFICIAL DEPOSITS	Qu4	RELATIVELY FLAT AREAS
	Qu3	RELATIVELY FLAT TO GENTLY SLOPING AREAS, LOCALLY WITH DUNE MORPHOLOGY
	Qu2	AREAS WITH UNDULATING RELIEF
	Qu1	COLLUVIAL FOOTSLOPES
BEDROCK	K1	ISOLATED HILLS
	K2	MOUNTAINOUS AREAS

SYMBOLS	
	Lithological unit-boundary based on aerial photo-interpretation
	Geomorphological unit-boundary based on aerial photo-interpretation
	Drainage lines
	Drainage zone
	Meandering stream
	Drainage divide [4]
	Thaw lake
	Drained thaw lake basin
	Abandoned channel (in point bar system)
	Drained abandoned channel (in point bar system)
	Relatively low and high terrace scarp
	Point bar system (arrow pointing in direction of build up)
	Alluvial fan
	Longitudinal dunes
	Parabolic dunes
	Simple transverse and complex dune ridges
	Complex barchanoid dune ridge
	Irregular-shaped dunes
	Linear feature visible on aerial photographs: origin uncertain
	Ambler village and airstrip with connecting roads
△ 600	Elevation in meters above sea level



Areal extent of eolian sand deposits and alluvial deposits as mapped by Fernald(1964)



Location of Study Area

Photo-interpretation map of surficial deposits and landforms of the Kobuk Sand Dunes and part of the Kobuk Lowland, Alaska

by

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1985

This report is preliminary and has not been editet or reviewed for conformity with Geological Survey standards and nomenclature.