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Surficial geologic map of the Anchorage B-7 NE quadrangle, Alaska

By

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INTRODUCTION

The Anchorage B-7 NE map area is located in south-central Alaska about 38 km northeast of downtown Anchorage (fig. 1) within the political jurisdictions of the Municipality of Anchorage and the Matanuska-Susitna Borough. It is one in a series of geologic maps at 1:25,000 scale in the vicinity of Knik Arm (Daniels, 1981a,b; Reger, 1981a,b,c,d; Yehle and Schmoll, 1987).

The map area includes parts of two physiographic provinces, the Kenai-Chugach Mountains and the Cook Inlet-Susitna Lowland (Wahrhaftig, 1965), which are subdivided informally in local usage as shown on figure 1. The Cook Inlet-Susitna lowland includes the upper end of Knik Arm, an extension of Cook Inlet, that here contains large areas of tidelands intermittently exposed over much of its width.

The map area is dominated by the rugged Chugach Mountains composed of structurally complex and variably metamorphosed sedimentary and igneous rocks as well as an area of ultramafic rocks (Rose, 1966; Clark and Bartsch, 1971; R.G. Updike and C.A. Ulery, Alaska Division of Geological and Geophysical Surveys, written communs., 1986, 1987; G.R. Winkler, written commun., 1986). Mount Eklutna, 1,239 m, dominates the south-central part of the map area; other mountain peaks are progressively higher to the southeast where two reach altitudes over 1,300 m. Three major subparallel valleys, those of the Eklutna River, Thunder Bird Creek, and Peters Creek, as well as the valley of a major tributary of Peters Creek, Four Mile Creek, transect the mountains in a generally southeast to northwest direction. The valleys are cut as much as 700 m below the mountain crests. The Chugach Mountains are bordered on the northwest by the Anchorage lowland to which they descend in a very steep to precipitous front; floors of the major mountain valleys are hanging with respect to the lowland, lying a few hundred meters above the general altitude of the lowland.

The Anchorage lowland (Schmoll and others, 1984), an informal subunit of the Cook Inlet-Susitna Lowland, is characterized mainly by low- to moderate-relief hills of glacial drift, some of which are cored by bedrock. The broad, gently sloping alluvial fan at the mouth of the Eklutna River transects the area of glacial drift and extends into Knik Arm. Southwest of this fan the outer margin of the Anchorage lowland is marked by cliffs that rise about 40 m above the mean level of Knik Arm. Northeast of the fan the Chugach Mountains front directly onto the Eklutna Flats, an area of tidal estuary deposits that border Knik Arm.

The northern part of the map area consists of a complex of estuarine features that are a product of the major hydrographic element of the area, Knik Arm, and of the Knik and Matanuska Rivers which drain into it at its poorly defined head. Knik Arm is an estuary that is flooded twice daily by brackish water that flows in and out from Cook Inlet. Mean tidal range at Anchorage (the closest tidal station) is 7.9 m while the difference between mean higher high water and extreme low water approximates 10.8 m (U.S. National Ocean Survey, 1982). Where the arm and rivers merge, the complex interplay between the flood and ebb of tide water and seasonally variable river discharge results in substantial variation in size of the numerous islands on a daily basis.

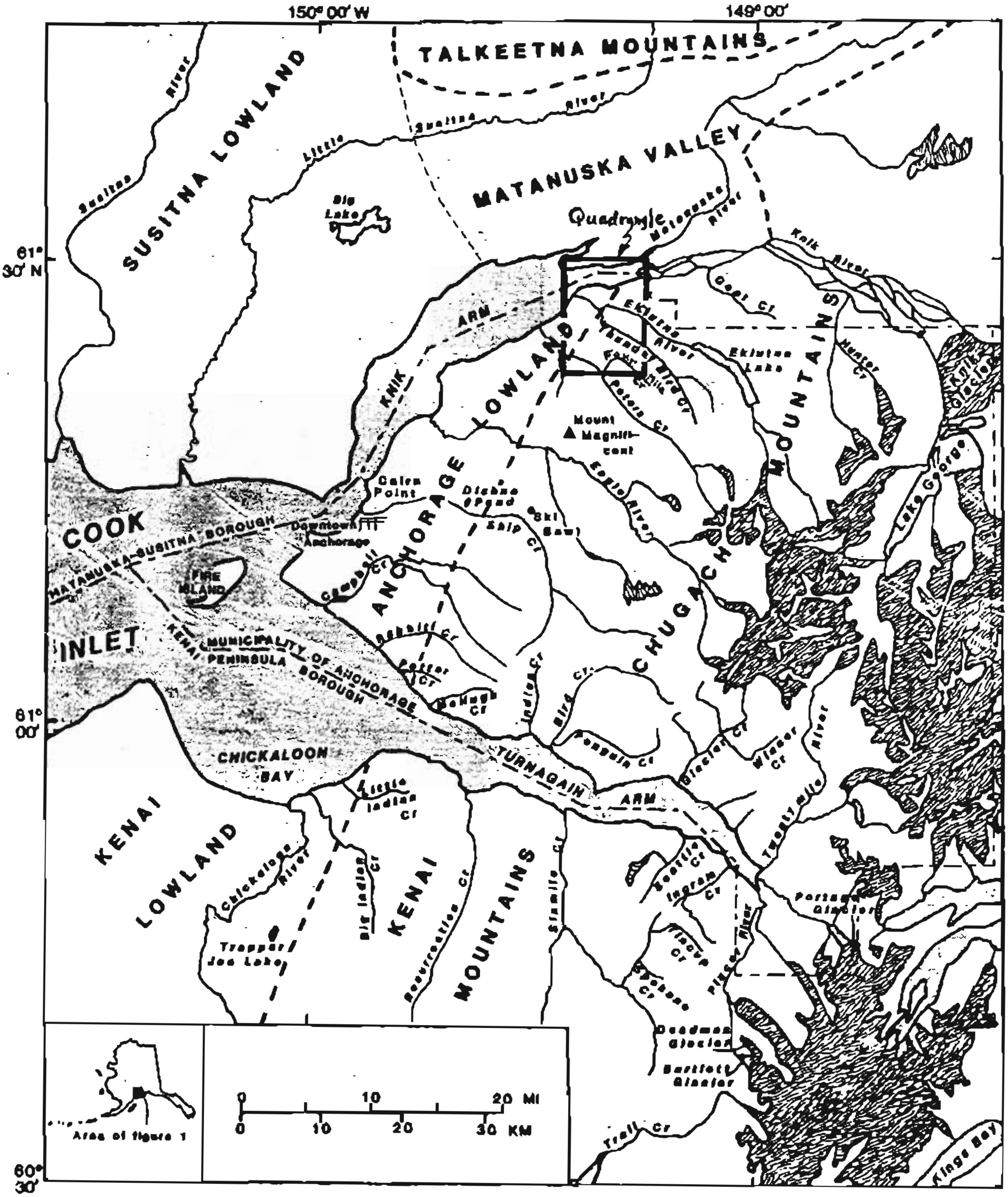


Figure 1.--Location of quadrangle with respect to major geographic features. Double-weight dashed line indicates boundary between major physiographic provinces of Wahrhaftig (1965); single-weight dashed line separates physiographic subprovinces of local, informal usage.

Principal streams within the map area include the Eklutna River, Thunder Bird Creek, and Peters Creek, all of which head in the Chugach Mountains where they emerge from one or more glaciers southeast of the map area. The streams are deeply entrenched where they descend the mountain front. At the base of the mountain front Thunder Bird Creek flows into Eklutna River which then crosses the Anchorage lowland close to its northeastern limit and empties into Knik Arm near the southern side of its large alluvial fan. Peters Creek flows across the lowland just west of the map area.

SURFICIAL DEPOSITS

Surficial deposits within the map area consist of glacial drift (moraine, glacioalluvial, and glaciolacustrine deposits) that is entirely Pleistocene in age and colluvial, intertidal (estuarine), alluvial, and minor bog and lake deposits that are mainly Holocene in age but some of which may include deposits of Pleistocene age as well. A ubiquitous mantle of organic soil and windblown materials, including minor amounts of tephra, forms a thin cover over all but the most recent or still actively accumulating deposits. This mantle has not been mapped separately.

Several glacial advances and subsequent retreats have successively modified the terrain in the area. Older glaciers probably had complex source areas to the north and east and extended well south and west of the map area (Schmoll and Yehle, 1986), but only fragmentary deposits from these events remain. Glaciers of the last relatively widespread advance developed to the northeast of the map area; they mostly filled the Knik and Matanuska valleys, coalesced, and flowed westward and southwestward, spreading onto the Anchorage lowland almost as far as downtown Anchorage to form the Elmendorf Moraine (Miller and Dobrovolny, 1959). The downstream ends of major valleys of the Chugach Mountains in the map area were free of ice at this time and were blocked by the glacier covering the lowland. Local lakes thus formed in each of these valleys and probably broke out at times from the confines of their glacier-ice or moraine barriers to form some of the kames and the later channeled deposits southwest of the valley mouths. (Similar relationships between major glaciers and glacier-free tributary valleys are well described by Sturm and Benson, 1985, and by Booth, 1986). Just prior to the last glacial advance into the area, and probably at earlier times as well, glacioestuarine deposits occupied at least that part of the Anchorage lowland within the map area that is closest to Knik Arm; the late Pleistocene Bootlegger Cove Formation (Miller and Dobrovolny, 1959; Updike and others, 1982), or a similar but older deposit, is probably present beneath some of the glacial deposits that occur at the surface.

Beginning about 12,000 yr ago, climatic warming resulted in the final stagnation and retreat of glacier ice that ended glacier domination of the map area. During the Holocene, estuarine, alluvial, erosional, colluvial, and eolian processes have prevailed. These processes have resulted in: (1) widespread deposits of estuarine and alluvial origin, (2) locally steep slopes along streams and along Knik Arm, (3) extensive colluvial deposits that include a variety of massive landslides, especially on mountain slopes, and (4) the ubiquitous eolian mantle.

GLACIAL DEPOSITS

Glacial deposits are located mainly in the areas of the Anchorage lowland and the principal mountain valleys and occur, in order of abundance, as deposits of (1) moraines and kames, (2) meltwater plains and channels, and (3) glacial lakes. Many of the resulting landforms are aligned parallel to the southwestward direction of glacier flow. Moraine and kame deposits range from diamicton and poorly sorted silty and sandy gravel (till), to gravel and sand, and to lesser amounts of silt and clay. Glacioalluvial deposits consist chiefly of gravel and sand. Some channels that carried glacial meltwater no longer contain even minor streams, and instead, contain organic deposits that grade laterally into, but may be substantially thicker than, the organic and eolian mantle. Deposits of local glacier-dammed lakes are preserved mainly along the sides of the principal valleys. Comparable deposits in smaller valleys formed in smaller lakes and (or) accumulated subaerially against blockading glacier ice and are here called kame-fan deposits. Both glaciolacustrine and kame-fan deposits are varied in character, ranging from silt and clay to sand, gravel, and diamicton.

The glacial deposits are identified by to the principal named lateral and end moraines with which they are correlated, as discussed by Schmoll and Yehle (1986). The lateral moraines that are most continuously preserved along the flank of the Chugach Mountains descend southwestward in the map area from about 400 m to 300 m in altitude. These moraines and the ground moraine that covers most of the lowland are directly traceable to the massive Elmendorf Moraine near Anchorage (Miller and Dobrovolny, 1959, p. 59). Older glacial deposits occur locally at higher altitudes along the mountain front and bordering the mountain valleys and are related with varying degrees of confidence to the successively older Dishno Pond, Fort Richardson, and Rabbit Creek moraines, which have informal type localities about 30-40 km to the southwest along the Chugach Mountain front. Deposits of the next older Ski Bowl moraine have not been identified within the map area. A small patch of drift and scattered erratics, some striated, on a planed bedrock surface at about 950 m in altitude west-northwest of Mount Eklutna are the highest known evidence for glaciation within the map area. These deposits are correlated with the Mount Magnificent ground moraine that occurs at a similar altitude about 10 km to the southwest.

Intermittently exposed along the inner valley walls of Eklutna valley are glacial deposits mainly of outwash, deltaic, and (or) glaciolacustrine origin, that are here informally called Eklutna deposits. The somewhat oxidized and compacted nature of the deposits suggest that they may be older than most or all of the mapped moraines, but, as discussed briefly by Schmoll and Yehle (1986), their age relationship to named lateral moraines or to the Mount Magnificent ground moraine cannot be demonstrated. The Eklutna deposits served as the principal type deposits on which the concept of the Eklutna glaciation of Karlstrom (1964) was based.

COLLUVIAL DEPOSITS

Flanks of the mountains exhibit dominantly colluvial deposits of various mass-wasting origins admixed with (1) glacial deposits, (2) minor alluvium, (3) windblown deposits, (4) organic soils, and (5) frost-riven bedrock, and can be derived either directly from bedrock, from other surficial deposits, or from a combination of these. Colluvial deposits, as that term is used here, are those deposits that occur on a slope and that have accumulated primarily through the action of gravity and secondarily with the aid of running water. They include deposits that have moved en masse, both rapidly (such as debris avalanches) and slowly (such as creep), as well as deposits that have accumulated particle by particle over a long period of time. The former deposits commonly occur in irregularly lumpy to hummocky topography, whereas the latter occur on smooth, concave-upward slopes.

Landslide deposits are the most important among the colluvial deposits; they vary from individual earthflows and slumps in surficial deposits and (or) bedrock to huge retrogressive block failures in bedrock; of the various types of landslides present, only earthflows larger than about 100 m in length are mapped separately. Many of the landslides can be positively identified on the basis of airphoto interpretation of surface morphology; others, however, are subject to varying degrees of uncertainty not only as to mode and amount of failure, but also as to whether they are landslide-caused at all; such deposits are queried on the map. Detailed investigation may suggest alternate interpretations for these features, and some of them thus might become pseudo-landslides (Shlemon and Davis, 1986).

Landsliding in the area is facilitated by (1) the structural complexity and highly fractured or sheared nature of the rock; (2) steepness of slopes, caused in part by glacial erosion; and (3) slope orientation. Landslides occur prominently on northeast-facing mountain slopes.

Rock glaciers and their deposits are transitional landforms that have characteristics of both mass-wasting deposits and glaciers. An attempt has been made to differentiate active rocks glaciers, those still in the transport mode, from the deposits of those probably no longer moving. Both forms occur in the southeastern part of the map area.

Large areas of mountain slope are covered by undifferentiated colluvium as well as by colluvium thought to contain a large component of glacial deposits; the mixed deposits usually lie on lower slopes than the undifferentiated deposits and locally occur in association with separately mapped remnants of lateral moraines. Talus and solifluction deposits, as well as colluvium that is mixed with alluvium, occupy smaller areas.

The steep walls of valleys and sea bluffs incised into surficial deposits are particularly subject to instability and renewed erosion, and are mainly veneered by a downslope-thickening wedge of colluvium derived mainly from parent material on which the wall is developed when it was last subject to major erosion. Such erosion is likely to occur again at any point along the wall when the stream or the sea renews its attack, removes the colluvium, and additionally erodes the parent material. Valley-wall colluvium is best developed where the major streams have cut into relatively soft, potentially unstable glaciolacustrine deposits. Here, bluffs about 100 m high are common; elsewhere valley-wall colluvium forms long, narrow belts on terrace and channel escarpments and on sea bluffs.

A special type of gravitational slope process that occurs on some steep mountain slopes but that does not give rise directly to colluvium is inferred from small, narrow, bedrock-flanked trenches interpreted as sackung features. The trenches occur along or just downslope from and subparallel to the crests of a few high mountain ridges and are interpreted to have formed by gravitational spreading of a ridge by gradual displacement along a series of disconnected planes or by deep-seated plastic deformation of the rock mass without formation of a through-going slide plane (Zischinsky, 1966, 1969; Radbruch-Hall, 1978). The process possibly was initiated after glaciers retreated from the adjacent valley, leaving oversteepened valley walls unsupported; earthquake shaking and tectonic or glacio-isostatic uplift may have enhanced or accelerated development of the sackung features. They are well exhibited in the northeastern part of the map area. Similar but more extensively developed features have been noted on high altitude mountain slopes east of the map area (Schmoll and Dobrovolny, unpublished mapping). Special lineations mapped by Updike and Ulery (1983) may also be sackung features. Prominent sackung trenches are shown on the map by line symbol.

INTERTIDAL DEPOSITS

Large areas bordering Knik Arm are occupied entirely by either present-day intertidal deposits or older intertidal deposits which now lie above present tidal range. The modern intertidal deposits are divided into upper and lower zones, following the usage of Ovenshine and others (1976) and Bartsch-Winkler (1982). All of the intertidal deposits consist mostly of a mixture of silt and medium- to fine-grained sand; coarser deposits occur near major channels, and are coarsest at the poorly defined head of Knik Arm in the zone of transition from estuarine to deltaic and then to alluvial sedimentation which occurs about 8.8 km up Knik River from the Glenn Highway bridge (Bradley and others, 1972). Such coarse deposits are known to occur at depth near the bridge (Updike, 1984). The finest-grained deposits occur on relatively higher intertidal surfaces away from major channels. The fineness of these deposits may have resulted in part from seismically caused subsidence such as the 0.6 m reported by Plafker (1969, fig. 3) to have occurred in the map area during the 1964 Alaska earthquake.

The boundary between land and water is continually changing because of the great tidal range in upper Cook Inlet, and thus difficult to delineate. In effect, the lower intertidal deposits mark a broad area within which the land-water interface shifts continuously. Complicating the portrayal of the land-water interface on the topographic base map is that it was prepared using several different series of airphotos taken at several different tide- and river-level stages in 1972 and 1973. These various stages were not adjusted altitudinally to a uniform stage level. As a result, and to attempt to portray islands and their deposits as accurately as possible on the geologic map, several additional maps and charts were examined and interpreted (U.S. Geological Survey, 1960; U.S. National Ocean Survey, 1976, 1977, 1982). The water-land contact that was selected is an approximation of a mean tide line, and it must be understood that it does not represent a fixed position but rather one that occurs only at times of mid-tide conditions.

OTHER DEPOSITS

Other surficial deposits mapped include alluvial deposits, peat, bog, pond, and lake deposits, and anthropogenic deposits. Alluvium is restricted mainly to narrow zones in the bottoms of mountain valleys except for the large alluvial fan at the mouth of the Eklutna River. Most of the alluvium consists of sand and gravel. Lacustrine and bog deposits occur only very locally, and range from sand and silt with some gravel around Mirror Lake to dominantly peat in a few bogs. Engineered fill is mappable at the 1:25,000 map scale only along the Glenn Highway and the Alaska Railroad, but other areas in which naturally occurring surficial deposits have been extensively reworked by human activity, such as gravel pits and rock quarries, are included in the same map unit.

HISTORY OF INVESTIGATIONS

The surficial geology initially was mapped at 1:63,360 scale by H.R. Schmoll and Ernest Dobrovolny between 1965 and 1971, by interpretation of 1:40,000-scale airphotos taken in 1957 and by field investigations. Additional field investigations were undertaken by H.R. Schmoll in 1973, 1975, and 1976. Mapping subsequently was enlarged to 1:25,000 scale by L.A. Yehle and H.R. Schmoll in 1986 and 1987 with additional detail derived from interpretation of 1:24,000-scale airphotos taken in 1972 and 1973 augmented by field investigations in 1986 and 1987. Early versions of surficial geologic maps of the area were presented by Zenone and others (1974) as derived from Schmoll and others (1971), and by Brunett and Lee (1983) as derived from Schmoll and Emanuel (1983). Additional surficial geologic data are from Daniels (1981a). Bedrock data are modified from Clark and Bartsch (1971), Schmoll and others (1971), and R.G. Updike and C.A. Ulery, Alaska Division of Geological and Geophysical Surveys (written communs., 1986 and 1987).

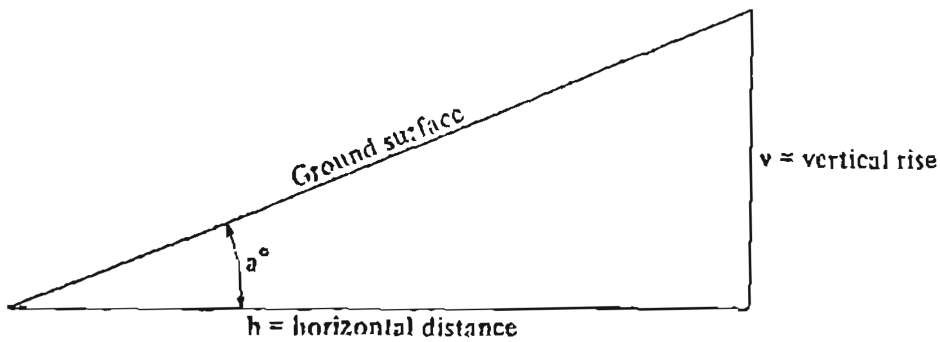
DESCRIPTION OF MAP UNITS

[The map (plate 1A, in pocket) delineates deposits estimated to be 1 m or more in thickness. Estimates are based primarily on field observations. Grain sizes of unconsolidated particles follow the classification of the American Geological Institute (1958). Slope categories, from Schmoll and Dobrovolny (1972), are illustrated in figure 2, and are generalized estimates derived mainly from the slope map in Zenone and others (1974, p. 2 and fig. 3). Standard age designations are omitted from map symbols because all units except bedrock are entirely of Quaternary age. Correlation of map units is shown on plate 1B (in pocket)]

SURFICIAL DEPOSITS

Moraine Deposits

Subdivided according to the individually named moraines as discussed in the text, and according to type of moraine, lateral moraines and various kinds of ground moraine. Lateral moraines occur as remnants along the Chugach Mountain front, whereas ground moraine occupies much of the Anchorage lowland and parts of major tributary valleys. The till that composes most moraine deposits is chiefly a diamicton consisting of massive, unsorted to poorly sorted mixtures of gravel, sand, silt, and relatively minor amounts of clay; includes scattered large boulders; it is generally moderately to well compacted.



Diagrammatic representation of slope-measuring terms

Slope in percent = v/h X 100

Slope angle in degrees = a°

Slope ratio = h:v (h to v) where v is equal to 1 unit of measurement

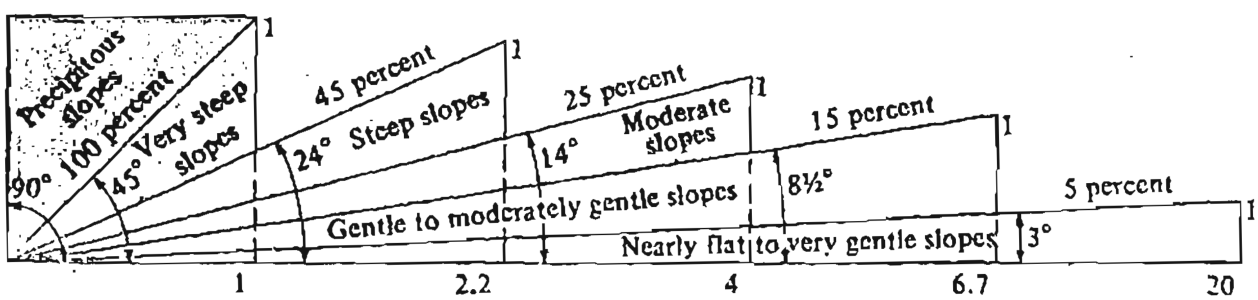


Figure 2.--Diagram illustrating slope categories used on this map (after Schmoll and Dobrovolny, 1972).

Lateral-moraine deposits

eml Deposits of the Elmendorf Moraine (late Pleistocene)--Thickness poorly known, but probably several to about ten meters; in places bedrock may occur at relatively shallow depth. Contacts with colluvium generally gradational, other contacts more sharply defined. Topography moderately irregular; slopes gentle to moderate on small areas on ridge tops, steep on ridge sides. Relatively more stable than other deposits on mountain slopes except for bedrock; some instability likely on steeper slopes. Occur as remnants of narrow ridges on the lower flanks of and adjacent to the Chugach Mountains

dml Deposits of the Dishno Pond moraines (Pleistocene)--Thickness poorly known, probably at least several meters. Contacts fairly well defined. Topography moderately irregular; slopes generally moderate. Occur only on the north side of Eklutna valley at the Chugach Mountain front; correlation of this lateral-moraine remnant with type Dishno Pond moraines is uncertain, based only on its position relative to other lateral moraines nearby

fml Deposits of the Fort Richardson moraines (Pleistocene)--Thickness poorly known, probably several meters. Contacts gradational. Topography moderately irregular; slopes moderate to steep. Some instability likely because of location on colluviated valley walls of Eklutna, Peters, and Four Mile valleys

rml Deposits of the Rabbit Creek moraines (Pleistocene)--Probably more compacted and oxidized than other lateral-moraine deposits. Thickness poorly known, probably several meters. Contacts gradational. Topography moderately irregular, slopes generally moderate. Occur only in the upper part of a southern tributary to Thunder Bird valley

Ground-moraine deposits

emg Deposits of the Elmendorf Moraine (late Pleistocene)--Till may be a poorly sorted silty sandy gravel in places; may include discontinuous beds of better sorted gravel and sand. Thickness several to a few tens of meters, commonly overlying older glacial deposits. Contacts generally well defined, gradational with colluvium and bedrock. Topography smooth, slopes generally moderately gentle to gentle

fmg Deposits of the Fort Richardson moraines (Pleistocene)--Thickness poorly known, probably several meters. Contacts generally gradational. Topography smooth to somewhat irregular, slopes gentle to moderate. Occur mainly in Eklutna valley

mmg Deposits of the Mount Magnificent ground moraine--Restricted mainly to central part of mapped area. In much of area, bedrock is either veneered by loose rubble with some glacial erratics ranging in size from pebbles to boulders, or is well-exposed. The glacially-planed bedrock having smooth surface and roche-moutonée form; between these forms small patches of glacial diamicton (till) may veneer bedrock. Occurs west of Mount Eklutna on a gently sloping mountaintop surface of low relief adjacent to the mountain front at an average altitude of about 950 m

Ground-moraine deposits that may thinly cover bedrock--Similar to ground moraine but may be only one to a few meters thick. Bedrock may be exposed locally

emb Deposits of the Elmendorf Moraine (late Pleistocene)--Occur mainly near the mouth of Eklutna valley

fmb Deposits of the Fort Richardson moraines (Pleistocene)--Occur near the mouth of Peters Creek valley

Ground-moraine and kame deposits--Similar to deposits of ground moraine but may include gravel and sand in large part or locally in areas too small to map separately at 1:25,000 scale

emk Deposits of the Elmendorf Moraine (late Pleistocene)--Occur in the Anchorage lowland both north and south of the Eklutna River

fmk Deposits of the Fort Richardson moraines (Pleistocene)--Occur in Eklutna valley

Glacioalluvial and Glaciolacustrine Deposits

Subdivided into (1) kame, kame-terrace, outwash-plain, terrace, and meltwater-channel deposits that are glacioalluvial in origin and that consist dominantly of gravel and sand, (2) kame-fan and glacial-lake delta deposits that are transitional between glacioalluvial and glaciolacustrine in origin and that include a variety of coarse, fine, and mixed-size materials, and (3) glaciolacustrine deposits that are dominantly fine-grained with variably admixed well to poorly sorted coarser materials.

Kame deposits of the Elmendorf Moraine (late Pleistocene)--Chiefly pebble and cobble gravel and sand, moderately to well bedded and sorted; some silt, and, especially in the cores of hills, diamicton similar to that of ground moraine; locally may include large boulders. Moderately loose, but compact in cores of hills.

ek Deposits in kames of high to moderate relief--Includes some areas of pitted outwash. Thickness a few to several tens of meters in central parts of hills. Contacts well defined. Topography sharply hilly to hummocky, depressions common locally; slopes moderate to steep, except gentle to nearly flat in minor channels, on depression floors, and on some small areas on tops of hills

ekl Deposits in kames of low relief--May alternatively be pitted outwash-plain deposits. Thickness poorly known, may be thinner than other kame deposits. Occur in moderately irregular topography with gentle to moderate slopes. Single occurrence in western part of map area, more extensive to the southwest (Yehle and Schmoll, 1987)

ekt **Kame-terrace deposits of the Elmendorf Moraine (late Pleistocene)**--Gravel and sand, well bedded and sorted; may include some lenses of diamicton and some large boulders. Thickness probably a few to several tens of meters. Contacts well defined. Topography smooth, slopes nearly flat to gentle; commonly bordered by steep escarpments

Outwash-plain and terrace deposits--Chiefly gravel and sand, well bedded and sorted eo Deposits of the Elmendorf Moraine (late Pleistocene)--Thickness poorly known, probably one to several meters; in places ground moraine may be present instead. Contacts well defined. Topography smooth, slopes nearly flat to very gentle. Occur in relatively broad areas west of Chugach Mountain front, at levels lower than ground-moraine surface but higher than adjacent meltwater channels

fo Deposits of the Fort Richardson moraines (Pleistocene)--Chiefly gravel and sand, well bedded and sorted. Thickness probably a few to several meters. Contacts well defined. Topography smooth, slopes gentle. Stable except near contact with valley-wall colluvium (map unit cw) where susceptible to erosion and minor landsliding. Occur only along Four Mile Creek where terrace extends downvalley from an inferred end moraine to near mouth of valley where deposits grade laterally to glaciodeltaic deposits mostly eroded and not mappable at 1:25,000 scale

Meltwater-channel deposits--Chiefly gravel and sand, well bedded and sorted; at the surface may include some finer-grained material with thin organic accumulations. Thickness poorly known, probably one to a few meters. In places, channel deposits may be very thin or lacking and ground moraine or bedrock may floor the channel or lie at shallow depth

ec Deposits of the Elmendorf Moraine (late Pleistocene)--Generally well incised below surface level of ground moraine and outwash terraces. Contacts well defined. Topography smooth, slopes nearly flat to very gentle

fc Deposits of the Fort Richardson moraines (Pleistocene)--Contacts generally well defined. Topography smooth, slopes very gentle

oc Older deposits (Pleistocene)--Gravel and sand may be less well bedded and sorted and probably more oxidized than other channel deposits, and more likely to include bedrock outcrops. Thickness poorly known, probably a meter or less. Contacts fairly well defined. Topography smooth, slopes gentle to moderately gentle

Kame-fan deposits--Probably mainly gravel and sand that is well to poorly bedded and sorted and that accumulated in alluvial fans or small lakes in small valleys blocked by glacier ice; may include beds of silt, fine sand, and some clay, as well as some diamicton. Thickness poorly known, possibly as much as a few tens of meters. Contacts gradational with colluvium. Topography generally smooth, slopes moderately gentle to moderate, locally steeper

fkf Deposits related to the Fort Richardson moraines (Pleistocene)--Well developed near mouth of a southern tributary to Thunder Bird valley

rkf Deposits related to the Rabbit Creek moraines (Pleistocene)--Occur only in southern tributaries to Thunder Bird valley.

fgd **Glacial-lake delta deposits related to the Fort Richardson moraines (Pleistocene)**--Chiefly gravel and sand, generally well bedded and sorted; may include thin beds of finer-grained material. Thickness poorly known, probably 10 m or less. Contacts generally well defined. In Thunder Bird valley in SE1/4 Sec. 4, T. 15 N., R. 1 E., gravel near surface may be underlain by finer-grained materials; surface exhibits prominent ridge and trench form which is lower in altitude closer to Thunder Bird Creek. This relationship suggests formation by extensive retrogressive rotational or lateral-spreading landsliding that does not appear presently active. Elsewhere, topography generally smooth, slopes gentle

Glacial-lake deposits--Formed in major tributary valleys when blocked by glacier ice in the Anchorage lowland

egl Glacial-lake deposits related to the Elmendorf Moraine (late Pleistocene)--Chiefly interbedded sand, gravel, diamicton, silt, and clay in varying proportions; well to somewhat poorly sorted. Thickness about 5-10 m. Contacts relatively well defined. Topography generally smooth, slopes gentle. Moderately stable except near contact with valley-wall colluvium (map unit cw) where susceptible to erosion, earthflowage, and other landsliding

fgl Glacial-lake deposits related to the Fort Richardson moraines (Pleistocene)--Chiefly bedded diamicton, interbedded with silt, sand, and some gravel; generally rather poorly sorted; locally material may be finer grained and somewhat better sorted. Thickness poorly known, probably 10 m or more. Contacts relatively well defined. Topography smooth, slopes gentle, except where well exposed in steep, irregularly eroded bluffs along Thunder Bird Creek. Moderately stable except near contact with valley-wall colluvium (map unit cw) where susceptible to erosion and minor landsliding

e **Eklutna deposits (Pleistocene)**--Chiefly gravel, silty sandy gravel, and gravelly diamicton of a distinctive yellowish-gray color; in part well bedded, with moderately dipping beds indicative of a source up Eklutna valley and possibly deltaic in origin; generally poorly sorted. Moderately compacted and slightly indurated. May represent outwash and (or) deposition in a glacial lake of an older glaciation. Occurs in outcrops on the inner valley walls along Eklutna River; probably underlies younger deposits mapped at the surface in Eklutna valley. Thickness as much as 40 m in outcrop, base not exposed. Contacts with colluvium gradational, many small outcrops not shown. Outcrops generally very steep and subject to continuing erosion

Alluvial deposits

Alluvium deposited by moderate and small streams. Generally well bedded and sorted, clasts commonly well rounded. Thickness variable, probably a few to several meters, and thickest in larger valleys. Contacts well-defined. Topography smooth, slopes nearly flat to very gentle

al **Alluvial deposits along modern streams and in lowest terraces (late Holocene)**--Chiefly gravel and sand. Generally at or no more than a few meters above stream level. Includes the narrow active floodplains of major streams that are subject to continual erosion and redeposition of material as well as occasional flooding

at **Alluvial deposits in terraces (Holocene)**--Somewhat older alluvium, chiefly gravel and sand, generally several meters above stream level. Well developed along Eklutna River and Thunder Bird Creek

ath **Alluvial deposits in high terraces (early Holocene)**--Still older alluvium, chiefly gravel and sand, that occur in local remnants about 60 m above the Eklutna River

Alluvial-fan deposits (Holocene)--Formed mainly in moderate to small fans where small tributaries enter larger streams of lower gradient. Graded to or just above modern stream levels. Materials commonly less well sorted than other alluvium. Slopes moderate to moderately gentle, steeper near heads of fans

af Coarse-grained deposits--Chiefly gravel and sand; may include some silt and thin diamicton beds resulting from minor mudflows

aff Fine-grained deposits--Chiefly silt and fine sand. Occur mainly southeast of the intertidal deposits

afo **Older alluvial-fan deposits (Holocene and Pleistocene)**--Gravel and sand, possibly admixed with some finer-grained material. Deposits may be less well sorted and have steeper slopes than in other alluvial units. Occur as remnants commonly in association with, but graded to levels above modern streams, and at higher altitudes than nearby, younger alluvial fans. In part may include minor deltaic deposits

afe **Principal alluvial-fan deposit at mouth of Eklutna River (late Holocene)**--Chiefly gravel and sand located mainly northeast of present-day river; graded as fan-delta mostly to present-day level of Knik Arm. Topography smooth, slopes gentle to very gentle. Constitutes major source of gravel and sand.

afp **Principal alluvial fan deposits along Peters Creek (Holocene)**--Chiefly gravel and sand located southwest of present-day stream, mainly west of map area; possibly may be graded as a fan delta to a level above present sea level. Topography smooth; slopes moderately gentle. Occur in only one locality at western edge of map area, but extensively developed to the west (Yehle and Schmoll, 1987)

Peat, Bog, Pond, and Lake Deposits (Holocene and late Pleistocene)

p **Peat, bog, and pond deposits**--Chiefly mosses, sedges, and other organic material in various stages of decomposition; includes organic-rich silt, minor woody horizons, and a few thin interbeds of mainly ash-size tephra. At depth may include silt, clay, marl, or fine-grained sand. Developed mostly in small former lakes or stream channels now the site of bogs. Soft and moist. Thickness as much as 4 m; adjacent mapped deposits extend beneath these deposits. Contacts well defined. Surface smooth, slopes less than one percent. Poorly drained

pm **Lake and deltaic deposits of a formerly more extensive Mirror Lake**--Chiefly sand and gravel reworked from nearby kame and meltwater-channel deposits; may include finer-grained material at depth. Well sorted and probably well bedded. Poorly exposed; character and genesis mainly inferred. Thickness not known, probably a few meters. Contacts well defined. Surface generally smooth, slopes gentle. Generally stable. Water table may be relatively high

Intertidal Deposits (Holocene)

Modern intertidal deposits--Chiefly silty sand; somewhat coarser near major channels and toward the far northeastern part of the map area, especially at depth. Well bedded and sorted. Loose, water saturated. Thickness less than one to a few meters, probably underlain by several meters or more of older intertidal deposits. Contacts variable in location with each tide as well as from season to season and year to year. Surface generally smooth, but incised one to a few meters by numerous channels that may have steep margins. Slopes otherwise nearly flat to gentle, commonly less than one percent. Subdivided into lower and upper zones

il Deposits of the lower intertidal zone--Includes driftwood and gravel at shoreward-most part of deposit in a discontinuous storm beach. Reworked several times daily by tides; covered by water of Knik Arm estuary at high tide, and exposed at low tide. Lower boundary of map unit is a very generalized mean tide line; upper boundary may be as much as several meters above mean high water line.

iu Deposits of the upper intertidal zone--Less sandy and more silty than the deposits of the lower zone; covered by water of Knik Arm only during exceptionally high tides coupled with extreme storms. Contain some organic and windblown material. Surface marked by some areas of standing water. Drainage very poor. Subsidence during 1964 Alaska earthquake indicated by drowned trees northeast of diked channel of the Eklutna River

io **Older intertidal deposits**--Chiefly silt and fine-grained sand, well bedded and sorted; locally may include thin beds of peat and other organic material and some windblown material. More firm than the modern intertidal deposits. Not flooded by present-day high tides. Thickness several to a few tens of meters. Contacts well-defined, except gradational in part to younger intertidal deposits

Colluvial (including Landslide) Deposits (Holocene and Pleistocene)

c **Colluvial deposits on mountain slopes, undifferentiated**--Mainly apronlike deposits of loose sandy to rubbly diamicton derived directly from weathering of bedrock upslope and moving downward by gravity with little hydrofluidity; at times of smowmelt, however, some sheetwash or minor flowage likely. Thickness poorly known, probably less than one to several meters, thicker in lower slopes. Contacts gradational. Topography smooth, surface gently concave upward, slopes generally steep to very steep, but usually not in excess of 70 percent. Commonly veneered by thin low vegetation; some instability expectable

ct **Talus deposits**--Cone-shaped to apronlike deposits on valley walls within rugged mountains. Mainly loose, coarse rubbly diamicton derived directly from weathering of bedrock upslope and moving downward by gravity. Thickness variable, generally thickest in middle to lower parts of cones and aprons, probably several to a few tens of meters, thinning gradually upward toward apexes and more abruptly downward near toes. Contacts generally gradational, feather edges at toe and at apex, where talus too small to map separately occurs within bedrock map unit; individual cones commonly have well-defined boundaries. Topography smooth, slopes steep to very steep, as much as 100 percent near apex, rarely less than 35 percent near toe. Commonly free of even low vegetation and subject to continuing deposition from above, including rockfalls and debris-laden snow avalanches; generally unstable

cs **Solifluction deposits**--Chiefly loose, organic-rich, sandy to rubbly diamicton, commonly lacking phenoclasts larger than pebbles; generally derived from weathering of easily frost-shattered bedrock directly upslope, moving very slowly down broad mountain slopes either with the aid of interstitial ice (solifluction in a rigorous sense) or of water derived largely from snowmelt. Thickness poorly known, probably one to a few meters. Contacts gradational to (1) very thinly covered bedrock, (2) other colluvium, and (3) thicker accumulations of material that has moved downslope by landsliding; includes some landslide deposits too small to map separately at 1:25,000 scale. Topography generally fairly smooth, but with many minor irregularities especially in the form of small lobes with flatter upper surfaces and steeper fronts. Slopes steep to moderately steep. Generally unstable

ca **Mixed colluvial and alluvial deposits**--Intimately entwined areas of colluvium and alluvium too small to map separately. Chiefly moderately loose sandy to rubbly diamicton and partly interbedded poorly sorted sand and gravel, with some organic debris. Thickness poorly known, probably a few meters. Contacts generally gradational. Topography generally irregularly gullied, slopes steep to very steep, generally ranging between 35 and 70 percent. Commonly covered by low vegetation, active deposition occuring within restricted gullies. Some instability expectable. Occur mainly on side and headwalls of small mountain valleys in southern part of map area cg **Mixed colluvial and glacial deposits**--Diamicton consisting chiefly of gravelly to rubbly sand, silt, and clay; locally bouldery. Derived from both bedrock and from glacial deposits, either of which are likely to occur at the surface in areas too small to map separately at 1:25,000 scale. Poorly bedded and sorted. Loosely to moderately compacted in most places. Thickness varies from a few to several meters. Contacts gradational. Slopes smooth to slightly irregular, steep to very steep

cm **Colluvial deposits derived from moraines or other glacial deposits**--Diamicton similar to that of adjacent upslope moraines, but less compact; includes minor amounts of better sorted sand, silt, and fine to medium gravel that occur in irregular beds and that may have been derived from better-sorted glacial deposits and moved partly with the aid of running water. Commonly a few meters thick. Contacts generally gradational, especially upslope. Slopes generally moderate and moderately stable

Colluvial deposits on walls of sea and stream bluffs--Loose accumulations derived from adjacent, upslope deposits that form a veneer on bluffs following erosion. Generally a few meters thick, thinner at the upslope part; may be thicker downslope. Some contacts well defined. Slopes steep to precipitous. Although stabilized locally by vegetative cover, subject to instability because of renewed gully, sea, or stream erosion and accompanying mass-wasting processes

cw Mixed coarse- to fine-grained deposits--Chiefly diamicton consisting of pebbly silt and sand with some clay, cobbles, boulders, and a variable amount of organic material. Poorly bedded and sorted. Generally unstable when excavated

cwf Fine-grained deposits--Chiefly silt, clay, and fine-grained sand; poorly bedded and sorted. Occurs along Knik Arm where upslope deposits are dominantly fine grained and may be equivalent to the Bootlegger Cove Formation. Thickness poorly known, probably a few to several meters. Slopes irregularly moderate to steep, and particularly susceptible to instablity. Occurs at western edge of map area along Alaska Railroad

cl **Landslide deposits, undifferentiated**--Chiefly diamicton consisting of gravelly silt and sand and relatively minor amounts of clay and some organic material; may include boulders and some very large masses of bedrock. Includes some small earth-flow deposits not mappable at 1:25,000 scale. Nonbedded and poorly sorted. Relatively loose. Thickness poorly known, probably several meters to possibly hundreds of meters. Contacts moderately well to poorly defined. Topography irregular to slightly hummocky, slopes moderate to steep. Queried where identity uncertain; these deposits are probably similar to those positively identified, but may include larger masses of unbroken bedrock. Alternatively they may consist mainly of bedrock, perhaps thinly veneered by colluvium, that has been subject to very little or no displacement; characteristic hummocky surface may have resulted instead from other processes such as differential glacial erosion of bedrock cle **Landslide deposits in earthflows**--Similar to other landslide deposits but interpreted on the basis of landform to have been emplaced in a more fluid medium and therefore may include a higher proportion of finer-grained material. Contacts generally well defined

Rock-Glaciers and their Deposits

rg **Rock glaciers (late Holocene)**--Accumulations of mainly angular to some subrounded rock fragments still actively being transported, derived from upslope talus or landslide deposits; contain ice-rich matrix and move very slowly downslope; surface generally lacking in vegetation; upper part dominated by angular to subangular cobble- and boulder-size fragments; at depth substantially more fine-grained material may be present to form coarse, rubbly, massive, and poorly sorted diamicton. Thickness several to a few tens of meters. Contacts generally well defined except gradational to talus at upslope margin. Surface moderately hummocky and rough; slopes generally moderate, but steep to very steep along margins. Unstable because of continuing very slow movement and potential for melting of ice-rich matrix

rd **Rock-glacier deposits (Holocene)**--Similar to active rock glaciers except that movement has probably ceased and some vegetation covers surface. Generally more stable than rock glaciers; some instability likely, especially if excavated, because of loose nature of material and likelihood that some interstitial ice may still be present. In places may still be active

Anthropogenic Deposits (late Holocene)

f **Engineered fill and land areas extensively modified by earthmoving equipment**--Chiefly compacted pebble gravel underlain by a more poorly sorted base course of sandy to silty gravel; in modified areas may include a more heterogeneous assemblage of material. Mapped mainly along Alaska Railroad and Glenn Highway, and at major construction sites and in sand and gravel pits and bedrock quarries where adjacent geologic units may be exposed. Thickness one to a few meters, thicker where railroads and highways cross major valleys. Contacts well defined, width shown on map may be slightly exaggerated where necessary to accommodate railroad and highway symbols

BEDROCK

b **Undifferentiated (Permian to Cretaceous)**--Chiefly metamorphosed igneous rocks of the Peninsular terrane (Jones and others, 1981, 1984, 1987; Coney and Jones, 1985), including mainly greenstone, greenschist, and gneiss, as well as metadiorite, metaquartz-diorite, chert, metaargillite, and some marble. A few bodies of ultramafic rocks are present, especially near Mount Eklutna (Rose, 1966). In southeastern half of map area, includes rocks of the Chugach terrane, mainly variably metamorphosed graywacke, argillite, phyllite, and conglomeratic graywacke of the Valdez Group and the McHugh Complex (Clark, 1972, 1973)

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