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Surficial geologic map of the Anchorage A-8 SE quadrangle, Alaska

By

Lynn A. Yehle[1], Henry R. Schmoll[1], and Ernest Dobrovolny[1]

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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SURFICIAL GEOLOGIC MAP OF THE ANCHORAGE A-8 SE QUADRANGLE, ALASKA

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INTRODUCTION

The Anchorage A-8 SE quadrangle is located in south-central Alaska almost entirely within the Municipality of Anchorage and centered about 20 km southeast of downtown Anchorage (fig. 1). Suburban Anchorage, including both locally concentrated and widely scattered residences and businesses, extends into the northwestern part of the map area; the remainder of the area is either mountainous and part of Chugach State Park or is covered by the water and bordering intertidal flats of Turnagain Arm. Both The Alaska Railroad and the Seward Highway hug the shoreline as they traverse the area from northwest to southeast (pl. 1A in pocket). The quadrangle is one of a series in the upper Cook Inlet-Knik Arm region for which geologic or surficial geologic maps have been published at a scale of 1:25,000 (fig. 2; Daniels, 1981a,b; Reger, 1981a,b,c,d; Updike and Ulery, 1988; Yehle and Schmoll, 1987a,b; 1988; 1989; Yehle and others, 1990, 1991).

The geology of this quadrangle was mapped at 1:24,000 scale (northern part) and 1:63,360 scale (southern part) by H.R. Schmoll and Ernest Dobrovolny mainly between 1965 and 1971 by interpretation of 1:20,000-scale air photos taken in 1962 and 1:40,000-scale air photos taken in 1957 and by field investigations that continued intermittently through 1988. Generalized versions of parts of the mapping were included in Schmoll and Dobrovolny (1972a) and Schmoll and Emanuel (1981). The original 1:24,000-scale mapping subsequently was reduced photographically to a scale of 1:25,000 and the 1:63,360-scale mapping photographically enlarged to and further modified for the 1:25,000 scale by L.A. Yehle and H.R. Schmoll in 1990 and 1991 and variously modified to accommodate the change to the new 1;25,000-scale base map. Additional interpretations were derived from examination of 1:24,000-scale air photos taken in 1972 and from field investigations in 1991; selected data from earlier geologic maps by Dobrovolny and Miller (1950) and Miller and Dobrovolny (1959) also were utilized.

PHYSIOGRAPHY

Two physiographic provinces, the Kenai-Chugach Mountains and the Cook Inlet-Susitna Lowland (Wahrhaftig, 1965), occur within the map area; both are subdivided informally as shown on figure 1. The rugged Chugach Mountains dominate the area, whereas the Anchorage lowland occupies only the northwestern part of it. Although only a single line is shown on figure 1 separating the lowland and the mountains, they are separated in this map area by a transition zone about 4 km wide that straddles this line. This transition zone is known locally as the Hillside area (Dearborn and Barnwell, 1975), and in recent years it has developed rapidly into a major suburban residential area.

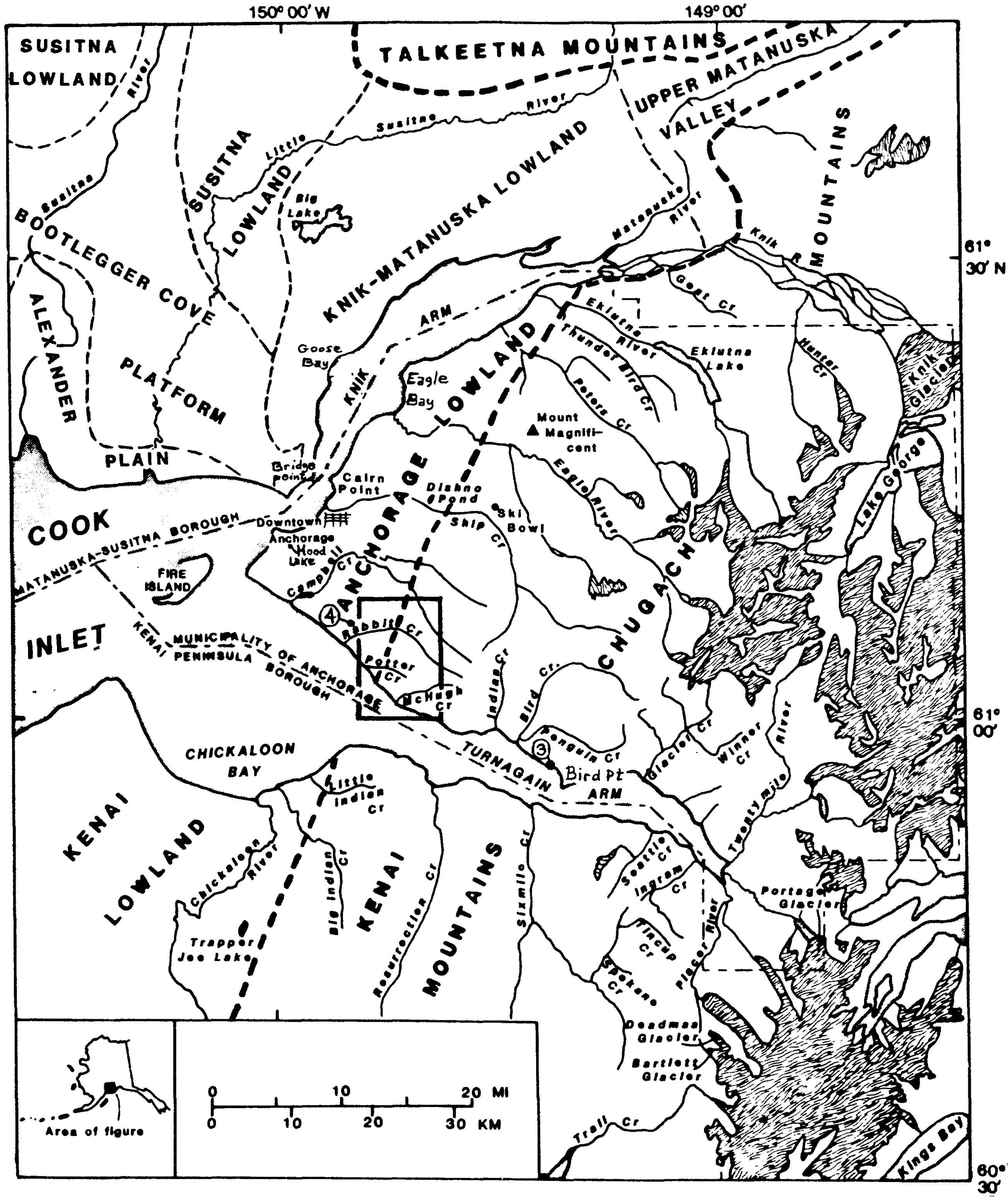


Figure 1. Location of map area (heavy rectangle) and major geographic features. Thick dashed lines indicate boundaries between major physiographic provinces of Wahrhaftig (1965): Kenai-Chugach Mountains, Talkeetna Mountains, and Cook Inlet-Susitna Lowlands; thin dashed lines and water bodies separate physiographic subprovinces of informal usage. Heavy pattern indicates glaciers. ③ ④ locations of radiocarbon-dated samples, see table 2 and text.

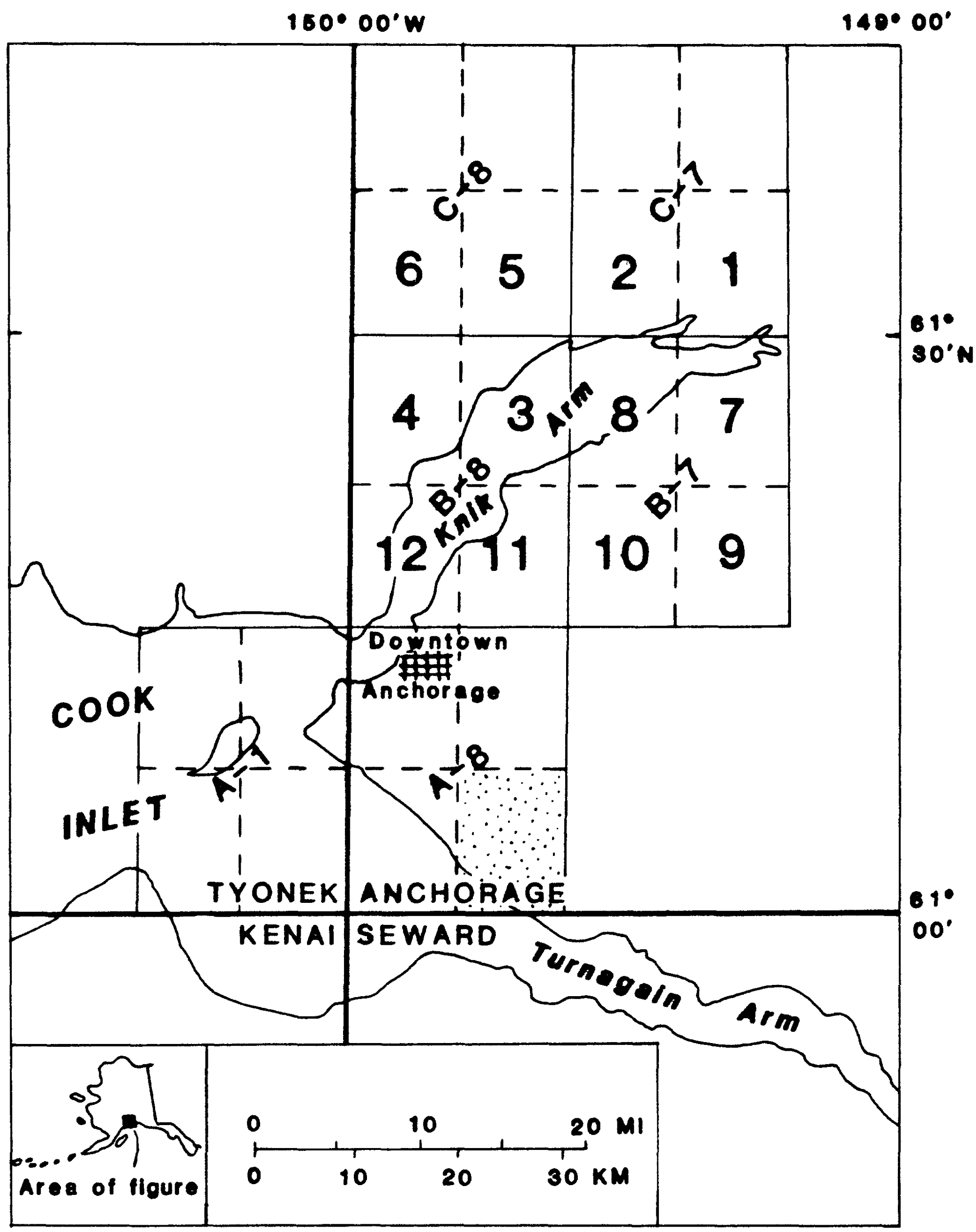


Figure 2. Index map showing location of geologic maps in the Anchorage-Knik Arm region published at 1:25,000 scale (1, Daniels, 1981a; 2, Daniels, 1981b; 3, Reger, 1981a; 4, Reger, 1981b; 5, Reger, 1981c; 6, Reger, 1981d; 7, Yehle and Schmoll, 1987a; 8, Yehle and Schmoll 1987b; 9, Updike and Ulery, 1988, and Yehle and Schmoll, 1988; 10, Yehle and Schmoll, 1989; 11, Yehle and others, 1990; 12, Yehle and others, 1991). Area of this report is indicated by stippled pattern.

The Chugach Mountains consist of a central core of very steep mountains with peaks in excess of 2,000 m and a flanking region where peaks and ridges are generally 1,000-1,500 m in altitude. Only this lower region is present in the map area, where the highest peak, not formally named, rises to 1,368 m near the east edge; also prominent about 3 km to the south of this high point are McHugh Peak at 1,314 m and two slightly lower, flanking peaks. The Chugach Mountains are transected by a series of northwest-trending U-shaped valleys that merge with the Hillside transition zone at their mouths and thus are hanging with respect to the Anchorage lowland. They are separated by prominent, generally sharp-crested ridges which descend in altitude toward the northwest where many of them are relatively smoothed. Some ridges have gently sloping to nearly flat crests; these occur north of McHugh Peak and at Flattop Mountain in the northeastern part of the map area. In the southern part of the map area no transition zone exists, and the mountains descend abruptly to Turnagain Arm. Near the base of this steep slope at an altitude no higher than about 130 m above mean sea level, there is a somewhat discontinuous, much gentler sloping bench-like area that is commonly less than 1 km in width.

A pronounced structural grain is evidenced by the subparallelism of the northwest-trending valleys that transect the mountains, as well as by the similarly trending shore of Turnagain Arm. This grain is exhibited by the drainage lines shown on figure 1 and on the geologic map, and have the same trend as major Chugach Mountain valleys and a facing pair of embayments along Knik Arm to the north (Yehle and others, 1990). In the southeastern part of the map area, however, two small valleys trend generally north to northeast, alignments that are more characteristic of the general structural grain of this part of the Kenai-Chugach Mountains province (Magoon and others, 1976).

The Anchorage lowland (Schmoll and others, 1984) lies southeast of Knik Arm (fig. 1) and is characterized within the map area mainly by hills of low to moderate relief composed of glacial drift. The hills are separated by meltwater channels some of which have boggy surfaces or contain minor alluvial channels. Much of the lowland within the map area lies in the Hillside transition zone where the hills and channels are subparallel to, or arc gently away from, the mountain front. A few of the hills in the northern part of the map area near the mountain front are cored by bedrock. In the northwestern part of the map area, much of the transition zone has a smoothly sloping surface that is not characteristic of the Hillside zone, but descends from it to the Anchorage lowland proper.

HYDROGRAPHY

The hydrography of the southwestern part of the map area is dominated by Turnagain Arm, the more southerly of the two branches of Cook Inlet (fig. 1). Turnagain Arm is characterized by semidiurnal tides that have the second highest recorded range in North America; the mean tidal range at Anchorage (the closest tidal station) is about 7.9 m and the difference between mean higher high water and extreme low tide approximates 10.6 m (U.S. National Ocean Service, 1990). The turning of the tides in the arm is characterized by large tidal bores (Bartsch-Winkler and Lynch, 1988) and swiftly moving currents that variably redistribute the soft intertidal deposits. Considerable changes in sedimentation occurred following the 1964 Alaska earthquake (Bartsch-Winkler and others, 1985; Bartsch-Winkler, 1985, 1988) when this part of the Cook Inlet region subsided tectonically about 1.5 m (Plafker, 1969, fig. 3; McCulloch and Bonilla, 1970, fig. 72). By 1975, however, some of the subsidence apparently had recovered, as about 0.5 m of post-seismic uplift was reported (Brown and others, 1977).

Within the Chugach Mountains, shores along Turnagain Arm are predominantly in bedrock and are poorly developed except where narrow gravelly to sandy beaches are present at the few stream mouths and at a few other places. Within the Anchorage lowland northwest of Potter Creek, the shore was formerly developed along a sandy to gravelly bar that bounded Potter Marsh, an area previously subjected to wave and tidal current action during high tide. Since construction of The Alaska Railroad in 1915, however, the entire shore is protected by boulder-size riprap of the railroad embankment. Although sedimentation within Potter Marsh and smaller such areas to the southeast is minor, there has been a decrease in water-surface area.

The land surface of the entire map area drains into Turnagain Arm, principally by the South Fork Campbell Creek, Rabbit Creek, and McHugh Creek, all of which head in mountain cirques east of the map area. The first two of these, along with the smaller Potter and Little Rabbit Creeks, flow northwesterly in their respective mountain valleys before turning westerly in the Hillside area to flow across the Anchorage lowland to Turnagain Arm. All these streams are entrenched within their valleys, flowing in narrow inner valleys that are bounded by steep bluffs developed in glacial deposits. Because the main levels of the valley floors are graded to the level of the Hillside area rather than to sea level at Turnagain Arm, the greatest entrenchment of the inner valleys, and consequently the highest bluffs, occur where the streams cross the Hillside area. McHugh and Rainbow Creeks in the southern part of the map area flow southwesterly directly into Turnagain Arm from their mountain valleys and are most deeply incised as they approach the arm.

Large parts of the map area are drained by smaller streams tributary to the larger streams. Within the mountains, some of these tributary streams have sizable valleys of their own. In the Hillside area and extending across the rest of the Anchorage lowland, there are several small streams that do not emanate from major valleys in the mountains and mainly do not have well-developed valleys. Little Campbell Creek is the largest of the named water courses, and others have local names that are not named on the base map. Some of these streams are incorrectly shown in a few places on the base map because of the difficulty in tracing their courses around hills as they leave and enter previously developed channels. Several streams have changed courses from time to time, due to both natural and anthropogenic processes during urbanization, and some streams now flow in roadside ditches. Although Furrow Creek, for example, is shown on the base map, it apparently is not now present within the map area, but instead emerges as a flowing stream just north of the map area.

The only sizable natural lake in the map area is Hideaway Lake (Lake Hideaway), located near the north edge in a complex of glacial deposits. About 1 km to the southwest is Lake of the Hills, held in by a small dam constructed on what probably is a partial diversion of Little Campbell Creek. Because a previous dam failed in 1972 (Dearborn and Barnwell, 1975), only a relict pond is shown on the 1979 base map. Subsequently, the dam has been rebuilt and both the dam and the lake are shown on the geologic map.

BEDROCK

Bedrock in the Chugach Mountains consists of structurally complex and variably metamorphosed sedimentary and igneous rocks (Capps, 1940; R.G. Gastil, U.S. Army Corps of Engineers, written commun., 1956; Clark, 1972; Clark and others, 1976; Madden and others, 1988; Updike and Ulery, 1988; Winkler, 1990; in press; Madden, 1991a,b; Nelson and Blome, 1991) of both the Peninsular and the Chugach tectonostratigraphic terranes (Coney and Jones, 1985; Jones and others, 1987). All of the rocks in the mountainous part of the map area are part of the Chugach terrane and are assigned to the McHugh Complex (Clark, 1973) that is Cretaceous and Jurassic in age of assemblage but includes protoliths as old as Late Triassic (Plafker and others, 1989).

Bedrock beneath the Anchorage lowland is concealed by a northwest-thickening wedge of glacial and glacioestuarine deposits (Dearborn and Barnwell, 1975; Schmoll and Barnwell, 1984; Schmoll and others, 1986). In the Hillside area where the cover is thin, the underlying bedrock comprises Chugach terrane rocks probably similar to those that crop out in the mountains. To the west, metamorphic rocks of Permian to Jurassic age and part of the Peninsular terrane crop out in a few places, whereas in the northwestern part of the area the cover is thicker and the Peninsular rocks probably are present at depth. Neither the relatively soft, continental sedimentary rocks of the Kenai Group (Calderwood and Fackler, 1972) of Tertiary age that underlie the glacial deposits at depth in areas to the north (Yehle and others, 1986; 1990; Stricker and others, 1988) nor the mainly marine sedimentary rocks of the Matanuska Formation of Cretaceous age (Plafker and others, 1982; Schmoll and others, 1986) are known to occur within the map area. Either or both of these major rock units may be present, however, beneath the northwesternmost part.

The boundary between the Peninsular and Chugach rocks is marked by the Border Ranges fault (MacKevett and Plafker, 1974), originally named by Clark (1972) and known locally as the Knik fault (Dearborn and Barnwell, 1975; Magoon and others, 1976). The location of this fault is not known precisely; its inferred position is about 1 km northwest of and parallel to the physiographic boundary between the lowland and mountains shown on figure 1. Neither the Knik fault, nor any faulting suggested by the steepness of the Chugach Mountain front northeast of the map area (Yehle and others, 1990) are known to offset the glacial or younger deposits within this map area. Thus, no evidence of Quaternary faulting has been found here.

SURFICIAL DEPOSITS

Surficial deposits within the map area consist mostly of Pleistocene-age glacial drift that includes extensive areas of moraine deposits as well as related glacioalluvial, glaciolacustrine, and glacioestuarine deposits. Nonglacial deposits are more restricted in individual areal extent, although some are widely distributed; mostly Holocene in age, they include alluvial, colluvial, intertidal, peat, pond, and anthropogenic deposits. Glacial deposits occur on the Anchorage lowland, including the Hillside transition zone that flanks the Chugach Mountains, and in the lower parts of major valleys and in one cirque within the mountains. In addition there are a few small tracts of glacial till on some gently crested ridge tops, indicating that at times glacier ice filled the Cook Inlet-Susitna Lowland to a sufficient altitude to overtop and erode the adjacent mountain margins. Alluvial deposits occupy the floors of most valleys and are most extensive in the South Fork Campbell Creek and Rabbit Creek valleys. Variably thick colluvial deposits cover bedrock on most of the gentler mountain slopes throughout the area. Deposits of landslides and of one rock glacier are present locally along the flanks of the mountains. Peat and pond deposits occur mainly in the numerous glacial meltwater channels in the Anchorage lowland. A ubiquitous mantle of organic and windblown materials, including minor amounts of tephra, covers all but the most recent deposits. This mantle has not been mapped separately but is included with the underlying deposits. Mapped anthropogenic deposits include the more important areas of engineered fill and of extensively reworked ground, mostly adjacent to Turnagain Arm.

GLACIAL DEPOSITS

Glacial deposits in the map area are the products of several glacial advances from and retreats to distant mountains to the north and east as well as the advance and retreat of local glaciers in major mountain valleys, especially the large valley of Turnagain Arm (Dobrovolny and Miller, 1950; Miller and Dobrovolny, 1959; Karlstrom, 1964; Cederstrom and others, 1964; Reger and Updike, 1983, 1989; Schmoll and Yehle, 1986). Each of these glaciers successively modified the terrain in the map area. As in most glaciated mountain regions, however, evidence for older glaciations is based largely on relict landforms rather than on deposits in stratigraphic sequence. The landforms resulting from the most recent glacier to occupy a given area are the most likely landforms to be preserved. Consequently, the oldest glacier advance for which there is evidence is probably the most extensive one, and successively younger advances from which landforms still survive were successively less extensive. Landform evidence for intervening advances of lesser extent than following advances is lacking, because the succeeding more extensive advances tend to destroy previously existing landform evidence. That such intervening but lesser ice advances probably occurred is attested to, for example, by the deep-sea record of glaciation; they might be recognized locally in stratigraphic sequences, but such sequences have not been found within the map area.

In addition to glaciers from distant sources, glaciers in Turnagain Arm and in the smaller mountain valleys contributed deposits to the area. The interplay between glaciers from distant and nearby sources varied, depending on a variety of climatic and geographic factors. Four generalized situations that can be identified on the basis of existing morainal landforms and their deposits and that may have recurred commonly when glacier ice terminated at successively less extensive positions are outlined as follows:

1. The most widespread glaciers to reach the map area from distant sources overwhelmed nearby valley glaciers in the Chugach Mountains, including the glacier in Turnagain Arm, filled the Cook Inlet-Susitna Lowland and covered parts of the adjacent mountains with ice.
2. When glaciers from the distant sources were less extensive, the glacier in Turnagain Arm and its tributaries in the more southerly valleys in the map area joined the major trunk glacier in the Anchorage lowland and the combined glacier flowed southwestward down the Cook Inlet-Susitna Lowland. Glaciers in the more northerly mountain valleys did not reach far enough downvalley to join with the lowland ice and the lower parts of these valleys were free of glacier ice. When drainage in such local valleys was blocked by the lowland glacier or its lateral moraines, lakes formed between the lowland glacier and the mountain-valley glaciers. The local glaciers either terminated directly in lake water, or were separated from lake water by tracts of outwash that formed deltas into the lakes. (Similar relations between major glaciers and glacier-free tributary valleys along other mountain margins are described by Booth, 1986, and Sturm and others, 1987).
3. When glacier advances were still less extensive, the Anchorage lowland within the map area was free of ice from distant sources, but may have been occupied by glacioestuarine water of an ancestral Cook Inlet with water levels relatively higher than at present. At this time the Turnagain Arm glacier was able to advance unhindered into the lowland, probably terminating in inlet water. Stream flow in the more northerly mountain valleys was probably not blocked but flowed into the inlet, while drainage from the southern valleys either drained through Turnagain Arm ice or may have been blocked by the ice at times.
4. When glacier ice was most restricted and was present only in areas farther north of the map area in the Anchorage lowland and east of the map area in Turnagain Arm, inlet water extended both up the Anchorage lowland and up Turnagain Arm to levels higher than at present. At this time, mountain valleys drained into Cook Inlet at a high level, commonly forming deltas that are now hanging with respect to the present level of inlet water.

The glacial deposits that are found at the land surface make up landforms of various kinds; the types and spatial relations of the landforms serve as guides to mapping the type of deposit inferred to be present and to interpreting the relative ages of the deposits. The three principal types of glacial deposits mapped are (1) morainal deposits--those that were deposited directly by glacier ice and that occur in end, lateral, and ground moraines; (2) glacioalluvial deposits--materials deposited by running water within, around, and draining away from the ice and that occur in kames, meltwater-channels, outwash trains, and glacial lakes and related deltas; and (3) glacioestuarine deposits--materials deposited in estuaries ancestral to Cook Inlet that were bordered in part by glacier ice; many of the glacioestuarine deposits in the map area represent reworking of morainal and glacioalluvial deposits. Morainal deposits consist of till that is composed mainly of diamicton (a poorly sorted mixture of clay, silt, sand, and gravel) and poorly sorted silty to sandy gravel; some sand and gravel are present locally, as are lesser amounts of silt and clay. Glacioalluvial deposits consist mostly of gravel and sand, although some diamicton and finer-grained material are commonly present in kames. Glacioestuarine deposits consist mainly of fine sand, silt, and minor diamicton that has a dominantly silty fine sand matrix; silt and clay may be present locally.

The glacial deposits are further subdivided and relative ages determined with reference to named lateral and end moraines, as discussed by Schmoll and Yehle (1986). Those authors also discuss difficulties in using the glaciation terminology developed by Karlstrom (1957; 1964) in classifying glacial deposits in the Anchorage area and used by Miller and Dobrovolny (1959) and most later workers. The localities from which Karlstrom's names are derived are located both to the north of this map area in the Anchorage lowland and to the south on the Kenai Lowland (fig. 1). Because most of these typical deposits are not well dated and successive deposits are neither in stratigraphic or geomorphic contiguity, there are many uncertainties in correlations of deposits throughout the Cook Inlet-Susitna Lowland. Thus we do not use Karlstrom's terminology, but instead, rely on local terminology and relate our deposits directly to a standard chronology for the Quaternary (Bowen and others, 1986). We apply this chronology without using queries, but recognize that the age of many deposits in the region is still somewhat uncertain.

Moraine deposits are subdivided according to their occurrence in end, lateral, and ground moraines, all of which are found in the map area. Well-formed lateral moraines dominate the Hillside transition zone along the front of the Chugach Mountains. Lateral moraines also occur as scattered remnants along mountain valley walls, including the steep slope that borders Turnagain Arm. Small end moraines occur in the easternmost part of the map area in the mountain valleys that extend farther eastward. Ground moraine occurs most extensively near the mouths of mountain valleys where they merge with the Hillside area and elsewhere on a few high-level mountain surfaces. Correlations of moraine segments have been aided by graphically determined gradients of these moraines. The till that forms most moraines is composed mainly of diamicton and poorly sorted silty to sandy gravel; the latter material is common especially in some areas of ground moraine in the lowland, especially where the deposits have been modified by the action of waves or tidal currents. Some gravel and sand are present locally, as are lesser amounts of silt and clay.

The deposits of seven named morainal systems are identified in this map area. Five of these were included in the discussions by Schmoll and Yehle (1983, 1986) and two others are reported here for the first time. Each of these systems occurs within characteristic altitudinal ranges in and upslope from the Hillside area; these ranges are presented for three general sites in table 1. A generalized single characteristic altitude is also given for each system, to provide a more readily visualized approximation of the altitudinal distribution of the moraine systems.

Three of these systems, from youngest to oldest the Potter Creek, Fort Richardson, and Rabbit Creek moraines, are represented by nearly continuous lateral moraines in the Hillside area, each of which is composed of two or more generally parallel ridges separated by abandoned meltwater channels. The Fort Richardson and Rabbit Creek lateral moraines descend southwestward in the northern part of the Hillside area, representing glaciers that flowed southwestward in the Anchorage lowland. South of about Rabbit Creek, however, all three lateral moraines descend northward and were formed mainly by glaciers that flowed down Turnagain Arm.

Table 1. Characteristic altitudes of moraines in and upslope from the Hillside area along the Chugach Mountain front, Anchorage A-8 SE quadrangle, Alaska

[Ranges given in meters above mean sea level; where no range is given, the range is less than 25 m. Leaders (--), moraine does not occur at this site]

Moraine name	Range in altitude			Generalized characteristic altitude
	North of Rabbit Creek	Near Little Rabbit Creek	Near Potter Creek	
Potter Creek	140	200-220	275-300	250
Fort Richardson	280-340	230-240	280	300
Rabbit Creek	400-425	300-325	300-375	375
Little Rabbit Creek	450	325	400	400
Ski Bowl	500-600	475	500	500
Glen Alps	625-700	650	500-550	600
Mount Magnificent	800	--	725	750
Older deposits	1,070	--	1,190-1,260	1,200

The Potter Creek moraines (Schmoll and Yehle, 1983, 1986; Bartsch-Winkler and Schmoll, 1984) are the lowest-lying and youngest of these lateral moraine systems. They comprise a series of arcuate ridges that extend northwest from near Turnagain Arm to the area between Rabbit Creek and Little Rabbit Creek. Here, at altitudes of about 140 m, the ridges become more subdued and are mapped as glacioestuarine deposits. The glacier is interpreted to have terminated in inlet water near here; ultimately the water covered and modified previously formed morainal ridges. This occurrence of the Potter Creek moraines constitutes their typical locality.

The Fort Richardson lateral moraines lie just upslope from the Potter Creek moraines in the southern part of the Hillside area, but in the northern part they are the lowest-lying moraines on the Hillside area slope where they become subdued in an area of glacioestuarine deposits. The Fort Richardson moraines extend about 40 km northeast to about the Eklutna River (fig. 1; Yehle and Schmoll, 1987a) and are best developed in the map area to the north where their typical locality is located (Schmoll and Yehle, 1986).

The Rabbit Creek lateral moraines occur next upslope and are the most continuous of the lateral moraines within the map area, extending from the north edge nearly to Turnagain Arm. They too reach their lowest altitude near Rabbit Creek, but the moraine ridge crests are about level, suggesting that the source glaciers from the Anchorage lowland and from Turnagain Arm merged in this vicinity. These well-developed lateral moraines throughout the Hillside area constitute the typical locality for Rabbit Creek moraines. They also extend intermittently northeastward as far as the Eklutna River.

Deposits of ground moraine and scattered lateral-moraine segments occur at several distinctly separable levels at successively higher altitudes above the Rabbit Creek lateral moraines. Deposits at these various levels are identified as those of the successively older and higher Little Rabbit Creek, Ski Bowl, Glen Alps, and Mount Magnificent moraines.

Deposits of the Little Rabbit Creek moraines are described here for the first time. They consist of a discontinuous series of lateral- and ground-moraine remnants that lie about 25 to 50 m higher on the slope than deposits of the Rabbit Creek moraines. The most prominent occurrences are near Little Rabbit Creek and constitute the typical locality; remnants also occur near the north edge of the map area and near Turnagain Arm. Because deposits of the Little Rabbit Creek moraines are areally restricted and are not far above the Rabbit Creek moraines in altitude, their existence was formerly acknowledged only as a subunit within the Rabbit Creek deposits. However, both the lack of continuity of these moraines relative to the Rabbit Creek moraines and their more subdued nature suggest that deposits of the Little Rabbit Creek moraines might be substantially older than those of the Rabbit Creek moraines, and they are now regarded as more likely the deposits of a separate, older glacial event.

Deposits of the Ski Bowl moraines are fairly widespread as ground moraine and occur commonly on broad surfaces in the upper part of and upslope from the Hillside area. They are the highest-level deposits that occur as an extensive drift sheet. The deposits can be traced from their typical locality about 15 km northeast of the map area (Yehle and Schmoll, 1989) where they consist mainly of well-developed but subdued lateral moraines. Some lateral-moraine segments have been preserved locally within this map area where the glacier entered mountain valleys and formed reentrants that merged with, but mainly overwhelmed, minor glaciers of the mountain valleys.

Deposits of the Glen Alps moraines are described here for the first time. These moraines were not previously regarded as occupying a sufficiently large area or clearly enough separated from either the Ski Bowl or Mount Magnificent moraines to constitute a separate moraine system. The area of these moraines is characterized by glacially smoothed bedrock knobs whose summits are covered by variously thick to very thin patches of glacial drift. Because these knobs occupy a level about 100 m higher than most of the Ski Bowl deposits and about 150 m lower than most Mount Magnificent deposits, and because this much altitudinal separation is at least as great as the separation between other morainal systems (table 1), we now regard that the deposits are the products of a clearly separate intermediate glaciation. The typical locality for these deposits occurs on a prominent bench-like area ("alp") on the ridge between Rabbit Creek and South Fork Campbell Creek which has long been the locale of an exurban community known as Glen Alps, noted for its fine views on clear days.

At still higher altitudes are widely scattered patches of drift or bedrock rubble containing numerous erratics. These deposits are thought to correlate with the Mount Magnificent morainal deposits about 25 km to the northeast (Yehle and Schmoll, 1989). They occur in isolated patches on some mountain ridges and on bench-like areas similar to, but much less extensively developed than, those of the lower Glen Alps moraines. Above these named morainal deposits are a few areas at even higher levels that contain a few glacial erratics mixed with bedrock rubble and that are thought to have been covered by glacier ice. These areas occur only on the top of Flattop Mountain and near McHugh Peak. Similar deposits at high altitudes in the Chugach Mountains were reported by Yehle and Schmoll (1989).

Other glacial deposits in the map area include glacioalluvial, glaciolacustrine, and glacioestuarine deposits that formed both within and marginal to the areas of moraine. These deposits are correlated with deposits of mountain-front and valley moraines on the basis of physical proximity and relative altitudes. Among such deposits are (1) deposits of kames and minor eskers that formed mainly by running water within the glacier during the early stages of stagnation when large amounts of glacier ice were still present; (2) outwash-plain deposits that formed at the margin of the glacier by drainage from within it; (3) meltwater-channel deposits that formed in channels developed either adjacent to the glaciers or within morainal areas during the waning stages of glacier stagnation or perhaps when ice was no longer present; (4) glaciolacustrine and associated deltaic and kame-fan deposits that formed marginal to the sides of a lowland glacier in valleys that were not occupied by glacier ice in their lower courses and the drainage of which was blocked by the lowland glacier; and (5) glacioestuarine deposits that formed in inlet water in which the lowland glacier terminated and which partly covered the morainal deposits as the ice front withdrew.

Kames are locally prominent landforms that include irregular hills and areas of hummocky terrain mainly within the Potter Creek and Fort Richardson moraines. Near the lateral moraines the kames are aligned roughly parallel to the moraines. The kame deposits are subdivided in part on the basis of differences in amount of local relief. They consist mostly of gravel and sand, but also include varying amounts of diamicton and finer-grained deposits. In places within the map area these deposits have been utilized as major sources of sand and gravel; this process has altered drastically some of the original kame landforms.

Deposits of glacial outwash consisting of gravel and sand in terrace remnants extend downvalley from end moraines in several of the mountain valleys. Meltwater-channel deposits occur extensively in the map area, mainly associated with morainal deposits. These deposits consist mainly of gravel and sand, but in some small channels peat may be common at the surface; diamicton or bedrock (especially along Turnagain Arm) may be present at shallow depths.

Deposits of glacier-dammed lakes and related deltas are found mainly in the middle reaches of Rabbit, Little Rabbit, and Potter Creeks. Roadcuts along both the original and reconstructed alignments of Rabbit Creek Road where it crosses Rabbit Creek valley reveal about 12 m of mainly interbedded fine sand and silt and laminated silt and clay. Several holes drilled for water-resources investigations in the Little Rabbit and Potter Creek valleys confirm the existence of soft, fine-grained sediments beneath the valley floors (Emanuel and Cowing, 1982). Farther upstream the surface appears underlain by coarser-grained deposits that are interpreted as having accumulated in fan deltas that formed where valley streams entered the glacier-dammed lakes. These deposits grade upvalley into glacial outwash.

Kame-fan deposits formed marginal to glaciers in small valleys or gullies that were blocked by the glacier. They occur at several places within the area of the Potter Creek moraines, and at scattered localities on mountain slopes near inferred margins of older glaciers. These deposits are poorly exposed, but are thought to be typically coarse grained and poorly sorted; they may include diamicton.

Glacioestuarine deposits dominate the Anchorage lowland in the northwestern part of the map area. Here they overlie morainal deposits and in places only partly conceal morainal landforms. They are subdivided into four informally named deposits, those respectively near Huffman Road, DeArmoun Road, Abbott Road, and Birch Road. Each of these deposits differs from the others either in material, thickness, moraine association, landform, or certainty of identity. They are referred to in the following discussion as, for example, "Huffman Road deposits." Remnants of the coarser glacioestuarine-shore deposits occur locally along Turnagain Arm at levels generally below the levels of the abovementioned deposits.

Both the Huffman Road deposits and the DeArmoun Road deposits occur near the western edge of the map area mainly south of Huffman Road, extending south across DeArmoun Road about as far as Little Rabbit Creek. They lie below about 140 m in altitude. The occurrences of both the Huffman Road and DeArmoun Road deposits within this map area constitute the typical localities for these deposits.

The Huffman Road deposits are more extensively developed to the west where good exposures along The Alaska Railroad at the railroad grade known as Potter Hill (Bartsch-Winlker and Schmoll, 1984) are interpreted as Huffman Road deposits. These include rudely bedded diamicton, silt, and fine sand that contain a microfauna (mainly foraminifera) associated with a brackish water depositional environment (P. B. Smith, written commun., 1971). Within the map area, the Huffman Road deposits are not well exposed; they occupy narrow channel-like areas between elongate ridges that are more subdued than those of the Potter Creek moraines. A small area of Huffman Road deposits are also mapped at a lower level near Rabbit Creek. The deposits may be veneered locally by alluvium consisting of gravel and sand or by thin peat and pond deposits that are not mapped separately.

DeArmoun Road deposits include fine sand and silt that occupy subdued elongate ridges extending northwest from similar but bolder ridges of the Potter Creek moraines. The DeArmoun Road deposits are interpreted to have been formed by modification and reworking of Potter Creek moraine deposits by glacioestuarine water; thus the former moraine ridges are partly buried by glacioestuarine deposits that probably overlie glacier-deposited diamicton at depths of a few meters.

Abbott Road deposits occur in a small belt that extends northeasterly between Huffman Road and the north edge of the map area near O'Malley Road. They are developed more extensively north of the map area where their typical locality occurs along Abbott Road between Abbott Loop Road and Birch Road. The deposits are poorly exposed, but include mainly silt, fine sand, and diamicton. They occupy a surface of subdued relief between about 110 m and 145 m in altitude downslope from the Birch Road deposits. The deposits may grade laterally to the Huffman Road deposits in part, but the latter are somewhat younger as well.

Birch Road deposits occur in the northwestern part of the map area upslope from the Abbott Road deposits and occupy a smoothly sloping area traversed by both Birch Road and Huffman Road between about 140 m and 240 m in altitude. This area constitutes the typical locality for these deposits. They are known from small road cuts where they consist mainly of fine sand and silt. Locally, especially at higher altitudes, diamicton may be the principal constituent. They may have been deposited in the glacioestuarine water in which the Fort Richardson glacier terminated and that modified the presumably underlying Fort Richardson morainal deposits. However, because of the high altitude to which the deposits extend and because no marine-associated microfauna have been found in the deposits, it is possible that they were deposited instead in glaciolacustrine water. Such a lake could have been either a relatively restricted lake impounded between glaciers in the Anchorage lowland and emanating from Turnagain Arm, or the large glacial lake (Lake Cook) postulated by Karlstrom (1964) to have formed when lower Cook Inlet was blocked by glacier ice, thus forming a fresh-water lake separate from and at higher level than the contemporaneous Pacific Ocean.

Glacioestuarine shore deposits occur near the shore of Turnagain Arm in a discontinuous bench about 30 m in altitude that is present locally between about the mouth of Little Rabbit Creek near the west edge of the map area and Rainbow Creek near the southeast corner. The deposits in large part are poorly exposed but are thought to include silt, fine sand, and, locally, diamicton and well sorted pebble gravel. About 1.2 km south of Little Rabbit Creek an exposure of silt and clay mapped by Miller and Dobrovolny as "Bootlegger Cove Clay" is included with these deposits. It is likely that they represent a near-shore facies of what is now designated the Bootlegger Cove Formation (Updike and others, 1982), because similar deposits farther up Turnagain Arm contain macrofossils similar to those of the Bootlegger Cove Formation and of about the same age (Bartsch-Winkler and Schmoll, 1984; Schmoll and Yehle, 1986).

CHRONOLOGY OF THE GLACIAL DEPOSITS

The age of the deposits described above is known in a relative way but is not well established in an absolute sense. Previous workers (Miller and Dobrovolny, 1959; Karlstrom, 1964) have differed, and we have been uncertain (Schmoll and Yehle, 1986) as to which of these deposits should be regarded as late Pleistocene in age, that is, part of the Wisconsin glaciation (Bowen and others, 1986). Radiocarbon age determinations are of only limited use in resolving this question. Only two radiocarbon ages have been determined for samples from sites within the map area. They are listed in table 2 together with selected age determinations from nearby areas that are pertinent to inferring the ages of deposits within the area. Both dated samples from within the area (radiocarbon localities 1 and 2, pl. 1A) are Holocene in age, and are from basal peat deposits that overlie morainal or glaciolacustrine deposits. They thus provide only minimal ages for the glacial deposits with which they are associated.

A somewhat close minimum age for deposits of the Potter Creek moraines can be inferred from the late Pleistocene age of about 14,000 yr B.P. determined for the Bootlegger Cove Formation near downtown Anchorage (Schmoll and others, 1972). A similar age was determined on mollusk shells from a locality 14 km east of the map area (radiocarbon locality 3, fig. 1). Although the deposits containing these shells are neither well exposed nor well evidenced geomorphically, their altitudinal position suggests that they are similar to the glacioestuarine shore deposits present within this map area, and, like them, these deposits were thought to represent a near-shore coarse facies of the Bootlegger Cove Formation (Bartsch-Winkler and Schmoll, 1984, p. 29). Since the glacioestuarine shore deposits lie somewhat below the level of Huffman Road deposits, the glacioestuarine deposits most closely associated with the Potter Creek moraines, we infer that the Potter Creek moraines are somewhat older than 14,000 yr.

The Huffman Road deposits and other, older, glacioestuarine deposits are exposed in the Potter Hill railroad cut about 1.5 km west of the map area (radiocarbon locality 4, fig. 1; Bartsch-Winkler and Schmoll, 1984, p. 22). There, an organic horizon beneath these deposits has yielded an age greater than 40,000 yr, thus indicating no finite lower age limit for the Huffman Road deposits on the basis of radiocarbon age determinations.

Because of the limited applicability of radiocarbon ages in determining the ages of most of the glacial deposits here, other criteria must be used. We rely, instead, mostly on geomorphic relationships because of the paucity and indeterminate nature of existing exposures of the deposits for age-determining purposes. The reasonably close areal association of the Potter Creek moraines and related glacioestuarine deposits to the late Pleistocene Bootlegger Cove Formation has lead us to consider (Schmoll and Yehle, 1986) that all of these units are late Pleistocene in age, In that publication, however, two alternate chronologies were given for the older deposits: the long chronology has deposits of all moraines older than the Potter Creek pre-late Pleistocene in age; the short chronology has deposits of all moraines as old as the Ski Bowl included within the late Pleistocene. Mainly because of the similar geomorphic appearance of the Fort Richardson moraines to the younger moraines, the Fort Richardson deposits have more recently been assigned a late Pleistocene age (Yehle and Schmoll, 1989).

Within the map area the morainal deposits may be grouped into three categories on the basis of geomorphology and degree of preservation of both landforms and deposits: (1) those in well-preserved and fairly continuous lateral moraines--these are the Potter Creek, Fort Richardson, and Rabbit Creek moraines; (2) those in extensive ground moraine but in only sporadically preserved lateral moraines--these are the Little Rabbit Creek and Ski Bowl moraines; and (3) those in ground moraines that are poorly preserved and associated with few to no lateral moraines--these are the Glen Alps and Mount Magnificent moraines, and include as well the higher-level deposits. On this basis, we here include the deposits of the Rabbit Creek moraines with those similarly preserved as being late Pleistocene in age, and regard the deposits of the older moraines as of undivided (but presumably pre-late) Pleistocene age.

Table 2. List of radiocarbon dates in and near the Anchorage A-8 SE quadrangle, Alaska

[Localities 1 and 2 shown on plate 1A; localities 3 and 4 shown on figure 1. W-, data from Meyer Rubin, U.S. Geological Survey radiocarbon laboratory, Washington, D.C. (now Reston, Virginia); I-, data from Isotopes, Inc. Ages given in years before present (1950) as reported by laboratory]

Locality number and name	Location	Material	Lab number	Radiocarbon age
1. Rabbit Creek[1]	NE1/4SE1/4 sec. 35, T. 12 N., R. 3 W.	Peat	W-2932	7,340±250
2. Potter Creek[1]	NE1/4SW1/4 sec. 11, T. 11 N., R. 3 W.	Peat	W-3785	6,240±250
3. West of Bird Point[2]	SE1/4SW1/4 sec. 14, T. 10 N., R. 1 W.	Shells	W-2919	13,900±400
4. Potter Hill[2]	SW1/4NE1/4 sec. 32 T. 13 N., R. 3 W.	Peat	I-11,000	>40,000

[1]First reported here.

[2]Bartsch-Winkler and Schmoll (1984)

INTERTIDAL DEPOSITS

Intertidal deposits are mapped only in very limited areas along Turnagain Arm, most of which is bordered by engineered fill of The Alaska Railroad. Deposits of the modern intertidal zone are divided into those of the upper and lower zones, following the usage of Ovenshine and others (1976). These deposits are subject to the twice-daily flood and ebb of brackish water that circulates within the Turnagain Arm estuary. The original configuration of the intertidal deposits in the near shore areas has been affected greatly by construction of the railroad and the highway. Further changes to the configuration were caused by the average of 1.4 m of tectonic subsidence that occurred during the 1964 earthquake (Plafker, 1969) and by the subsequent uplift of about 0.5 m that had apparently occurred by 1975 (Brown and others, 1977). These effects have been blurred, however, by the raising of the railroad embankment following the 1964 event.

Deposits of the lower intertidal zone are mapped only in small areas outside the railroad embankment east of the mouth of McHugh Creek. They extend, however, many kilometers offshore from the embankment and are exposed there at low tide. The water-land contact selected for these map units is an approximation of a mean tide line; it does not represent a fixed position but rather one that occurs only at times of mid-tide in a tide cycle. Deposits of the upper intertidal zone are mapped locally in small embayments inland from the railroad and highway fills that are still connected to arm water. The intertidal deposits are chiefly saturated fine sand and silt; coarser sand is present near major tidal channels, while crests of intertidal bars are finer grained (Bartsch-Winkler and Ovenshine, 1984; Bartsch-Winkler, 1985).

Modern intertidal deposits formerly occupied the extensive area of Potter Marsh between the railroad and highway embankments and the Hillside area northwest of the mouth of Potter Creek. Since construction of the embankments, this area has become partly isolated from the regular daily effects of the tides, and is now mainly affected by fresh water. The deposits in the marsh therefore are mapped separately in two units, those formerly upper zone deposits and those that include much standing water and formerly of the lower zone.

Deposits of the modern beach formerly occurred at the mouth of Potter Creek and extended northwest as a gravelly beach bar (McCulloch and Bonilla, 1970), but these deposits have been extensively modified by railroad construction beginning about 1915 and by later addition of fill for relocation of the Seward Highway in this area. The beach deposits probably consisted of gravel and sand, with boulders prominent locally.

Older intertidal deposits are mapped in areas bordering Potter Marsh that probably were not affected by the tides even prior to 1915 when the present marsh was open to the arm. Older deltaic deposits are mapped in a small area at the mouth of Potter Creek. These deposits, probably gravel and sand, occur at a level somewhat above that of the former modern beach in that area and were graded to the level of the older intertidal deposits.

COLLUVIAL DEPOSITS

The term colluvial deposits (colluvium), as used here, includes those deposits that occur on a slope and that have accumulated primarily through the action of gravity and secondarily through the aid of running water. Colluvium is broadly subdivided into deposits that have accumulated particle by particle over a long period of time (for example, talus) and deposits that have moved en masse (mass-wasting deposits), either rapidly, such as debris avalanches, or slowly, such as by solifluction. The deposits that accumulated particle by particle commonly underlie relatively smooth, mostly concave-upward slopes, whereas mass-wasting deposits, including rock-glacier deposits, are generally characterized by sloping topography that is irregularly lumpy to hummocky.

Most colluvial deposits contain minor admixtures of organic-rich soil and windblown material, and can be derived either directly from bedrock, from unconsolidated surficial deposits, or from a combination of these materials. Colluvium generally is poorly sorted, ranges widely in grain size, and is only somewhat compact. Good exposures of colluvial deposits are uncommon, and our descriptions are based largely on inference from exposures in similar landforms elsewhere in the region.

Smooth-surfaced colluvium occupies large areas on mountain slopes, commonly in the middle part of the slope, and is derived mainly from bedrock and mapped as undivided colluvium (map unit c). Other types of colluvium that accumulated particle by particle have more specialized characteristics and are mapped separately. Talus deposits (map unit ct) generally occur high on the slopes and along the upper courses of tributary valleys, usually downslope from prominent bedrock outcrops. On slopes on which remnants of lateral- and ground-moraine deposits are mapped or are thought to be present at depth, colluvium (map unit cg) contains material derived from glacial deposits as well as from bedrock; some of these slopes have an irregular surface and only partly conceal in-place morainal deposits. On slopes below the proximal (toward-ice) side of some lateral moraines, colluvium (map unit cm) is derived largely from morainal deposits and is similar to ground moraine except that it has been subjected to some mixing during its downslope movement. Colluvium that is mixed with alluvium (map unit ca) occupies small areas generally restricted in width and commonly in gullies and small ravines.

The steep walls of valleys that are incised into surficial deposits are particularly subject to instability and any renewed stream erosion. These valley walls commonly are veneered by a downslope-thickening wedge of colluvium (map unit cw) derived mainly from material into which the wall was cut during the last episode of erosion. Such erosion is likely to occur at any place along the wall when the stream renews its lateral attack, removes at least part of the colluvium, and erodes anew the underlying material. Valley-wall colluvium is thickest and most extensive where major streams have cut into relatively soft, potentially unstable glaciolacustrine deposits; here, irregular, lumpy valley-wall profiles are common and the deposits are mapped separately (map unit cwf). Elsewhere, valley-wall colluvium forms long, narrow belts on terrace and channel escarpments; some of these bluffs are too narrow to map separately, but occur commonly where alluvial deposits of different ages are in contact. Some of the small bluffs are indicated by linear scarp symbol.

Colluvial deposits that have formed en masse include mainly landslide deposits. These are the most important among the colluvial deposits in terms of their potential impact on human activity. They vary from individual earthflows and slumps in surficial deposits and (or) bedrock to huge retrogressive block failures developed entirely in bedrock. Deposits of all but one of these landslide typse are included in an undivided map unit. Only earthflows larger than about 100 m in length are mapped separately (map unit cle); most of these occupy pre-existing gullies and ravines; two such flows occupy the narrow inner valley floors of Rabbit Creek and its major southern tributary in the eastern part of the map area. Solifluction deposits (map unit cs) accumulated more slowly than landslides, generally by creep, and occupy relatively small areas on broad slopes.

In many places landslides can be readily identified on the basis of surface morphology visible on air photos. In other places, however, surface morphology is merely suggestive that landslide deposits might be present. The substantial number of suspected landslide deposits are indicated by query on the map. Detailed investigation may suggest alternate interpretations for these features and some of them, for which alternate origins can be confirmed, would be relegated to the category "pseudo-landslides" (Shlemon and Davis, 1986). The widespread occurrence of landsliding in the area is facilitated by (1) the structural complexity and highly fractured or sheared nature of bedrock in a locality; (2) occurrence of fine-grained deposits, mainly silt and clay; (3) steepness of slopes, caused in part by glacial erosion, and (4) slope orientation.

A special type of slope process that occurs on some steep mountain slopes and on ridge crests but which commonly does not give rise directly to colluvium, is inferred from small, narrow, bedrock-flanked trenches which we interpret as sackung features. The trenches occur along or just downslope from and subparallel to the crests of a few high-mountain ridges. Sackung features are thought to have formed through 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 discrete slide surface (Radbruch-Hall, 1978; Savage and Varnes, 1987). Although the process is not fully understood, conditions especially conducive to sackung formation are thought to include oversteepened valley walls left unsupported after retreat of a glacier. Earthquake-shaking and tectonic- or glacio-isostatic uplift might enhance or accelerate development of the sackung features, but are not regarded as the primary cause. All these conditions obtain in the Chugach Mountains where we recognize sackung features. A cluster of these features is present in the northeastern part of the map area (NE1/4 sec. 28, T. 12 N., R. 2 W.); others are well exhibited farther to the east (Schmoll and Dobrovolny, unpublished mapping) and northeast (Updike and Ulery, 1983; Yehle and Schmoll, 1987b, 1988, 1989).

Rock-glacier deposits are the products of rock glaciers that are no longer active. These deposits are transitional in nature between colluvial and glacial deposits, although recent evidence suggests that rock glaciers probably have a closer affinity to true glaciers than previously thought (Moore and Friedman, 1991). Only deposits comparable to the older rock-glacier deposits discussed by Yehle and Schmoll (1988) are present within the map area. They are probably similar to ground-moraine deposits, but at least near the surface may be more bouldery and the surface morphology is generally more massive and uniformly hummocky in appearance than is true of normal ground moraine.

OTHER DEPOSITS

Other surficial deposits mapped include alluvial, pond, bog, lake, and anthropogenic deposits. The alluvial deposits are subdivided into stream alluvium and fan alluvium. Stream alluvium has been mapped mainly in the narrow inner valleys within the major mountain valleys, as well as along a few small streams where they cross the Anchorage lowland. Alluvium also occurs along small streams in areas that are too narrow to map separately. Fan alluvium is deposited where tributary valleys enter a larger valley or the lower-lying parts of the Anchorage lowland.

In places, alluvial deposits thought to be significantly older are mapped separately. These older alluvial deposits generally occur in terraces, two levels of which are distinguished, that are several to more than 10 meters above present stream levels, or in similarly high-level fans that have been incised by streams which subsequently developed fans near levels of present streams.

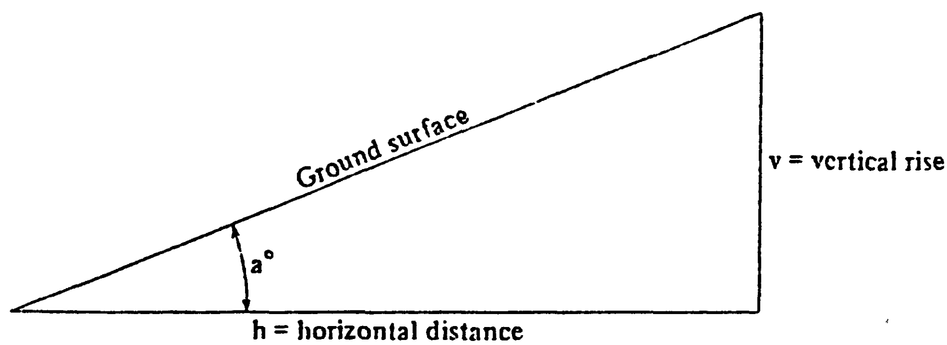
Alluvial deposits consist mostly of sand and gravel. Locally, alluvium is finer grained, mainly fine sand and silt; some of these occurrences are mapped separately (map units alf and aff).

Pond and bog deposits are mapped mainly in poorly drained areas around moraines and kames, in glacial meltwater channels, in areas of glaciolacustrine deposits, and on some very gently sloping terrain of the Anchorage lowland. Lake deposits are mapped in the South Fork Campbell Creek valley near the east edge of the map area where that stream may have been blocked by a landslide or massive earthflow. Deposits consist of varying amounts of silt and sand, peat, and thin lenses of tephra. The pond and bog deposits grade laterally into, but are thicker than, the mantle of organic and eolian deposits that overlie most other deposits, but that is not mapped separately.

Anthropogenic deposits are those that have been emplaced or significantly disturbed by the activities of man. Engineered fill has been mapped mainly along The Alaska Railroad and the Seward Highway where they border Turnagain Arm. Smaller areas of fill are mapped mainly in the northwestern part of the map area where the main roads cross major channels and in the dam at Lake of the Hills. Areas in which naturally occurring materials have been extensively reworked are shown by underscored map-unit symbols. They include areas of both cut and fill and occur mainly along Turnagain Arm where extensive blasting of bedrock was necessary for regrading the railroad and highway following the 1964 earthquake (McCulloch and Bonilla, 1970) and for subsequent widening and straightening of these transportation lines.

DESCRIPTION OF MAP UNITS

Characteristics of the geologic materials delineated by the units of the surficial geologic map (plate 1A) described here are based primarily on field observations; they are supported in part by laboratory analyses, especially of grain size, the description of which follows the modified Wentworth grade scale (American Geological Institute, 1989). Slope information is derived from or based on geomorphic analogy to estimates presented in Schmoll and Dobrovolny (1972b), whose slope categories are used (fig. 3). Standard age designations are omitted from map symbols because all units except bedrock are of Quaternary age. The correlation of map units is shown on plate 1B (in pocket). The units described here may be overlain by as much as one meter of organic and windblown materials as discussed above.



Diagrammatic representation of slope-measuring terms

Slope in percent = v/h × 100

Slope angle in degrees = a°

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

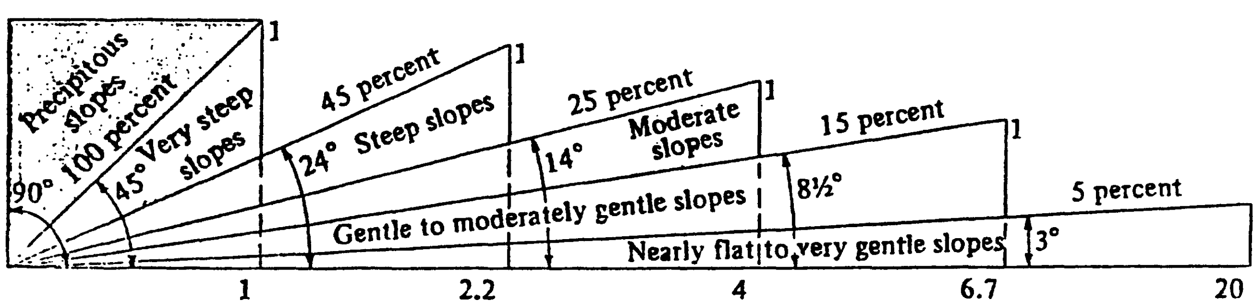


Figure 3. Diagram illustrating slope categories used on this map (after Schmoll and Dobrovolny, 1972b).

SURFICIAL DEPOSITS

Moraine deposits

Subdivided according to type of moraine (end, lateral, and three types of ground moraine) and according to correlations with named end and lateral moraines along the Chugach Mountain front within and northeast of the map area. 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; in places may consist of poorly sorted silty sandy gravel; includes scattered large boulders; generally moderately to well compacted.

End-moraine deposits--Thickness poorly known, probably about 10 m or less. Contacts well defined. Topography irregular; slopes gentle to moderate on small areas on some ridge tops, steep on ridge sides

fme Deposits of the Fort Richardson moraines (late Pleistocene)--Occur at east edge of map area in major valleys where they form small moraines in bottoms of valleys along Rabbit Creek, McHugh Creek, and the northern tributary to South Fork Campbell Creek

rme Deposits of the Rabbit Creek moraines (late Pleistocene)--Occur in valleys of South Fork Campbell Creek and its northern tributary, and in Potter Creek valley. In northeastern part of map area characterized by numerous narrow, sharp-crested ridges that slope arcuately toward valley center; elsewhere topography is more subdued

lme Deposits of the Little Rabbit Creek moraines (Pleistocene)--Single occurrence in northeastern part of map area

Lateral-moraine deposits

pml Deposits of the Potter Creek moraines (late Pleistocene)--Thickness probably several to about 10 meters. Contacts well defined, but at about 140 m in altitude grade laterally to DeArmoun Road deposits, becoming increasingly concealed to the northwest beneath cover of glacioestuarine deposits. Moraine ridges elongate and gently arcuate with moderately irregular topography; slopes gentle to moderate on small areas on some ridge tops, steep on ridge sides. Occur in central and southern parts of Hillside area, locally upslope from Turnagain Arm, and in Rainbow Creek valley

fml Deposits of the Fort Richardson moraines (late Pleistocene)--Thickness probably several to 10 meters. Contacts well defined. Moraine ridges generally well formed to moderately irregular; slopes moderate to steep. Occur throughout the Hillside area and in South Fork Campbell Creek valley at east edge of map area

rml Deposits of the Rabbit Creek moraines (late Pleistocene)--Thickness probably several to 10 meters. Contacts relatively well defined. Moraine ridges well formed to moderately irregular; slopes generally moderate, locally steep on ridge sides. Occur throughout the Hillside area and locally on slopes of large mountain valleys

lml Deposits of the Little Rabbit Creek moraines (Pleistocene)--May be more oxidized than younger lateral-moraine deposits. Thickness probably a few to several meters. Contacts moderately well defined to gradational. Moraine ridges moderately irregular; slopes generally moderate, locally steep. Occur discontinuously in upper part of Hillside area, in South Fork Campbell Creek valley, and locally upslope from Turnagain Arm

sml Deposits of the Ski Bowl moraines (Pleistocene)--Probably more compacted and oxidized than younger lateral-moraine deposits. Thickness poorly known, probably several meters. Contacts mostly gradational. Topography includes remnant ridges and irregular ground; slopes generally moderate to steep. Occur locally on slopes of large mountain valleys and upslope from Turnagain Arm gml Deposits of the Glen Alps moraines (Pleistocene)--Probably well compacted and oxidized. Thickness poorly known, probably a few to several meters. Contacts gradational. Topography includes remnant ridges and irregular ground; slopes moderate to steep. Occur at widely scattered locations fairly high on slopes along large mountain valleys, especially south side of Potter Creek valley

mml Deposits of the Mount Magnificent moraines (Pleistocene)--Probably well compacted and oxidized. Thickness poorly known, probably a few to several meters. Contacts gradational. Topography includes remnant ridges and irregular ground; slopes moderate to steep. Occur at two localities, one north and the other southeast of McHugh Peak

Ground-moraine deposits

pmg Deposits of the Potter Creek moraines (late Pleistocene)--Thickness poorly known, probably several meters; may overlie older glacial deposits. Contacts generally well defined. Topography smooth to gently hummocky, slopes generally gentle to moderate. Occur in central and southern parts of Hillside area, and locally in McHugh and Rainbow Creek valleys and upslope from Turnagain Arm

pmb Deposits that thinly mantle bedrock--Thickness not well known but may be as much as a few meters. Bedrock outcrops present locally; includes some admixed bedrock rubble. Contacts relatively well defined. Topography irregular to hummocky, slopes gentle to moderate, locally steep. Occur mainly on bench on lower part of slope along Turnagain Arm and within ground moraine south of Little Rabbit Creek

fmg Deposits of the Fort Richardson moraines (late Pleistocene)--Thickness poorly known, probably a few to several meters. Contacts fairly well defined. Topography generally smooth, slopes moderate. Occur mainly downslope from lateral moraines in northern and central parts of the Hillside area and locally in McHugh Creek valley

fmb Deposits that thinly mantle bedrock--Thickness not well known but may be as much as a few meters. Bedrock outcrops present locally; includes admixed bedrock rubble. Contacts relatively well-defined. Topography smooth, slopes gentle to moderate. Occur in the southern part of the Hillside area and at one place along McHugh Creek

fmm Deposits modified by glacioestuarine water--Similar to other ground moraine but occur in a few elongated low ridges in northwestern part of map area where moraine deposits are thinly concealed beneath glacioestuarine deposits

rmg Deposits of the Rabbit Creek moraines (late Pleistocene)--Thickness poorly known, probably only a few meters. Bedrock may be present locally at shallow depth, especially near north edge of map area where may be admixed with colluvium derived mostly from bedrock. Contacts gradational. Topography smooth, slopes gentle to moderate. Occur at one site in central part of the Hillside area and in valleys of South Fork Campbell, Rabbit, Potter, McHugh, and Rainbow Creeks

rmb Deposits that thinly mantle bedrock--Thickness poorly known but may be as much as a few meters. Bedrock outcrops present; includes admixed bedrock rubble. Contacts relatively well defined. Topography smooth, slopes gentle. Occur at scattered places in southern part of Hillside area and in McHugh Creek valley

lmg Deposits of the Little Rabbit Creek moraines (Pleistocene)--May be more oxidized than younger lateral-moraine deposits. Thickness poorly known, probably only a few meters. Contacts gradational. Topography smooth, slopes gentle to moderate. Occur locally in northern and southern parts of Hillside area, in a few places in South Fork Campbell Creek valley and at one place upslope from Turnagain Arm

lmb Deposits that thinly mantle bedrock--Thickness poorly known but may be as much as a few meters. Bedrock outcrops may be present; includes admixed bedrock rubble. Contacts gradational. Topography smooth, slopes gentle to moderate. Occur in a few places upslope from Turnagain Arm smg Deposits of the Ski Bowl moraines (Pleistocene)--Probably more oxidized than younger ground-moraine deposits. Thickness poorly known, probably a few to several meters. Contacts gradational. Topography smooth, slopes moderate. Occur commonly in broad areas where mountain valleys merge with the upper Hillside area, and locally on the northwestern ends of mountain interfluve ridges

smb Deposits that thinly mantle bedrock--Thickness poorly known, probably one to a few meters; small bedrock outcrops probably common; admixed with or consisting mostly of bedrock rubble. Contacts gradational. Topography smooth, slopes gentle to moderate. Occur near the northwestern ends of mountain interfluve ridges and locally in McHugh Creek valley and upslope from Turnagain Arm

gmg Deposits of the Glen Alps moraines (Pleistocene)--Probably more oxidized than younger ground-moraine deposits. Thickness poorly known, probably a few meters. Contacts gradational. Topography smooth, slopes gentle to moderate. Occur on high areas near ends of major interfluve ridges above where they merge with the Hillside area, and locally in South Fork Campbell and Rabbit Creek valleys

gmb Deposits that thinly mantle bedrock--Thickness probably a few meters or less, bedrock outcrops common; admixed with or consisting mostly of bedrock rubble. Contacts gradational. Topography somewhat more irregular than in areas of younger ground moraine, slopes gentle to moderate, locally steep. Occur on high areas near ends of major interfluve ridges upslope from where they merge with the Hillside area and locally in McHugh Creek valley

mmg Deposits of the Mount Magnificent moraine (Pleistocene)--Probably more oxidized than younger ground-moraine deposits. Thickness poorly known, probably no more than a few meters. Contacts gradational. Topography smooth, slopes gentle. Occur over a broad area in the northeastern part of map area and in a cirque near McHugh Peak

mmb Deposits of the Mount Magnificent moraine including mainly bedrock rubble--Thickness poorly known, probably a meter or little more; only widely scattered erratics may be present; small bedrock outcrops common. Contacts gradational. Topography fairly smooth, slopes gentle. Occur on interfluve ridges on both sides of South Fork Campbell Creek and on the ridge between Little Rabbit and Potter Creeks

omg Older deposits (Pleistocene)--Probably the most oxidized and weathered of the ground-moraine deposits. Thickness poorly known, probably a meter or less. Bedrock outcrops may be present. Contacts gradational. Topography fairly smooth, slopes gentle to moderate. Occur on high-altitude surfaces northwest of McHugh Peak and northeast of Rabbit Creek at east edge of map area

omb Older deposits that include bedrock rubble--Thickness less than 1 m; may consist mainly of bedrock rubble with widely scattered erratics; bedrock present at shallow depth. Contacts fairly well defined. Topography smooth, slopes gentle. Occur on summit of Flattop Mountain and near McHugh Peak

Glacioalluvial and glaciolacustrine deposits

Glacioalluvial deposits include: (1) kame deposits and (2) kame-terrace deposits, both of which are dominantly gravel and sand but that locally include diamicton, silt, and clay; and (3) kame-channel, (4) meltwater-channel, and (5) outwash-train deposits, all of which consist dominantly of gravel and sand. Kame-fan and glacial-lake delta deposits are transitional between glacioalluvial and glaciolacustrine deposits as to origin and include a variety of coarse, fine, and mixed-size materials. Glaciolacustrine deposits are dominantly fine grained and include variably admixed, well to poorly sorted coarser materials.

Kame deposits--Chiefly pebble and cobble gravel and sand, moderately to well bedded and sorted; some silt, and, especially in the cores of hills, diamicton; locally may include large boulders. Includes deposits of small eskers. Moderately loose, but compact in cores of hills. Contacts generally well defined; merge with moraine deposits. Topography sharply hilly to hummocky with some local depressions; slopes moderate to steep, except gentle to nearly flat in minor channels, on depression floors, and on some small areas on tops of hills

pk Deposits of the Potter Creek moraines (late Pleistocene)--In landforms of high to low relief. Thickness a few to several tens of meters. Occur in central and southern parts of Hillside area

pkh Deposits that exhibit high relief--Probably thicker than other kame deposits, and topography more bold. Occur in a few localities in Hillside area south of Little Rabbit Creek

fk Deposits of the Fort Richardson moraines (late Pleistocene)--Thickness probably a few to several tens of meters. Occur mainly in northern part and locally in southern part of Hillside area and in northeastern part of map area

rk Deposits of the Rabbit Creek moraines (late Pleistocene)--Thickness poorly known, probably several meters. Occur in Hillside area mainly near Rabbit and Little Rabbit Creeks

rkh Deposits that exhibit high relief--Probably thicker than other kame deposits, and topography more bold. Single occurrence south of Rabbit Creek

lk Deposits of the Little Rabbit Creek moraines (Pleistocene)--May be somewhat more oxidized than younger kame deposits. Thickness poorly known, probably several meters. Occur in a few places in the northern and southern parts of the Hillside area, upslope from Turnagain Arm, and in the northeastern part of map area

sk Deposits of the Ski Bowl moraines (Pleistocene)--Probably more oxidized than younger kame deposits. Thickness poorly known, probably several to ten meters. Occur at a few places near Little Rabbit Creek and in northern part of map area near Little Campbell and South Fork Campbell Creeks

gk Deposits of the Glen Alps moraines (Pleistocene)--Probably more oxidized than younger kame deposits. Thickness poorly known, probably several meters. Occur at two localities, one northeast of South Fork Campbell Creek and the other on the interfluve between Rabbit and Little Rabbit Creeks

Kame-terrace deposits (late Pleistocene)--Chiefly pebble and cobble gravel and sand, moderately to well bedded and sorted; locally may include boulders. Moderately loose. Thickness poorly known, probably a few to several meters. Contacts generally well defined. Topography smooth, slopes gentle except steep at terrace edge

pkt Deposits of the Potter Creek moraines--A few occurrences in southern part of Hillside area and upslope from Turnagain Arm

fkt Deposits of the Fort Richardson moraines--Occur at a few localities in the Hillside area north of Rabbit Creek and north of Potter Creek

Kame-channel deposits--Chiefly pebble and cobble gravel and sand; locally may include some finer materials; may include pitted outwash and (or) meltwater-channel deposits. Thickness poorly known but probably only a few meters. Contacts well defined. Topography slightly hummocky in channel-like landforms of generally low relief that lie within broad areas of kame deposits of high relief; slopes typically gentle; locally steeper where hummocks well developed

pkc Deposits of the Potter Creek moraines (late Pleistocene)--Occur in a few channels north and south of Little Rabbit Creek in the Hillside area

fkc Deposits of the Fort Richardson moraines (late Pleistocene)--Occur in the Hillside area north of Rabbit Creek and at one place in the northeastern part of map area

rkc Deposits of the Rabbit Creek moraines (late Pleistocene)--Occur in a fairly broad channel in Hillside area mainly between Rabbit and Little Rabbit Creeks and at one place in the northeastern part of map area

lkc Deposits of the Little Rabbit Creek moraines (Pleistocene)--Occur at one place in the Hillside area south of Little Rabbit Creek skc Deposits of the Ski Bowl moraines (Pleistocene)--Probably more oxidized than younger kame-channel deposits. Single occurrence in northeastern part of map area west of South Fork Campbell Creek

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 absent and ground-moraine deposits or bedrock may floor the channel or lie at shallow depth. Contacts well defined. Topography smooth, slopes gentle

Channel deposits near Klatt Road (late Pleistocene)--Occur in northwesternmost part of map area in major channels graded to deltaic deposits a few kilometers west of map area

kc Deposits in channels cut below the level of the higher deposits--Graded to a level of about 65 m in altitude

kch Deposits at higher level--Graded to a level of about 110 m in altitude

pc Channel deposits of the Potter Creek moraines (late Pleistocene)--Occur in numerous places in central and southern parts of the Hillside area and extensively within the topographic bench area along the lowermost mountain slopes near Turnagain Arm

fc Channel deposits of the Fort Richardson moraines (late Pleistocene)--Occur in the northern part Hillside area and in a few places near the east edge of the map area in the valleys of McHugh Creek, South Fork Campbell Creek, and along its northern tributary

fcl Lower-level deposits--Occur in the altitudinally lower part of the northern Hillside area near Little Campbell Creek

rc Channel deposits of the Rabbit Creek moraines (late Pleistocene)--Occur in scattered localities along the Hillside area in western part of map area as well as in the northeastern corner of the map area

lc Channel deposits of the Little Rabbit Creek moraines (Pleistocene)--May be somewhat more oxidized than younger channel deposits. Occur at a few places in the northern and southern parts of the Hillside area, in the northeastern part of the map area, and upslope from Turnagain Arm

sc Channel deposits of the Ski Bowl moraines (Pleistocene)--Probably more oxidized than younger channel deposits. Occur commonly on northwestern ends of major mountain interfluve ridges

gc Channel deposits of the Glen Alps moraines (Pleistocene)--Probably more oxidized than younger channel deposits. Occur at a few localities near northwestern ends of major mountain interfluve ridges

mc Channel deposits of the Mount Magnificent moraine (Pleistocene)--Probably more oxidized than younger channel deposits. Occur on a few prominent topographic saddles crossing most of the mountain interfluve ridges

oc Older channel deposits (Pleistocene)--Gravel and sand of these deposits may be less well bedded and sorted, thinner, and probably more oxidized than other channel deposits; bedrock outcrops common. Tentatively identified at a mountain saddle northwest of McHugh Peak

Outwash-train deposits--Chiefly pebble and cobble gravel and sand, well bedded and well sorted that accumulated mainly in front of and downstream from valley glaciers in the large mountain valleys and that now occur in terraces and terrace remnants. Contacts well defined. Topography smooth, slopes gentle except steep at terrace edges

fo Deposits related to the Fort Richardson moraines (late Pleistocene)--Occur in Rabbit Creek and McHugh Creek valleys. May be concealed beneath lake deposits in South Fork Campbell Creek valley

ro Deposits related to the Rabbit Creek moraines (late Pleistocene)--Occur extensively in South Fork Campbell Creek, Little Rabbit Creek, and Potter Creek valleys, and locally in Rabbit Creek valley

lo Deposits related to the Little Rabbit Creek moraines (Pleistocene)--Occur at two places in Rabbit Creek valley

so Deposits related to the Ski Bowl moraines (Pleistocene)--Probably more oxidized than younger outwash-train deposits. Two occurrences near the headwaters of Little Campbell Creek in northeastern part of map area go Deposits related to the Glen Alps moraines (Pleistocene)--Probably more oxidized than younger outwash-train deposits. Single occurrence on the interfluve between Rabbit Creek and its southern tributary

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

pkf Deposits related to the Potter Creek moraines (late Pleistocene)--Occur in southern part of Hillside area near Little Rabbit and Potter Creeks and locally in McHugh and Rainbow Creek valleys and near a small stream between them

fkf Deposits related to the Fort Richardson moraines (late Pleistocene)--Occur at a few places in South Fork Campbell, Rabbit, and McHugh Creek valleys

rkf Deposits related to the Rabbit Creek moraines (late Pleistocene)--Occur only in Rabbit Creek valley southwest of Flattop Mountain

lkf Deposits related to the Little Rabbit Creek moraines (Pleistocene)--Single occurrence in northeastern part of map area

skf Deposits related to the Ski Bowl moraines (Pleistocene)--Probably more oxidized than younger kame-fan deposits. Occur at a few localities marginal to valleys of South Fork Campbell, Rabbit, Little Rabbit, Potter, and McHugh Creeks

gkf Deposits related to the Glen Alps moraines (Pleistocene)--Probably more oxidized than younger kame-fan deposits. Two occurrences, one in Rabbit Creek valley south of Flattop Mountain and the other near the center of the map area southwest of Little Rabbit Creek valley

mkf Deposits related to the Mount Magnificent moraines (Pleistocene)--Probably more oxidized than younger kame-fan deposits. Single occurrence in upper part of Little Rabbit Creek valley

Glacial-lake delta deposits--Chiefly gravel and sand, generally well bedded and sorted; may include thin beds of finer-grained glaciolacustrine deposits. Thickness poorly known, probably 10 m or less. Contacts generally well defined, gradational to glacioalluvial deposits upvalley. Topography generally smooth, slopes gentle except moderate to steep at small scarps on downvalley side

rgd Deposits related to the Rabbit Creek moraines (late Pleistocene)--Occur only in Little Rabbit Creek valley where it approaches the Hillside area

sgd Deposits related to the Ski Bowl moraines (Pleistocene)--May be more oxidized than younger delta deposits. Occur only in middle reach of Little Rabbit Creek valley

Glaciolacustrine deposits--Interbedded clay, silt, and sand; includes some gravel and diamicton in varying proportions; well to somewhat poorly sorted. Thickness poorly known, probably a few to more than ten meters. Contacts relatively well defined, but gradational upvalley to outwash-train, kame-fan, or delta deposits. Topography generally smooth, slopes gentle. Moderately stable except near contact with fine-grained colluvium where susceptible to some stream erosion, earthflowage, or other landslide processes

rgl Deposits related to the Rabbit Creek moraines (late Pleistocene)--Occur extensively in the middle reaches of Little Campbell, Rabbit, Little Rabbit, and Potter Creek valleys where they merge with the Hillside area

sgl Deposits related to the Ski Bowl moraines (Pleistocene)--May be more compacted than younger glaciolacustrine deposits. Occur only in the middle reach of Little Rabbit Creek valley

Glacioestuarine and estuarine deposits

Glacioestuarine deposits accumulated in an ancestral Cook Inlet that probably differed from the present-day inlet in configuration and in level with respect to the present land surface. Inlet water was probably in contact with glacier ice at various places around its perimeter during most of this time. At times the inlet may have been entirely cut off from the Pacific Ocean by glacier ice that covered much of the area of present-day lower Cook Inlet, and the body of water behind the ice dam may have become a fresh-water glacial lake (Karlstrom, 1964). Estuarine deposits formed in the present-day inlet or that of the recent past with similar configuration and tidal characteristics. These deposits border the inlet and are developed best in embayments around its perimeter.

Glacioestuarine deposits (late Pleistocene)--Consist of a variety of interbedded materials that generally have much fine-grained material and include diamicton, stony silt, fine-grained sand, and some clay. Well to obscurely bedded; individual beds commonly well sorted, but in gross aspect the deposits may appear rather poorly sorted because of the interbedding of thin beds of materials with widely disparate sizes. Thickness poorly known and probably quite variable, probably a few to more than 10 m; thinner in higher parts of slopes and toward morainal deposits. Contacts well defined except where gradational to morainal deposits; contacts between deposits of the subdivisions listed may be located only approximately but the deposits probably are not in gradational contact. Topography commonly smooth but marked locally by subdued hills; slopes gentle to moderate

gs Glacioestuarine shore deposits--Occur near Turnagain Arm on discontinuous topographic bench at about 30 m above mean sea level that is locally well developed north of the mouth of Potter Creek but sporadically present farther southeast. Include dominantly clay and silt in one exposure in the SW1/4 sec 3, T. 11 N., R. 3 W., mapped as Bootlegger Cove Clay by Miller and Dobrovolny (1959). Probably represent nearshore equivalent of what is now called Bootlegger Cove Formation

gsd Delta deposits--Chiefly gravel and sand. Occur near the mouths of Little Rabbit, McHugh, and Rainbow Creeks

ar Deposits near Abbott Road--Occur only in the northwesternmost part of the map area at altitudes below about 140 m. May grade in part with Huffman Road deposits

hr Deposits near Huffman Road--Occur in western part of map area; occupy mainly channel-like areas below about 140 m in altitude that may have originated as meltwater channels and may include gravel and sand at depth or locally at the surface

hrl Lower-level deposits--Limited to small channels cut below the level of most of the other deposits near Huffman Road; may have resulted from fluctuations in level of inlet water and include gravel and sand deposited as streams responded to the fluctuations

dr Deposits near DeArmoun Road--May include higher proportion of diamicton than most other glacioestuarine deposits. Occur mainly in subdued ridges in western part of map area that were formed originally as lateral moraines but have been modified by inlet water and partly buried by glacioestuarine deposits

br Deposits near Birch Road--Occur on relatively smooth terrain upslope from about 140 m in altitude in northwestern part of map area. May be in part or entirely glaciolacustrine in origin

Modern intertidal deposits (latest Holocene)--Chiefly silt and fine sand; somewhat coarser near major tidal channels. 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 or by bedrock. Contacts may vary 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 altitudinally into lower and upper zones. Mapped only at isolated locations along Turnagain Arm il Deposits of the lower intertidal zone--Reworked several times daily by the tides; covered by water at high tide; exposed at low tide. Upper boundary, commonly at railroad embankment, may be a few meters above mean high water

iu Deposits of the upper intertidal zone--Locally more sandy and gravelly than deposits of the lower zone, especially in its uppermost parts which are covered by tides only at times of exceptionally high tides. Contain some organic and windblown material. Surface marked by standing water in some areas. Drainage very poor

ip **Deposits of Potter Marsh (late Holocene)**--Chiefly silt and fine sand; may include minor coarser sand and fine gravel close to landward margin; probably include some interbedded and scattered organic material. Well bedded and sorted. May be loose, water saturated. Thickness less than one to a few meters; may be underlain by a few to several meters of older intertidal deposits. Contacts well defined. Surface generally smooth, but may be incised as much as 1 m by channels that have steep margins; slopes otherwise nearly flat, commonly less than one percent. Mapped only near west edge of map area. Formerly probably equivalent to deposits of the upper intertidal zone

ipw Deposits in wetter areas--Standing water common; formerly probably equivalent to deposits of the lower intertidal zone

io **Older intertidal deposits (Holocene)**--Chiefly silt and fine sand, well bedded and sorted; locally may include thin beds of peat, driftwood, and other organic material and some windblown material. More firm than modern intertidal deposits. Not flooded by present-day high tides. Thickness a few to several meters. Contacts well defined, except gradational to deposits of Potter Marsh, the landward edges of which constitute the only area where these deposits are mapped

iod Delta deposits--Chiefly sand and gravel, now largely reworked for construction materials. Mapped near mouth of Potter Creek

ib **Deposits of the former modern beach (late Holocene)**--Chiefly gravel and sand, grading to mainly sand at outermost end; locally driftwood laden. Entirely reworked during construction of The Alaska Railroad. Mapped only on a former beach bar that extended northwest from the mouth of Potter Creek

Alluvial deposits

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

al **Alluvial deposits along modern streams and in lowest terraces (Holocene)**--Chiefly gravel and sand. Generally at or no more than a few meters above stream level. Includes active flood plains that are too narrow to map separately

alf Fine-grained deposits along some minor streams (Holocene)--Chiefly silt and fine-grained sand; may include some peat deposits near surface. Occur locally in western part of map area

at **Alluvial deposits in terraces (Holocene)**--Somewhat older alluvium, chiefly gravel and sand, generally a few to several meters above stream level. Developed locally along most streams in large mountain valleys and in lower Rabbit Creek valley

ath Deposits in higher terraces (Holocene and late Pleistocene)--Occur more than 10 m above stream level mainly along South Fork Campbell, Rabbit, McHugh, and Rainbow Creeks

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. Extensively distributed throughout map area

aff Fine-grained deposits--Chiefly fine sand and silt. Occur in a few scattered places in map area afo **Older alluvial-fan deposits (Holocene and Pleistocene)**--Gravel and sand, possibly admixed with some finer-grained material and thin diamicton beds. Deposits typically less well sorted and have steeper slopes than those in other alluvial units. Occur as remnants commonly associated with younger alluvial fans, but graded to levels above modern streams; well exhibited on lower parts of mountain valley walls

Pond, bog, and lake deposits

p **Pond and bog deposits (Holocene and late Pleistocene)**--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-sized tephra. At shallow depth may include silt, clay, marl, or fine-grained sand; at deeper levels may be mostly sandy gravel. Accumulated mainly in small former lakes or in former stream channels which are now 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. Occur in scattered localities mainly in western part of map area

l **Deposits of a possible low-level lake along South Fork Campbell Creek valley (Holocene)**--Probably consist of silt, clay, and fine-grained sand; may include peat near surface. Deposits not exposed, character and genesis mainly inferential. Deposits may have formed when valley was blocked by landslide or earthflow in the NE1/4NW1/4 sec. 33, T. 12 N., R. 2 W. Thickness probably several to ten meters. Contacts well defined. Surface smooth to slightly irregular with low relief; general slope less than one percent. Poorly drained

Colluvial deposits (Holocene and Pleistocene)

c **Colluvial deposits on mountain slopes**--Mainly apronlike deposits of loose, sandy to rubbly diamicton derived directly from weathering of bedrock upslope; includes some sheetwash deposits. Thickness poorly known, probably less than one to several meters, thicker on lower parts of slopes. Contacts gradational. Topography smooth, surface gently concave upward, slopes generally steep to very steep, but usually not in excess of 70 percent; some instability likely

ct **Talus deposits**--Cone-shaped to apronlike deposits on valley walls within rugged mountains. Mainly loose, coarse rubble and rubbly diamicton derived directly from weathering of bedrock upslope. 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, to bedrock at apex, and to other map units at toe; individual cones commonly have well-defined boundaries. Talus deposits too small to map separately are included in bedrock map unit. 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; slopes generally unstable. Occur extensively along many high-altitude ridges, especially in the southeastern part of map area

ca **Colluvial and alluvial deposits**--Areas of colluvium and alluvium too small to map separately. Chiefly moderately loose, sandy to rubbly diamicton, poorly sorted sand and gravel, and some organic debris. Thickness poorly known, probably a few meters. Contacts generally gradational. Topography irregularly gullied, slopes steep to very steep, generally ranging between 35 and 70 percent. Commonly covered by low vegetation, active deposition occurring in many of these gullies. Some instability of slopes likely. Locally extensive in mountain areas especially near heads of small valleys cg **Mixed colluvial and glacial deposits**--Diamicton consisting chiefly of gravelly to rubbly sand, with some silt and clay; locally bouldery. Derived from both bedrock and glacial deposits, either of which may be present in areas too small to map separately. 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. Common along middle slopes of most major mountain valleys

cm **Colluvial deposits derived mainly from moraines**--Diamicton similar to that of adjacent upslope moraines, but less compact; includes minor amounts of better sorted sand, silt, and 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. Commonly associated with lateral moraines in the western and northeastern parts of the map area, and at scattered localities near high-altitude ground moraine

cw **Colluvial deposits on walls of stream bluffs**--Loose accumulations derived from adjacent, upslope surficial deposits that form a veneer on bluffs following erosion. Chiefly diamicton consisting of pebbly silt and sand with some clay, cobbles, boulders, and a variable amount of organic material. Non-bedded to poorly bedded; poorly sorted. Generally a few meters thick, thinner at the upslope part; usually thicker downslope. Contacts generally well defined. Slopes steep to precipitous. Although stabilized locally by vegetative cover, subject to instability because of renewed gully or stream erosion and accompanying mass-wasting processes. Common along inner valleys cut lower than the floors of major mountain valleys, extending westward across the Anchorage lowland

cwf Fine-grained colluvial deposits on walls of stream bluffs--Chiefly silt, clay, and fine-grained sand; non-bedded to poorly bedded; poorly sorted. Thickness probably as much as a few meters. Slopes irregularly moderate to steep, and particularly susceptible to instability. Occur along inner valley walls mainly where glaciolacustrine deposits are present upslope

cs **Solifluction deposits**--Chiefly loose, organic-rich, sandy to rubbly diamicton, commonly lacking clasts 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 strict 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 landslide deposits too small to map separately. 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. Occur locally throughout mountain areas, especially on middle and lower slopes

cl **Landslide deposits**--Include a wide variety of materials, chiefly diamicton, with lesser gravelly silt and sand, and relatively minor amounts of clay and organic material; include some large masses of bedrock and numerous earthflow deposits too small to map separately. Nonbedded, and nonsorted to 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 may be similar to those positively identified. Occur in many places on mountain slopes throughout map area, especially in the upper Rabbit and Little Rabbit Creek valleys

cle Landslide deposits resulting from earthflows--Similar to other landslide deposits but interpreted on the basis of landform to have been emplaced in a somewhat more fluid state and therefore may include a higher proportion of finer-grained material. Contacts generally well defined. Occur especially in the middle reach of Potter, Little Rabbit, Rabbit, and South Fork Campbell Creek valleys

Rock-glacier deposits (Pleistocene)

rdo **Older rock-glacier deposits**--Accumulations of mainly angular to subrounded rock fragments derived from upslope talus or landslide deposits, or directly from bedrock, and transported very slowly downslope in a rock glacier. Upper surface dominated by angular to subangular cobble- and boulder-size fragments; at depth, substantially more fine-grained material probably present to form coarse, rubbly, diamicton. Thickness poorly known, probably several to a few tens of meters. Contacts gradational to colluvial deposits. Surface may be gently hummocky to smooth; slopes moderate to gentle. Almost certainly not moving as an active rock glacier nor containing any glacier ice, as some active rock glaciers do (Moore and Friedman, 1991)

Anthropogenic deposits (latest Holocene)

f **Engineered fill**--Chiefly compacted pebble gravel underlain by a more poorly sorted base course of sandy to silty gravel, rubble, or bedrock; in modified areas may include a more heterogeneous assemblage of material. Mapped mainly along the Seward Highway and the Alaska Railroad along Turnagain Arm, and locally along roads in the northwestern part of map area. Thickness as much as several meters. Contacts well defined, width shown on map may be exaggerated to accommodate linear symbols for the highway and railroad

BEDROCK

b **Bedrock (Tertiary to Permian)**--Mainly rocks of the Chugach terrane, including variably metamorphosed graywacke, argillite, phyllite, and conglomeratic graywacke all of the Jurassic and Cretaceous McHugh Complex. Near the mouth of Little Rabbit Creek and along its lower valley, includes rocks of the Peninsular terrane, which here are mainly marble and metagraywacke. Just to the south includes a single outcrop of felsic to intermediate hypabbysal intrusive rocks of Tertiary age in SW1/4SW1/4 sec. 3 and extending to NW1/4NW1/4 sec. 10, T. 11 N., R. 3 W.

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