

GEOLOGIC MAP OF THE LOWER BELUGA-CHUITNA AREA, TYONEK A-3 AND A-4 QUADRANGLES, SOUTH- CENTRAL ALASKA

by

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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.

**GOLDEN, COLORADO
1992**

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GEOLOGIC MAP OF THE LOWER BELUGA-CHUITNA AREA,
TYONEK A-3 AND A-4 QUADRANGLES, SOUTH-CENTRAL ALASKA
by Henry R. Schmoll and Lynn A. Yehle

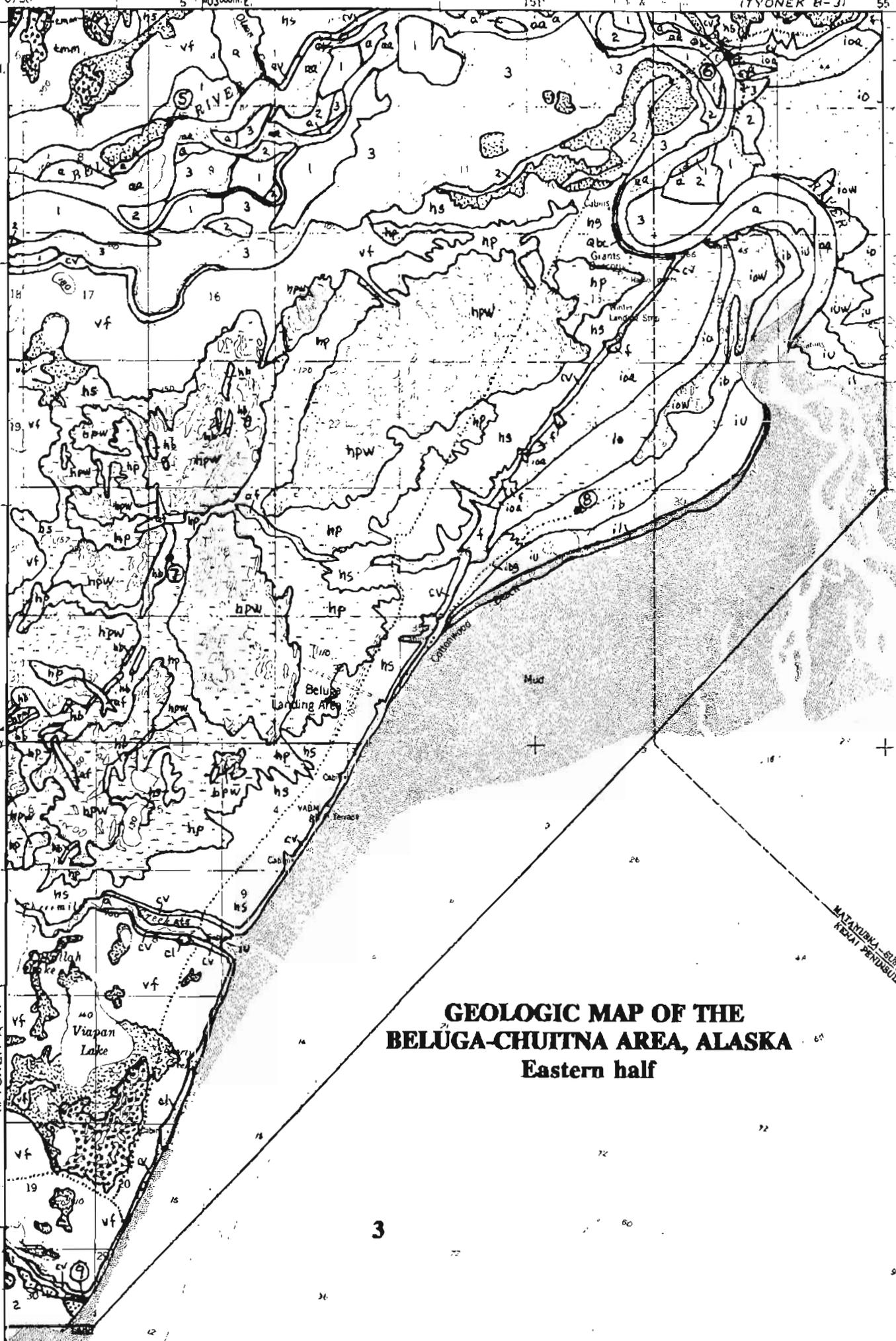
PART I—GEOLOGIC MAP

INTRODUCTION

The geologic map is presented in two parts, the western half (part of the Tyonek A-4 quadrangle) on the following page, and the eastern half (part of the Tyonek A-3 quadrangle) on the succeeding page. The correlation, explanation, and description of map units follow.

The geologic map was prepared by H.R. Schmoll using air photos taken in 1952, 1953, and 1957. Field investigations were undertaken by H.R. Schmoll and L. A. Yehle in 1977-1984, with A.F. Chleborad in 1978-1979 and with J.K. Odum in 1981-1982, assisted by A.D. Pasch in 1977, 1979, and 1980, J.M. Core in 1978, and C.A. Gardner in 1979-1982. The topographic base map is from U.S. Geological Survey 1:63,360 Series, Tyonek (A-3) and (A-4) quadrangles, 1958. Topography was drawn by photogrammetric methods from air photographs taken in 1952, 1953, and 1957.

61°15' 9/9 1000m N.



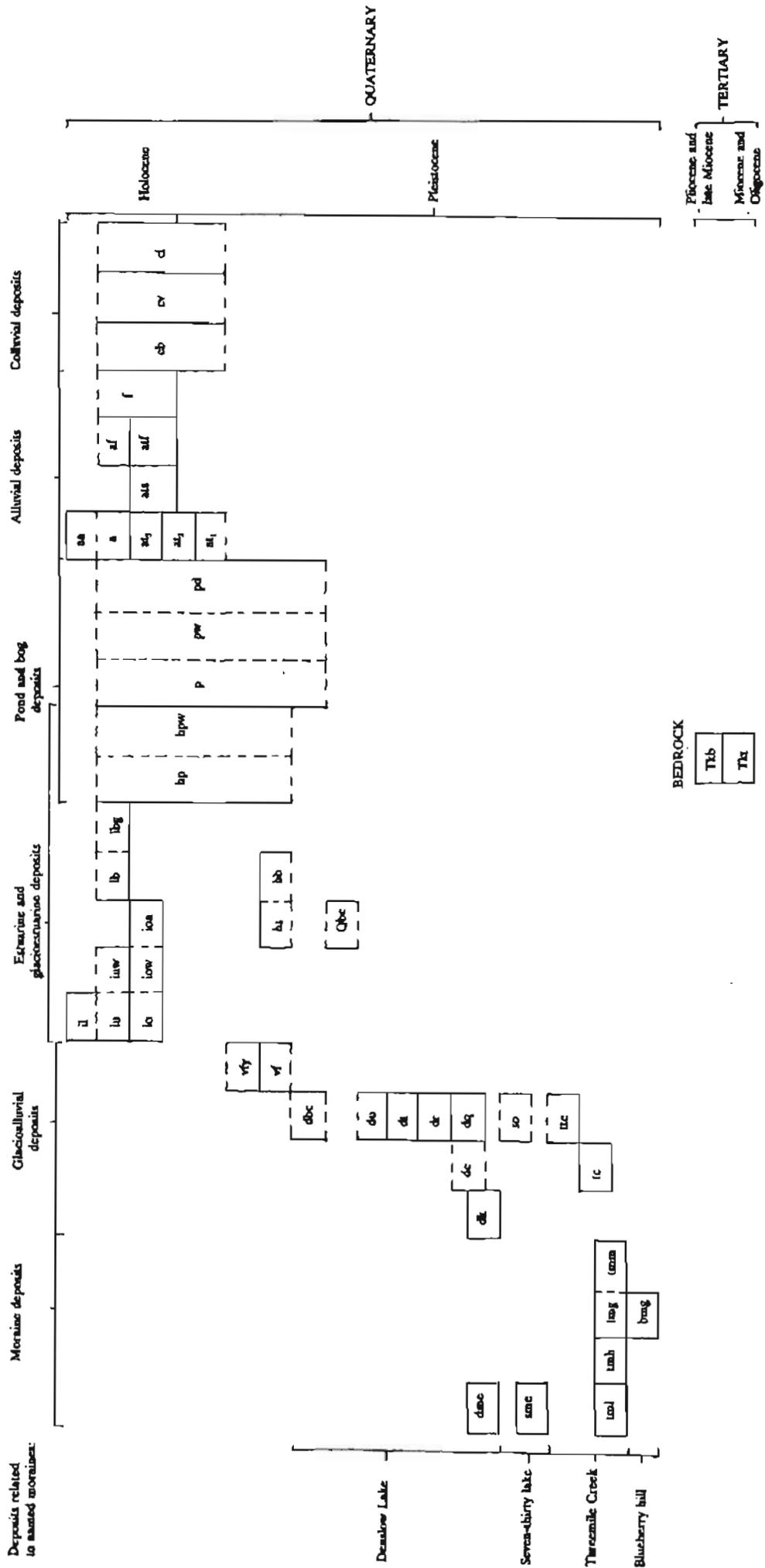
**GEOLOGIC MAP OF THE
BELUGA-CHUITNA AREA, ALASKA
Eastern half**

3

(17 YONEK A-4)

MAJANUNKA-SIBITNA
KEBAT PERDABULA 00

CORRELATION OF MAP UNITS
SURFICIAL DEPOSITS



EXPLANATION

SURFICIAL DEPOSITS

Moraine deposits

End- and lateral-moraine deposits (late Pleistocene)

dme	End-moraine deposits of the Denslow Lake moraine
sme	End-moraine deposits of the Seven-thirty lake moraine
tml	Lateral-moraine deposits of the Threemile Creek moraine
tmh	Hummocky-moraine deposits of the Threemile Creek moraine (late Pleistocene)
Ground-moraine deposits	
tmg	Deposits of the Threemile Creek moraine (late Pleistocene)
tmm	Modified deposits
bmh	Deposits of the Blueberry hill moraine (Pleistocene)

Glacioalluvial deposits (late Pleistocene)

dk	Kame deposits of the Denslow Lake moraine
Outwash-channel deposits	
dc	Deposits of the Denslow Lake moraine
tc	Deposits of the Threemile Creek moraine
Outwash-train and related deposits	
Deposits associated with the Denslow Lake moraine	
dbc	Deposits of the BC channel
du	Youngest unit of terrace sequence
dt	Sixth-oldest unit of terrace sequence
dr	Fourth-oldest unit of terrace sequence
dq	Third-oldest unit of terrace sequence
so	Deposits associated with the Seven-thirty lake moraine
 (ttc)	Deposits of the TC and related channels
Glacioalluvial-fan deposits near Viapan Lake	
vfy	Younger unit
vf	Older (main) unit

Estuarine and glacioestuarine deposits

Modern intertidal deposits (latest Holocene)

il	Deposits of the lower intertidal zone
iu	Deposits of the upper intertidal zone
iuw	Deposits with wetter surface areas
io	Older intertidal deposits (Holocene)
iow	Deposits with wetter surface areas
ioa	Deposits covered by alluvium
ib	Beach deposits (Holocene)
ibg	Deposits with large component of gravel
Sand deposits near Hood Lake	
hs	Deposits in broad plain (latest Pleistocene)
hb	Deposits in probable beach ridges (latest Pleistocene)
hp	Deposits overlain by peat (Holocene and latest Pleistocene)
hpw	Deposits with wetter surface areas
Qbc	Bootlegger Cove Formation (late Pleistocene)

Pond and bog deposits (Holocene and late Pleistocene)

-  Peat in bogs of normal wetness
(p)
 Deposits in wetter bogs
(pw)
 Deposits in drier bogs
(pd)

Alluvial deposits

Coarse-grained deposits

- aa Deposits within active floodplains (latest Holocene)
a Deposits in lowest terraces (Holocene)
Deposits in terraces above the lowest alluvium along major streams
3 Deposits in low-level terraces (Holocene)
(at₃)
2 Deposits in intermediate-level terraces (Holocene and latest Pleistocene)
(at₂)
1 Deposits in high-level terraces (latest Pleistocene)
(at₁)
ats Deposits in terraces above the lowest alluvium along small streams (Holocene)
Fine-grained deposits (Holocene)
af Deposits along low-gradient streams
atf Deposits in terraces along low-gradient streams
Deposits of variable texture (Holocene)
f Deposits in small alluvial fans and cones

Colluvial and landslide deposits (Holocene and late Pleistocene)

- Colluvial deposits on valley and sea-bluff walls
cb Deposits in areas of shallow bedrock
cv Deposits in areas of Viapan Lake and Hood Lake deposits
cl Landslide deposits

BEDROCK

Sedimentary rocks of the Kenai Group (Tertiary)

- Tkb Beluga Formation (Pliocene and late Miocene)
Tkt Tyonek Formation (Miocene and Oligocene)

OTHER SYMBOLS

-  Contact--Well-located, approximate, inferred, or indefinite
 Lineament--Observed on air photos
 Radiocarbon locality--Data given in table 1
 Principal roads--Presently or formerly in use

DESCRIPTION OF MAP UNITS

The geologic map delineates deposits thought to be about 1 m or more in thickness. Grain-size terminology for surficial deposits follows that of the Wentworth grade scale (American Geological Institute, 1989). All thicknesses given for deposits are estimates. The age symbol Q is omitted from informally named Quaternary deposits, but standard age symbols are used for formal stratigraphic units. Map symbols shown in parentheses are represented on the geologic map by the pattern or single-digit numerical symbol shown beneath them.

SURFICIAL DEPOSITS

Moraine deposits

Subdivided according to (1) deposits of individually named moraines and (2) deposits of the following types of moraines: end and lateral moraines are well-defined, fairly continuous belts of hummocky topography of generally high relief, commonly dotted with numerous ponds and other undrained depressions, that mark the marginal position of a former glacier. The designation "end moraine" is used for segments that clearly form part of a lobate configuration, whereas "lateral moraine" is used for linear marginal segments that do not lead to end-moraine lobes. Ground moraine constitutes the areas within the moraine belts that have relatively low relief and generally thinner deposits. Hummocky moraines are areas of moderately high relief that lie within generally lower-lying areas of ground moraine. Values of mean relief given below for principal moraine units have been estimated on the basis of values obtained in the map area to the west (Schmoll and Yehle, 1987) which were derived statistically from elevations determined by photogrammetric methods from random profiles across map units.

Moraines are composed chiefly of till, commonly a diamicton consisting of unsorted to poorly sorted gravelly sandy silt and variable, usually lesser, amounts of clay; clasts as large as boulders; locally include well-sorted, discontinuous lenses of sand and sandy pebbly gravel. Moderately compact. Include some kame, channel-outwash, alluvial, and pond and bog deposits too small to map separately

- End- and lateral-moraine deposits (late Pleistocene)**--In broadly lobate to linear hummocky ridges and ridge remnants having variable but relatively high relief in the form of many irregular, steep-sided hills and intervening depressions. The diamicton may contain a high percentage of coarse clasts. Thickness variable, may be 25 m or more in hills, substantially less beneath depressions
- dme End-moraine deposits of the Denslow Lake moraine--In a prominent lobate ridge a small part of which occupies northwestern part of map area; occur in many sharp hills and intervening depressions occupied by ponds or bogs. Mean relief about 4 m. This moraine is southernmost part of a large morainal lobe that is well developed northwest and north of map area (Yehle, Schmoll, and Chleborad, 1983a, 1983b; Yehle, Schmoll, and Gardner, 1983; Yehle and Schmoll, unpublished mapping)
- sme End-moraine deposits of the Seven-thirty lake moraine--In a ridge just southeast of, and outside, the Denslow Lake moraine and extending south as dissected remnants of a small lobe. Mean relief about 2 m. North of map area, the Seven-thirty lake moraine continues in an irregular belt just east of Denslow Lake moraine (Yehle and Schmoll, unpublished mapping)
- tml Lateral-moraine deposits of the Threemile Creek moraine--In massive, linear ridges that extend into north-central part of map area and are dissected by Beluga River and its tributaries. Grade southwest into ground-moraine deposits in the headwater area of Threemile Creek. This area serves as typical locality for these deposits
- tmh Hummocky-moraine deposits of the Threemile Creek moraine (late Pleistocene)--In landforms having uneven surface topography generally resembling that of end moraines but having somewhat less relief and little linear continuity and occurring in areas of ground moraine. Thickness may be as much as 25 m. Occur in west-central part of map area

- Ground-moraine deposits**--In rolling hills of generally low relief that are dissected into remnants bordered by areas of relatively steep slope
- tmg Deposits of the Threemile Creek moraine (late Pleistocene)--In low, rolling hills dissected by major north-south channels; occur in western part of map area. Ponds uncommon, but moderately large bogs widely present. Mean relief about 1.3 m. Some hills look like northeast-trending drumlins, presumably reflecting ice-flow from northeast and thus a Susitna lowland-Alaska Range provenance. Thickness at least 5 m
- tmm Modified deposits--Inferred to have been modified during glacioestuarine inundation of southeastern fringe of the area of ground moraine. Generally smoother-surfaced than other ground-moraine deposits. Neither winnowing of diamicton clasts nor cover of better sorted materials observed. Thickness at least 5 m
- bmg Deposits of the Blueberry hill moraine (Pleistocene)--In generally smooth terrain on hill 920 in northwestern part of map area. Ponds and bogs small and uncommon. Mean relief less than 2 m. Thickness at least 5 m

Glacioalluvial deposits (late Pleistocene)

- dk **Kame deposits of the Denslow Lake moraine**--Mostly gravelly sand; some gravelly, silty sand and diamicton. Most deposits loose, some relatively compact. In irregularly-shaped hills of generally low relief that occur locally within end moraine and that formed after ice margin became stagnant. Thickness probably less than 15 m
- Outwash-channel deposits**--Mostly bedded sandy gravel, gravelly sand, and sand. Most deposits loose and moderately well sorted; may be more gravelly at depth. Locally overlain by bog and pond or other organic deposits. Thickness probably less than 5 m
- dc Deposits of the Denslow Lake moraine--In northwestern part of map area in irregularly configured channels in low-lying areas between hills of end moraine
- tc Deposits of the Threemile Creek moraine--In northern part of map area in small channels and terrace remnants
- Outwash-train and related deposits**--Chiefly well-bedded gravel, sandy gravel, and gravelly sand. Most deposits loose and generally well sorted. Thickness probably 5-7 m; locally may be thicker; in other places, deposits may be very thin or lacking. Locally overlain by extensive pond and bog deposits
- dbc Deposits associated with the Denslow Lake moraine--Subdivided into five units, four of which occur in a sequence of seven terraces at successively lower levels described in map area to the west (Schmoll and Yehle, 1987, fig. 6); the fifth unit is probably younger than any of those
- du Deposits of the BC channel--Mainly in broad, sharply-incised channel in western part of map area. In central part of channel, extensively overlain by mapped pond and bog deposits. In this area not clearly distinguishable in level from deposits of map unit du. Likely to provide significant sources of sand and gravel for construction purposes, especially in northern and southern parts of channel
- dt Youngest unit of terrace sequence--Occurs discontinuously along Lone Creek in western part of map area. In map area to west seems to emanate from outwash channels within moraine near Denslow Lake; a radiocarbon date of 13,820 yr B.P. was obtained from deposits overlying this unit (Schmoll and Yehle, 1987, fig. 5). Deposits shown as map unit dt on that map in sec. 31, T. 13 N., R. 11 W. are more likely map unit du, as their continuation on this map is shown
- dr Sixth-oldest unit of terrace sequence--Occurs only in a few low terraces in western part of map area
- dq Fourth-oldest unit of terrace sequence--Occurs in high-level channels west of Lone Creek
- dq Third-oldest unit of terrace sequence--Occurs as terrace along northern tributary to Lone Creek in western part of map area; correlation of these deposits with most of those so mapped in map area to west is tentative

- so Deposits associated with the Seven-thirty lake moraine--Emanate mainly from now-dissected central part of end moraine in map area to west. Occur (1) as dissected outwash plain that drained mainly southeastward in western part of map area; (2) in meltwater channel that trends eastward across Threemile Creek ground moraine about 1 km farther north; and (3) in terrace and channel sequence that may extend from moraine in map area to the north
- (ttc) Deposits of the TC and related channels--Mainly in broad, shallow channel that slopes southward across area of Threemile Creek moraine, incised slightly lower than level of Threemile Creek channel deposits. Extensively covered by pond and bog deposits especially in southern part of map-unit area
- Glacioalluvial-fan deposits near Viapan Lake--Well-bedded gravel, sandy gravel, and gravelly sand, becoming finer grained eastward where dominantly sand. Most deposits loose and well sorted. Thickness 5-10 m, thinning eastward. Especially in western part of map-unit area, provide excellent sources of gravel and sand for construction purposes. Subdivided into younger and older units. Occurrence in this map area constitutes typical area for these deposits
- vfy Younger unit--Occurs only along south side of Chuitna valley at southern edge of map area
- vf Older (main) unit--Occurs extensively in eastern part of western map sheet. Deposits may grade laterally to those of map unit hs, or may overlie those, thinning to a feather edge

Estuarine and glacioestuarine deposits

- Modern Intertidal deposits (latest Holocene)**--Chiefly silt and fine sand; somewhat coarser near tidal channels. Well bedded and sorted. Loose, water saturated. Thickness as much as a few meters, probably underlain by several meters of older intertidal deposits. Contacts vary in location with each tide as well as over longer periods of time. Surface generally smooth, but incised one to a few meters by tidal channels that may have steep margins. Subdivided into lower and upper zones. Occur only in easternmost part of map area
- il Deposits of the lower intertidal zone--May include driftwood and gravel along landward edge of deposits in discontinuous storm berms. Reworked daily by tides: covered by water at high tide, exposed at low tide. Lower boundary of map unit approximates mean tide; upper boundary may be as much as several meters above mean high water
- iu Deposits of the upper intertidal zone--Locally coarser grained and more driftwood-laden than the deposits of the lower zone; covered by tides only when exceptionally high tides are coupled with extreme storms. Contain some organic and windblown material
- iuw Deposits with wetter surface areas--Standing water widely prevalent, numerous relatively permanent ponds common
- io **Older Intertidal deposits (Holocene)**--Chiefly silt and fine-grained sand, well bedded and sorted; locally may include thin beds of peat, driftwood, and other organic material, and some windblown material. More compact than modern intertidal deposits. Not flooded by present-day high seas. Thickness several to a few tens of meters
- iow Deposits with wetter surface areas--Standing water widely prevalent, numerous relatively permanent ponds common
- ioa Deposits covered by alluvium--Commonly overlain by and (or) graded laterally to deposits that are fine-grained distal portions of alluvial fans formed at the base of sea bluffs
- ib **Beach deposits (Holocene)**--Chiefly sand, minor gravel, and driftwood in low ridges in areas no longer reached by present-day highest tides
- ibg Deposits with large component of gravel--Driftwood occurs only locally; include deposits of the modern beach as well as older deposits. Extend southwestward from area where shown, in strip too narrow to map at base of sea bluffs

Sand deposits near Hood Lake--Chiefly medium to coarse sand, well bedded and well sorted; include interbeds of fine gravel. Probably deposited during waning phase of glacioestuarine environment in which underlying Bootlegger Cove Formation was deposited. Commonly overlain by organic deposits. Thickness as much as 10 m. Rationale for correlation of these deposits with the typical sand deposits near Hood Lake at Anchorage is given in the discussion of geology

- hs Deposits in broad plain (latest Pleistocene)
- hb Deposits in probable beach ridges (latest Pleistocene)--May include finer-grained material and organic material near surface. Ridges subparallel to present shore, rise only 1 to 2 m above surrounding plain
- hp Deposits overlain by peat (Holocene and latest Pleistocene)--Peat deposits about 1 m thick and similar to that of map unit p. Sand may be thin or lacking locally
- hpw Deposits with wetter surface areas--Standing water common, ponds more numerous than in other areas of peat deposits; similar to map unit pw
- Qbc **Bootlegger Cove Formation (late Pleistocene)**--Silty clay and clayey silt with minor interbedded silt, fine sand, fine to medium sand, and thin beds of diamicton, and with scattered pebbles and cobbles in widely varying concentrations. Deposited in glacioestuarine environment. Thickness poorly known, may be 10 m or more. Mapped only along Beluga River

Pond and bog deposits (Holocene and late Pleistocene)

- (p) **Peat in bogs of normal wetness**--Chiefly peat (mosses, sedges, and other organic material in varying stages of decomposition) and organic silt that include minor woody horizons and numerous thin interbeds of mainly ash-size tephra, and that are accumulating in bogs. Especially at depth, include mainly fine-grained deposits (silt, clay, and fine- to medium-grained sand) containing relatively little organic material; these deposits were laid down in ponds and small lakes that formerly occupied the sites of present-day bogs. Soft and moist. Occur throughout map area, but in eastern part, where especially widespread overlying Hood Lake sand deposits, mapped as units hp and hpw. Adjacent deposits extend beneath these deposits. Thickness as much as 4 m
- (pw) **Deposits in wetter bogs**--Standing water present at higher levels within the vegetation mat; include many ponds, some too small to appear on the base map, and many small areas of open water. May be somewhat thicker than other bog deposits, or may include higher proportion of pond deposits
- (pd) **Deposits in drier bogs**--Standing water generally not present; include only a few ponds or other areas of open water and possibly thinner organic deposits than other bogs contain. Because they are better drained than other bogs, may be underlain by coarse deposits such as gravel and sand

Alluvial deposits

Coarse-grained deposits

- aa **Deposits within active floodplains (latest Holocene)**--Chiefly gravel and sand, well bedded and sorted, in bars and very low terraces that are subject to continual reworking by the stream and generally not covered by vegetation. Thickness may be only a few meters or less; not shown where bedrock common in river bed, exposed during low water stages. Mapped only along Beluga and Chuitna Rivers, mainly in areas shown as land on base map; especially along lower course of Beluga River, configuration is likely to be different from that shown because of major episodic flooding caused by breakout of glacier-dammed lake. Occur locally in areas too small to map along smaller streams
- a **Deposits in lowest terraces (Holocene)**--Chiefly pebbly sand and sandy gravel, well bedded and moderately well to well sorted within beds. Thickness possibly as much as 15 m, commonly less; bedrock may occur at shallow depth along Chuitna River in southwesternmost part of map area and along Coffee Creek. Include deposits of the active floodplain where too small to map separately

- Deposits in terraces above the lowest alluvium along major streams--Chiefly gravel and sand, well bedded and sorted within beds. Thickness 5-10 m, but may be underlain by bedrock at shallow depth in places. Subdivided into three units on the basis of terrace levels
- (at₃) Deposits in low-level terraces (Holocene)--Locally covered by finer-grained material including organic deposits in bogs and former oxbow lakes
3
- (at₂) Deposits in intermediate-level terraces (Holocene and latest Pleistocene)--In places covered extensively by mappably thick peat and minor tephra deposits
2
- (at₁) Deposits in high-level terraces (latest Pleistocene)--Commonly well drained and covered only by unmappably thin peat and tephra deposits
1
- ats Deposits in terraces above the lowest alluvium along small streams (Holocene)--Probably sand and gravel, well bedded and sorted within beds. Thickness a few meters
- Fine-grained deposits (Holocene)**--Chiefly medium sand, fine sand, and silt, moderately well bedded and sorted. Commonly overlain by organic deposits
- af Deposits along low-gradient streams--May be of lacustrine origin in part. Thickness 5 m or less. Occur mainly along Threemile Creek and its tributaries
- atf Deposits in terraces along low-gradient streams--Thickness about 5 m. Occur mainly along Threemile Creek and its West fork
- Deposits of variable texture (Holocene)**
- f Deposits in small alluvial fans and cones--Chiefly sandy gravel, silty sandy gravel, gravelly sand, and possibly diamicton, irregularly to poorly bedded and moderately poorly to poorly sorted. Occur on lower parts of valley walls, mainly along Beluga River. Underlain by colluvium or bedrock. Thickness as much as 10 m in central part of deposit, perhaps as little as 1 m near upper and lower margins

Colluvial and landslide deposits (Holocene and late Pleistocene)

Colluvial deposits consist of irregularly mixed fragments of various sizes and types derived by weathering and gravity processes acting on older surficial deposits and bedrock. They are generally unsorted and loose to moderately compact. Landslide deposits are developed mainly by gravitational failure of materials along single or multiple buried surfaces in sedimentary bedrock or in the Bootlegger Cove Formation and include overlying surficial deposits as well. They resulted mainly from single slides along valley and sea-bluff walls; at least some formed in response to earthquake shaking

- Colluvial deposits on valley and sea-bluff walls**--Chiefly diamicton consisting of pebbly silt and sand, including also some clay, gravel, and local concentrations of boulders; locally include some organic material. Poorly bedded and sorted. Thickness 2-5 m, but thinner in places, especially higher on slope
- cb Deposits in areas of shallow bedrock--Locally include bedrock fragments of varying sizes. Commonly conceal bedrock or may include areas of bedrock outcrop too small to map separately. Occur mainly in western half of map area
- cv Deposits in areas of Viapan Lake and Hood Lake deposits--Diamicton may include a high proportion of sand and pebbles. Conceal Bootlegger Cove Formation on lower parts of slopes, and that formation may crop out locally in areas too small to map separately. Occur in eastern and southern parts of map area
- cl **Landslide deposits**--Chiefly diamicton consisting of gravelly silt and sand and relatively minor amounts of clay, boulders, and organic material. In western half of map area may include relatively large masses of bedrock or dominantly smaller fragments of bedrock. Generally nonbedded and poorly sorted; relatively loose. Thickness as much as 50 m

BEDROCK

Sedimentary rocks of the Kenai Group (Tertiary)

- Tkb** **Beluga Formation (Pliocene and late Miocene)**--Mainly sandstone, siltstone, and coal. Mapped only where major outcrops occur along the Beluga and Chuitna Rivers and in the bed of the Chuitna River, following the distribution of Barnes (1966) and Magoon and others (1976)
- Tkt** **Tyonek Formation (Miocene and Oligocene)**--Chiefly siltstone and claystone, carbonaceous siltstone and claystone, sandstone, and coal (Barnes, 1966; Odum and others, 1986, 1988). Mapped only where major outcrops occur along Beluga River, following the distribution of Barnes (1966) and Magoon and others (1976)

PART II--DISCUSSION OF GEOLOGY

INTRODUCTION

The lower Beluga-Chuitna area extends between the lower reaches of the Beluga and Chuitna Rivers on the northwest side of Cook Inlet in south-central Alaska and lies between about 55 and 75 km west of Anchorage (fig. 1). All of the area is in the Kenai Peninsula Borough except for the easternmost part (near the mouth of the Beluga River) which is in the Matanuska-Susitna Borough (fig. 2). The area is part of a region that has been especially the subject of coal exploration in recent decades (Patsch, 1975; Ramsey, 1981). Open-pit coal mining has been proposed at various sites to the west of the map area, and planned access routes from mine sites to port facilities cross the lower Beluga-Chuitna area (U.S. Environmental Protection Agency, 1990). We studied the area in order to gather and compile geologic data relevant to such potential development (Schmoll, Chleborad, and others, 1981), and this map is part of that effort. Other geologic maps of potential coal-mining areas within this region have been published previously (Schmoll, Yehle, and Gardner, 1981; Yehle, Schmoll, and Chleborad, 1983a, 1983b; Yehle, Schmoll, and Gardner, 1983; Schmoll and Yehle, 1987). The last of these adjoins this map area to the west.

PHYSIOGRAPHY AND DRAINAGE

The map area lies entirely within the Cook Inlet-Susitna Lowland physiographic province (Wahrhaftig, 1965) and straddles the boundary between two informal subdivisions of that province, the Beluga plateau to the northwest, and to the Susitna lowland southeast. The latter province is further subdivided into the Bootlegger Cove platform and, in the easternmost part of the map area, the Alexander plain (fig. 1; Schmoll and others, 1984). In addition to marking important differences in the nature and configuration of the ground surface, the physiographic boundaries correspond to differences in the surficial geology and the depth to bedrock as well.

The Beluga plateau is characterized by moderately rolling to hummocky terrain transected by deeply incised valleys. The altitude of the plateau surface ranges from about 75 to 275 m, the highest point being a hill in the northwestern part of the map area. This hill is shown on the base map as having an elevation of 920 ft, and is referred to in this report as hill 920 (fig. 2). The lowest altitudes lie along the southeast boundary of the plateau which is marked approximately by the 250-foot contour that extends northeasterly across the western map sheet. The surface geology of the plateau is dominated by glacial deposits, both morainal and glaciofluvial in genesis.

By contrast, both the Bootlegger Cove platform and the Alexander plain are nearly flat. The surface of the Bootlegger Cove platform lies between about 60 and 30 m above sea level and slopes gently downward to a steep bluff that separates it from the still lower surface of the Alexander plain (or Cook Inlet). Only the valleys of the Beluga and Chuitna Rivers are cut substantially lower than the surface of the platform, to a level graded to the surface of the plain. Although the shoreline that borders the Alexander plain is shown on the map as a line, it is actually a broad intertidal zone subjected to the twice-daily rise and fall of the tide which here has a maximum range of nearly 11 m. Glacioestuarine deposits, commonly covered by bogs, dominate the surface geology of the platform, whereas the plain is surfaced mainly by younger estuarine deposits.

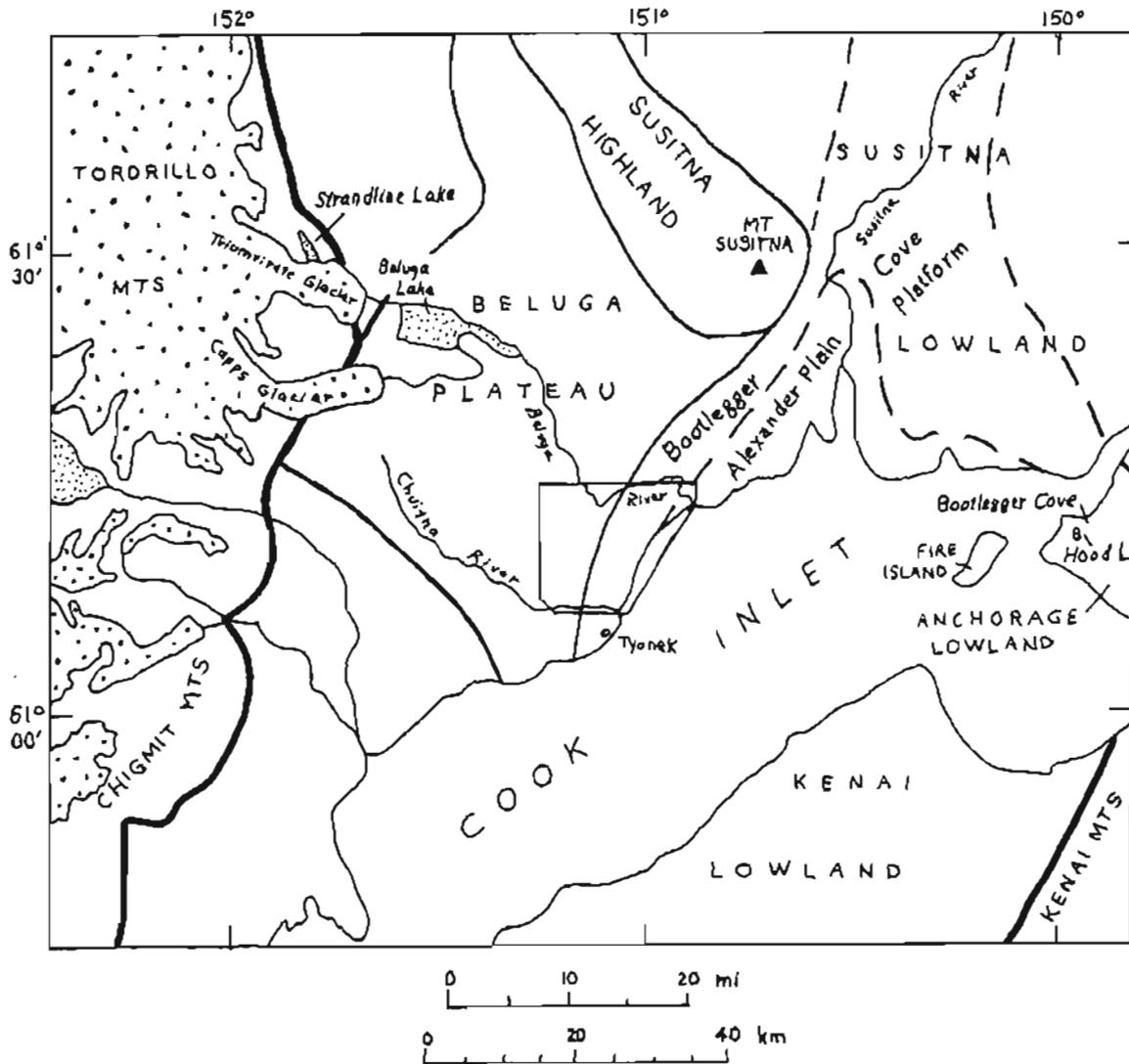


Figure 1. Map of upper Cook Inlet region showing relationship of the lower Beluga-Chuitna map area (doubly truncated rectangle) to selected geographic and physiographic features of the region. The heavy lines separate the Cook Inlet-Susitna Lowland from adjacent mountain provinces, Alaska Range to the west and Kenai-Chugach Mountains to the southeast (Wahrhaftig, 1965). Other solid lines separate informal subdivisions of the Cook Inlet-Susitna Lowland province; dashed lines separate subunits of the Susitna Lowland part of the province. Areas with large dots, glaciers and ice fields; areas with small dots, lakes. Modified from Schmoll and others (1984).

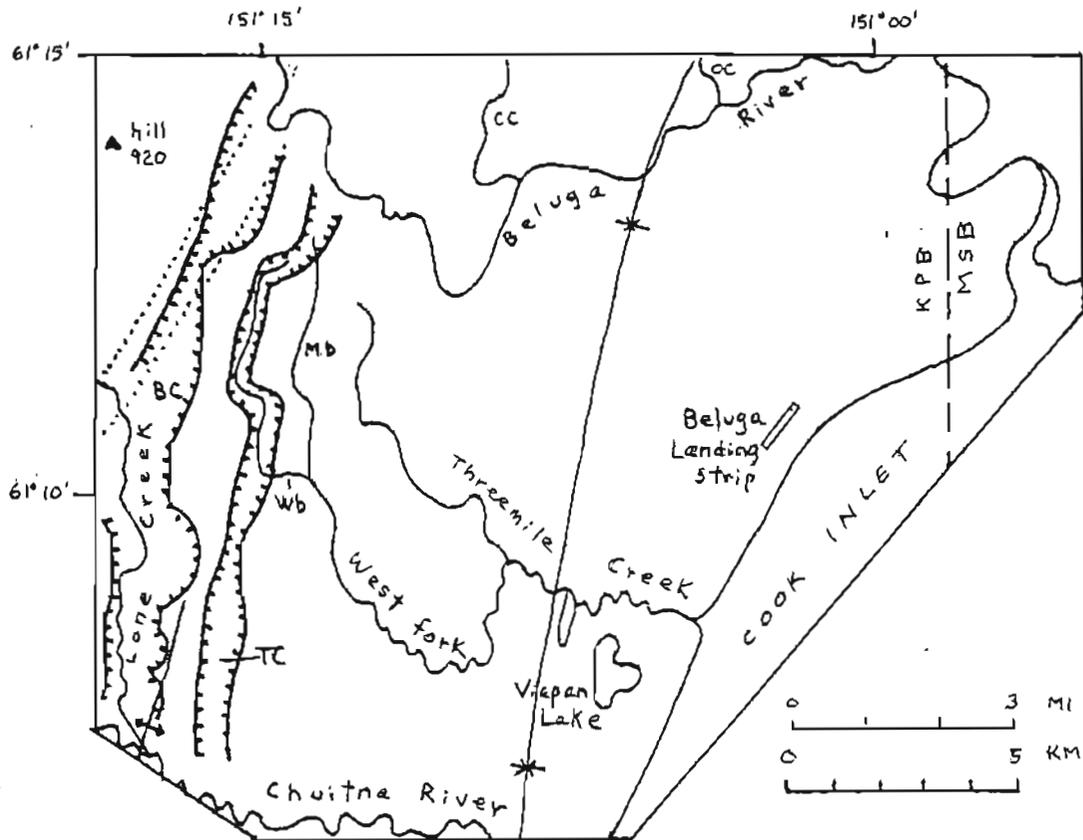


Figure 2. Map of the lower Beluga-Chuitna area showing selected streams and other geographic and geologic features. BC, BC channel; CC, Coffee Creek; KPB, Kenai Peninsula Borough; Mb, Middle branch (of the west fork of Threemile Creek); MSB, Matanuska-Susitna Borough; OC, Olson Creek; TC, TC channel; Wb, West branch (of the West fork of Threemile Creek); designations for informally named features not capitalized. Hachured lines, borders of BC and TC channels developed during glacial times. Other symbols indicate structural features: thin line with arrows pointing away from line, anticline; thin line with arrows pointing toward line, syncline; dotted lines, concealed faults.

Drainage of the lower Beluga-Chuitna area, including informally named features of both present-day and glacial-age drainage, is illustrated in figure 3. All of the area drains into Cook Inlet. A broad belt across the northern part is drained by the Beluga River and two tributaries, Coffee and Olson Creeks. Areas along the southern and western margins are drained by the Chuitna River and a principal tributary, Lone Creek. In its lower course, Lone Creek is the underfit occupant of the southern part of a broad, well-incised channel that is graded southward from the Beluga River valley to the Chuitna River and that is referred to informally as the BC [for Beluga-Chuitna] channel. Much of the central part of the area is drained by Threemile Creek and its tributaries, of which the principal streams are here informally called the West fork and its West and Middle branches. The two named branches and Threemile Creek itself occupy prominently incised but narrow canyons within the Beluga plateau. These canyons developed during or immediately following glacial episodes, probably at different times and perhaps during more than one glacial episode or stage of relatively high sea level. Downstream from the canyons these streams meander in shallow valleys across the Bootlegger Cove platform to Cook Inlet. The westernmost of these canyons is incised within a broad but shallow channel that may have been an ancestral Beluga River valley that drained to the Chuitna valley prior to development of the BC channel; this earlier channel is informally called the TC [for Threemile Creek] channel.

BEDROCK AND STRUCTURE

Bedrock beneath most of the map area consists of continental, coal-bearing sedimentary rocks of the Beluga Formation of late Miocene and Pliocene age (Wolfe and Tanai, 1980), a unit of the Kenai Group (Calderwood and Fackler, 1972). Similar rocks of the next oldest formation of the Kenai Group, the Tyonek Formation of early Oligocene through middle Miocene age (Wolfe and Tanai, 1980), are present in the northwestern part of the map area. Bedrock crops out mainly in bluffs along narrow canyons of the Beluga and Chuitna Rivers. We did not examine these rocks in detail, and the location and description of the mapped units is derived largely from Barnes (1966) as modified in Magoon and others (1976), and from Dettelman and others (1976). The geologic map does not show locally exposed coal beds; any emendation of the original mapping of Barnes (1966) would be dependent largely on proprietary data being developed for coal exploration (Patsch, 1975, oral commun., 1977-82; Ramsey, 1981; R.B. Saunders, formerly of Diamond Alaska Coal Company, oral commun., 1982).

Bedrock probably lies at relatively shallow depth at most places on the Beluga plateau, commonly less than 20 m. At the southeastern edge of the plateau, bedrock may be as deep as 75 m; southeastward across the Bootlegger Cove platform the depth to bedrock increases to as much as 500 m near the mouth of the Beluga River (Freethey and Scully, 1980). It is not known whether this increase in depth to bedrock is gradual, or whether, as seems possible, there is a relatively abrupt increase in the vicinity of the border between the Beluga plateau and the Bootlegger Cove platform.

One short anticline in the southwestern part of the map area and a syncline that trends north-northeast across the entire eastern map area are mapped by Magoon and others (1976); they are based on subsurface data compiled during oil exploration and are shown on fig. 2. No faults have been mapped crossing the surface of the map area and none are shown on the geologic map. However, two faults can be inferred from subsurface evidence and regional geology, based on the work of others as discussed below; these faults are shown trending northeasterly across the map area (fig. 2). The relationship of these and other faults to regional structure and to moraine deposits is discussed by Schmoll and Yehle (1987).

Both of the concealed faults (fig. 2) are based on subsurface data developed during coal exploration and are taken from Ramsey (1981) and U.S. Environmental Protection Agency (1990, fig. 2:4). Subsequent exploration may add other faults (Ramsey, 1981; R.B. Sanders, formerly of Diamond Alaska Coal Company, oral commun., 1982). On the basis of gravity data it is reasonable also to suspect that other faults exist (Hackett, 1977, pl. 3). The more northwesterly of the concealed faults is an interpolation between faults mapped at two outcrop sites by Barnes (1966), one along the Chuitna River west of the map area and the other along the Beluga River within the map area. The more southeasterly of the concealed faults, labeled Moquawkie fault by Ramsey (1981), is interpreted by several workers as a segment connecting the Bruin Bay fault far to the southwest through a complex of numerous faults identified in the subsurface (Boss and others, 1976), to join the Castle Mountain fault about 7 km north of the map area (Magoon and others, 1976). The position of such a fault coincides in part with the Moquawkie magnetic contact of Grantz and others (1963), and we, like Ramsey (1981), continue the use of this terminology. Furthermore, we consider that both of the northeast-trending concealed faults, and probably others not now recognized, constitute the Moquawkie fault zone. This feature may mark the contact between the Beluga and Tyonek Formations, as shown, for example, by Magoon and others (1976). Others working along the incised valley of the Chuitna River, however, are doubtful of this relationship. For example, Detterman and others (1976) map the Beluga Formation farther up the Chuitna valley, whereas Turner and others, (1980) indicate the presence of Seldovian fauna (indicative of all but the lowermost part of the Tyonek Formation) in rocks farther downstream. We infer that greater structural complexity is likely in the area of the Moquawkie fault zone than has been reported. Proprietary seismic and coal-exploration data may ultimately provide more definitive information.

We have no surface evidence that bears on the location or nature of these largely inferential faults. Although some surface features, for example, the BC channel, may be found to align with parts of these inferred faults (fig. 2), such coincidence is not compelling enough to be regarded as more than fortuitous. Consequently we believe that there has been no activity on these faults or related structures in late Pleistocene or Holocene time.

Several closely-spaced lineaments are shown in the central part of the map area in the area of the Viapan Lake alluvial fan deposits. These linear features are based entirely on airphoto interpretation and have not been observed on the ground. Their northeast trend is not parallel to the structures described above, and any structural origin for these features is obscure. They trend generally transverse to the axis of the fan, the deposits of which are presumably underlain by clay and silt of the Bootlegger Cove Formation. It is thus possible that the lineaments may represent fracturing of the coarse-grained fan deposits, possibly during great earthquakes, in response to movement of materials within the Bootlegger Cove Formation, but we have no direct evidence to support this idea. A few of the lineaments seem to extend across the moraine deposits of the Beluga plateau, which they probably would not do if related only to the fan and underlying deposits. Perhaps they are merely a figment of the photo interpreter's imagination, fired by angle of sunlight and (or) seasonality of the vegetation.

SURFICIAL DEPOSITS

The bedrock is covered in most of the area by the variably thick sequence of surficial deposits that have been the principal subject of our investigations. Most of these deposits are Pleistocene in age and of glacial origin, and can be subdivided into moraine, glacioalluvial, and glacioestuarine deposits. They have been eroded and modified mainly along stream channels where they have been replaced or covered at the surface by a series of minor alluvial and colluvial (including landslide) deposits mainly of Holocene age. All of these deposits are overlain locally by pond and bog deposits. Most of the surficial deposits have not been dated directly, but 15 radiocarbon ages from nine sites within the map area have been useful to some extent in determining some of the age relationships discussed below. The ages and other relevant data are listed in table 1.

Table 1. List of radiocarbon ages of sampled material from the lower Beluga-Chuitna map area, Alaska

[All samples previously unreported, except for W-4292 (Schmoll and Yehle, 1983, 1986). Locations are shown on the geologic map. Except as indicated, samples are of lowest collectable peat from stratigraphic sections of surface peat; two samples at the same locality are from the same stratigraphic section and are listed in stratigraphic order. W- lab numbers indicate data from Meyer Rubin, U.S. Geological Survey radiocarbon laboratory; I- lab numbers indicate data from Isotopes, Inc. Radiocarbon ages are given in years before present (1950) as reported by laboratory]

Locality number and name	Location	Material	Lab number	Radiocarbon age	Date of collection
1. Beluga River bog, west	SW1/4SE1/4 sec. 10, T. 13 N., R. 11 W.	peat ¹	W-4064	6,300 ± 300	July 7, 1977
		peat	W-4065	10,600 ± 300	
2. Beluga River bog, east	SE1/4SE1/4 sec. 3, T. 13 N., R. 11 W.	peat	W-5758	12,860 ± 300	July 10, 1982
3. Lone Creek terrace bog	SW1/4NW1/4 sec. 32, T. 13 N., R. 11 W.	peat	W-5753	610 ± 200	July 6, 1982
4. TC channel bog	NE1/4NW1/4 sec. 32, T. 13 N., R. 11 W.	peat	I-13,179	10,730 ± 150	July 6, 1982
5. Beluga River terrace bog	NW1/4NW1/4 sec. 9, T. 13 N., R. 10 W.	peat ¹	I-12,554	9,250 ± 160	August 6, 1981
		peat	I-12,402	10,110 ± 160	
6. Beluga River bridge	NW1/4SE1/4 sec. 6, T. 13 N., R. 9 W.	wood ²	I-10,780	440 ± 75	August 28, 1978
		shells ³	W-4292	14,350 ± 200	
7. Beluga beach ridge	NW1/4SW1/4 sec. 28, T. 13 N., R. 10 W.	peat ⁴	W-5784	8,570 ± 200	July 10, 1982
		peat	W-5756	9,450 ± 200	
8. Cottonwood Beach	NE1/4NW1/4 sec. 25, T. 13 N., R. 10 W.	wood ⁵	I-11,100	250 ± 75	August 28, 1978
		wood	I-10,781	600 ± 75	
9. Ladd terrace	SE1/4NE1/4 sec. 30, T. 12 N., R. 10 W.	peat ¹	I-11,098	3,690 ± 100	July 24, 1978
		peat	W-4409	6,690 ± 110	

¹Upper sample directly underlies volcanic ash bed.

²I-10,780 from Holocene-age channel adjacent to Pleistocene-age stratigraphic section containing W-4292.

³Mollusks from Bootlegger Cove Formation.

⁴W-5784 from auger hole on top of former beach ridge.

W-5756 from auger hole adjacent to former beach ridge.

⁵I-11,098 from less deeply buried and I-10,781 from more deeply buried former beach berm.

MORAINE DEPOSITS

Moraine deposits identified in the course of our studies are mapped on the basis of areal extent and morphology in terms of the informally named moraines that have been delineated in this part of the Cook Inlet region. We gave a brief description of our usage (Schmoll and Yehle, 1983) that has been further elaborated for the moraines on the west side of Cook Inlet in Schmoll and others (1984) and more fully described in Schmoll and Yehle (1986).

Four of the principal moraines that we have identified (Schmoll and Yehle, 1986) occur within this map area, and their location and correlations with other moraines in the region are shown in figure 3. One of these, the Threemile Creek moraine, is named from a small stream in the headwaters of which the southwest end of this moraine occurs. The other named moraines, the Denslow Lake, Seven-thirty lake, and Blueberry hill moraines, take their names from features in the map area to the west.

All these moraines are products of glaciers that had two different source areas, as determined mainly from their areal configurations. The Blueberry hill and Threemile Creek moraines were deposited by glaciers that flowed southward down the Susitna lowland from the Alaska Range to the north, filling most of the upper part of the Cook Inlet region, and preventing ice from closer, western sources from entering the map area. Because its margin is situated at a higher level, the Blueberry hill glacier was the more extensive of the two. It probably split into two lobes and occupied both the east and west sides of the highland around Mount Susitna, whereas the lower Threemile Creek glacier probably was restricted to the lower-lying area east of the highland. The Blueberry hill moraines are represented in the map area only by ground moraine that covers hill 920 in the northwestern part of the map area. By contrast, the Threemile Creek moraine dominates the central and northern parts of the western map area. North of the Beluga River, the moraine is a well-developed lateral moraine, but south of the river the surface of the moraine is more subdued and is mapped as ground moraine with only local patches of more rugged hummocky ground moraine. The reason for the lack of a lateral moraine in this part of the area is problematic; one hypothesis is that the glacier from the north merged with the glacier from the west in this vicinity. It is likely that the Threemile Creek glacier terminated in a glacioestuarine ancestor of Cook Inlet not far south of the map area (Schmoll and Yehle, 1986). The more subdued nature of the southeastern margin of the moraine is interpreted as the result of being modified by glacioestuarine inundation either shortly after the ice withdrew or during a subsequent episode of high-level glacioestuarine water.

The other moraines in the region are all products of glaciers that had a source to the west, in the Tordrillo Mountains (fig. 2), where the extensive Capps and Triumvirate Glaciers are still present in the headwaters of the Beluga River. Deposits of the most extensive of these moraines, the Eight-ten lake moraine, are well represented in the map area to the west (Schmoll and Yehle, 1987) where the glacier bulged southward. Comparable deposits have not been identified within this map area; the glacier may have been blocked by a massive Threemile Creek lateral moraine subsequently eroded, or by remnant Threemile Creek glacier ice itself. Deposits of the Seven-thirty lake moraine, less extensive to the west, do occur in the northwestern part of the map area on both sides of hill 920; the ice probably wrapped around the hill but did not cover it. The least extensive Denslow Lake moraine deposits occur only on the northwest side of hill 920, but are well developed in the Tyonek B-4 quadrangle, north of the map area (L.A. Yehle and H.R. Schmoll, unpublished mapping). The deposits of the Seven-thirty lake and Denslow Lake moraines are clearly younger than those of the Blueberry hill and Threemile Creek moraines, but none of these deposits have been observed in stratigraphic sequence; thus relative ages are inferred mainly from the geomorphic relationships of the moraines.

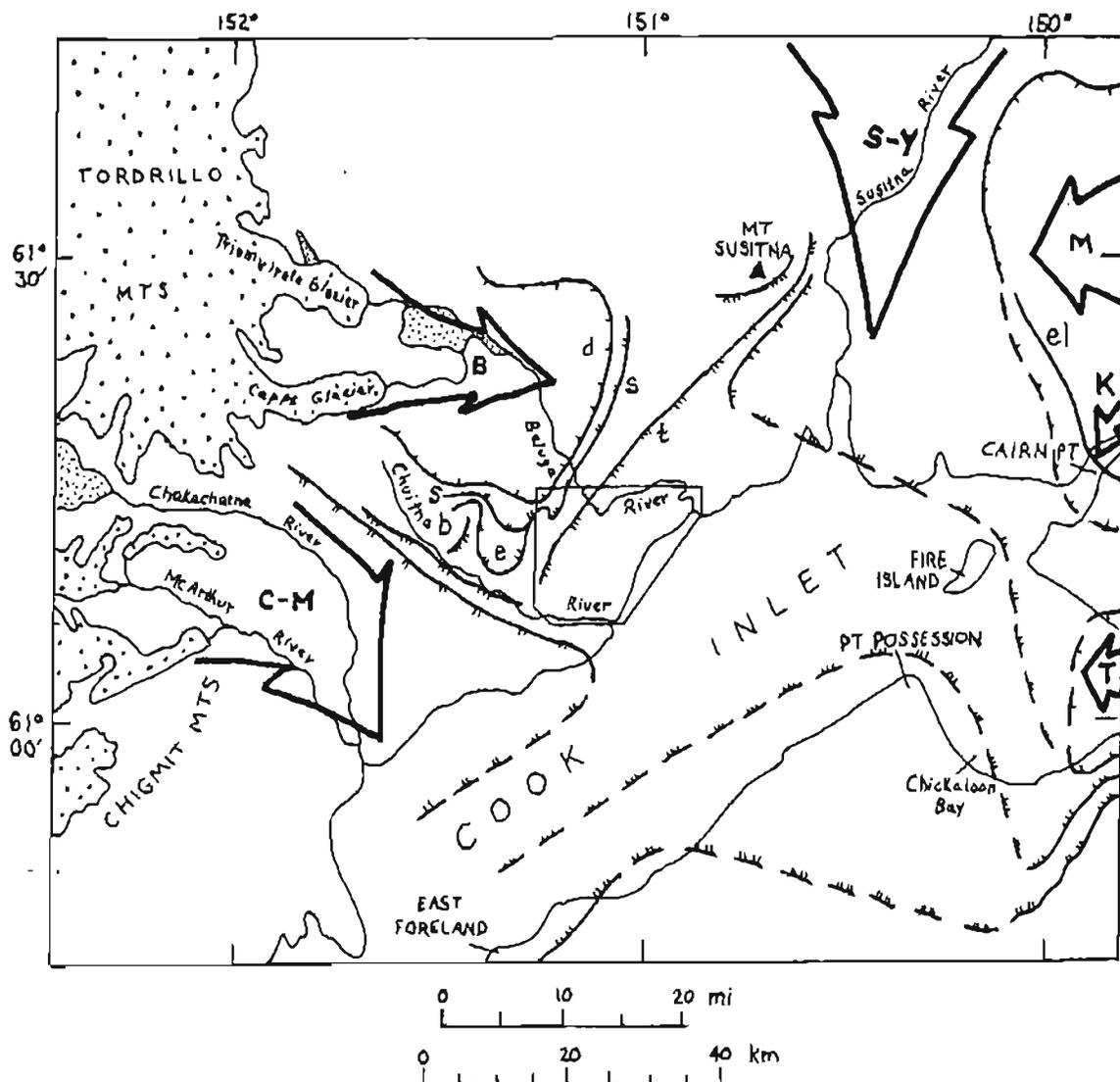


Figure 3. Map of upper Cook Inlet region showing its principal moraines related to those in the lower Beluga-Chukotna map area (doubly truncated rectangle) and indicating source areas and interpreted terminal positions for glaciers that deposited them. Outer boundaries of moraines shown by bold lines, dashed where glacier inferred to have terminated in water; ticks, on side toward glaciers, indicate grouping of moraines into glacioestuarine associations (GEAs; Schmoll and Yehle, 1986) by the following grouping of ticks: none, Cairn Point GEA; 1, Chickaloon Bay GEA; 2, Fire Island GEA; 3, Point Possession GEA; 4, East Foreland GEA. Selected moraines identified by lower-case letter as follows: b, Blueberry hill; d, Denslow Lake; e, Eight-ten lake; el, Elmendorf; s, Seven-thirty lake; t, Threemile Creek; other moraines identified and discussed in Schmoll and others (1984), from which this map is modified, and in Schmoll and Yehle (1986). Arrows indicate principal glacier lobes identified by upper-case letters and having source areas as follows: B, Beluga, from Tordrillo Mountains; C-M, Chakachatna-McArthur, from Tordrillo and Chigmit Mountains as well as Alaska Range farther west; K, Knik, and M, Matanuska, together forming a compound lobe from Chugach and Talkeetna Mountains; S-Y, Susitna-Yentna, principally from Alaska Range to north; T, Turnagain Arm, from Chugach and Kenai Mountains. Areas with large dots, present-day glaciers and ice fields; areas with small dots, lakes.

There is little evidence for absolute age differences among these moraines. On the basis of indirect radiocarbon evidence in the map area to the west (Schmoll and Yehle, 1987) we surmise that the Denslow Lake moraine, the youngest of the moraines in the map area, may be at least 14,000-15,000 radiocarbon yr old. It thus appears to be slightly older than the morphologically comparable Elmendorf Moraine at Anchorage, about 75 km to the east, which is radiocarbon-dated as about 13,000 yr old (Schmoll and others, 1972). The Denslow Lake moraine is clearly late Pleistocene in age, but ages of the older moraines were left open to alternate interpretations by Schmoll and Yehle (1986). We now believe, however, that the Blueberry hill moraine is probably pre-late Pleistocene in age whereas all the younger moraines are probably late Pleistocene in age. This conclusion is based on revised mapping in two areas: (1) in the map area to the west, the relationship of the Blueberry hill moraine to postulated activity on the Lone Ridge fault (Schmoll and Yehle, 1987) suggests a substantially greater offset of the Blueberry hill moraine than of any younger moraine; (2) in the Anchorage area (Yehle and others, 1992), moraines correlative with the Blueberry hill moraine, the Ski Bowl moraines, are regarded mainly on the basis of morphology and state of preservation as pre-late Pleistocene in age, and most younger moraines are of late Pleistocene age. It is likely that similar relationships are true in this map area as well.

GLACIOALLUVIAL DEPOSITS

Other glacier-related deposits of the map area are the deposits of streams that drained from glaciers. These deposits are identified on the map by the name of the moraine deposits to which they are related. The deposits include (1) kame deposits and (2) outwash-channel deposits, both of which lie within the boundaries of moraines and are of limited extent, and (3) the series of outwash-plain and valley-train deposits that extend outward from moraines.

Kame (ice-contact) deposits were laid down by streams flowing within, on, or around the glacier, probably after it had become stagnant, in tunnels or channels bounded by ice so that when the ice melted, the accumulated stream deposits remained lying in thicker mounds than the surrounding ice-deposited moraine. Outwash-channel deposits were laid down by streams within or just outside the bounds of the glacier, during and after the waning stages of ice stagnation. Deposition occurred in channels that were earlier eroded into areas of moraine and kame deposits. Outwash-train deposits were laid down by meltwater streams that extended beyond the margins of the glacier either in existing valleys or in channels newly eroded through the moraines of previous, more extensive glaciers. Valley trains of various ages extend through the central part of the map area, younger trains commonly incised beneath older ones of which only terrace remnants remain; in places trains of different ages occupied different channels, and both remain nearly intact. In general, within each glacial episode the older outwash-train deposits date from the time that the ice reached its maximum extent or soon thereafter; kame deposits date from the time when ice subsequently became stagnant and may correlate with some intermediate-age outwash-train deposits; outwash-channel deposits and younger outwash-train deposits date from later stages of ice stagnation, perhaps when the active glacier front had retreated some distance upvalley.

Kames and outwash-channel deposits of the Denslow Lake moraine are present only in small areas in the far northwestern part of the map area. Outwash-channel deposits of the Threemile Creek moraine occur mainly within the confines of the related lateral-moraine deposits.

Outwash-plain and outwash-train deposits of the Seven-thirty lake and Denslow Lake moraines, extensively developed and subdivided in the map area to the west (Schmoll and Yehle, 1987), are represented in this map area mainly by small, distal fringes of those deposits. One exception is the outwash in the broad BC channel in the western part of the map area; these deposits appear to grade to the same level as the youngest of the Denslow Lake outwash trains to the west, mapped as unit du, but as discussed below, they may be younger, and are mapped separately as unit dbc. A terrace and channel sequence in the northeastern part of the western map area is incised below the level of modified Threemile Creek moraine deposits and is mapped as outwash from the Seven-thirty lake moraine to the north, although the deposits cannot be traced unequivocally to that moraine.

Outwash-train deposits that are closely related in position to, but are younger than, the outwash-channel deposits of the Threemile Creek moraine extend north to south across all of the Threemile Creek moraine deposits. They occupy principally the TC channel (fig. 2) and appear graded to the presumed glacioestuarine water level responsible for the modification of the Threemile Creek ground moraine deposits. Like the BC channel that it closely parallels, the TC channel also may have served as a former course of the Beluga River valley drainage, as well as of drainage from streams farther north. Some of this drainage also coursed through the valleys of the Middle branch Threemile Creek and Threemile Creek itself (fig. 2) before they were as deeply incised as at present. Because the age of these outwash-train deposits is not well established--they are younger than the Threemile Creek channel outwash but could be as young as Seven-thirty lake outwash--the deposits of the TC channel and their equivalents are mapped separately as unit ttc.

Related to the outwash-train deposits are deposits of two large glacioalluvial fans that dominate the eastern half of the western map area and mark a transition from glacial to glacioestuarine deposition. The fans head where the valleys of the present-day Beluga and Chuitna Rivers emerge from their deeply incised courses across the Beluga plateau. The deposits appear to grade laterally into glacioestuarine deposits in the eastern part of the map area. Because they cannot be directly related to moraine deposits up either valley, the deposits are collectively termed deposits near Viapan Lake, an informal name derived from the lake that lies within the distal portion of the deposits in the southeastern part of the map area.

The Beluga valley fan deposits may have had as their source a glacier that terminated within inner parts of the Denslow Lake moraine in the map area to the north (L.A. Yehle and H.R. Schmoll, unpublished mapping). This weakly evidenced inner moraine is postulated to correlate with the massive Elmendorf Moraine at Anchorage. Although they are not morphologically similar, the correlation of these two moraines is strongly supported by relationships of fan deposits in both areas to glacioestuarine deposits of the same age, those of the Bootlegger Cove Formation. An alternative source for the fan deposits is the breakout of a lake that was dammed by the moraine or by a lobe of glacier ice. Lake deposits of uncertain age that post-date the Denslow Lake moraine are present in the central part of the Beluga valley (L.A. Yehle and H.R. Schmoll, unpublished mapping). Breakout of glacier-dammed lakes still occurs in the Beluga drainage basin (Sturm, 1989). This possible origin for the fan deposits is comparable to that postulated for the Mountain View alluvial fan deposits of similar age and appearance in the Anchorage area (Schmoll and Barnwell, 1984; Yehle and others, 1990).

The Denslow Lake glacier may also be the source for the Chuitna fan, the water draining by way of northern tributaries in the upstream Chuitna River drainage area (Yehle, Schmoll, and Chleborad, 1983a; H.R. Schmoll and L.A. Yehle, unpublished mapping), but there is little evidence in the form of terrace deposits that can be traced directly from the Denslow Lake moraine area to the Chuitna fan. An alternative is that the Chuitna fan also derived from the Beluga drainage area by way of the BC channel. In this case, the deposits in the channel could have either the same direct-glacial or glacial-lake outburst origins discussed for the Beluga-fan deposits. The width of the BC channel, an order of magnitude larger than any other channel in the area, and the size of meander scars within it (evidenced by arcuate bluff segments more than 1 km long), both support the outburst interpretation. Although the two fans appear coeval because they seem to merge and are graded to about the same level, the Beluga-source interpretation for the Chuitna-fan deposits probably requires (1) that they be slightly older than the Beluga-fan deposits, (2) that the BC channel provided an earlier course for the Beluga River, just prior to establishment of its present course across the Threemile Creek moraine, and (3) that the channel deposits are more nearly coeval with the deposits near Viapan Lake than portrayed on the correlation of map units.

GLACIOESTUARINE DEPOSITS

The flat-lying area of the Bootlegger Cove platform between the Beluga River and Threemile Creek is dominated by glacioestuarine deposits, principally the Bootlegger Cove Formation from which the physiographic unit takes its name. The Bootlegger Cove Formation ("blue clay" of Dobrovolsky and Miller, 1950; "Bootlegger Cove Clay" of Miller and Dobrovolsky, 1959; name revised to its present form in Updike and others, 1982) is thought to underlie most of the Bootlegger Cove platform. The formation was first recognized in the central part of the Anchorage lowland where it underlies sand and gravel near Bootlegger Cove (fig. 3). There it consists of clay and silt with numerous discontinuous interbeds of sandy silt, silty sand, and fine to medium sand, as well as scattered sand grains, pebbles, and cobbles in widely varying concentrations. A detailed description of the formation is given in Updike and others (1988). The potential of the formation for causing large-scale landslides during major earthquakes, recognized by Miller and Dobrovolsky (1959), was realized during the great Alaska earthquake of 1964 (Hansen, 1965). Within the map area, outcrops of the formation occur only along the Beluga River, but it probably is concealed beneath the colluvial cover in the lower part of bluffs all along Cook Inlet where clay and silt are exposed locally. Fossil mollusk shells found in a small riverbank outcrop at radiocarbon locality 6 are about 14,000 yr old (table 1), about the same age as similar shells from the Bootlegger Cove Formation at Anchorage (Schmoll and others, 1972). The similarity of shell ages indicates that the fine-grained sediments, mainly clay and silt, in this part of the Cook Inlet basin are indeed part of that formation.

In most places the Bootlegger Cove Formation is overlain by sand; in much of the map area extensive bogs conceal the sand where it is thin or perhaps lacking. The sand deposits may constitute the last phase of the glacioestuarine depositional sequence typified by the underlying, finer-grained deposits of the Bootlegger Cove Formation. The sand deposits that overlie the Bootlegger Cove Formation at Anchorage have been termed informally "deposits near Hood Lake," named for the lake near Anchorage International Airport that the deposits entirely surround (fig. 1). The name Hood Lake was extended to similar deposits on the northwest side of Knik Arm by Yehle and others (1991) and we apply that term to the sand deposits in this map area as well. Here, these deposits may grade laterally into the sand and gravel of the alluvial fan deposits near Viapan Lake, or the latter may overlie the Hood Lake deposits. A similar stratigraphic relationship of Bootlegger Cove Formation, Hood Lake sand, and laterally related Mountain View alluvial fan deposits is also seen in the Anchorage area (Miller and Dobrovolsky, 1959; Schmoll and others, 1972; Updike and Carpenter, 1986). The Hood Lake deposits in this area, however, probably have a local source on the west side of the ancestral Cook Inlet estuary. They include sand in low linear features that parallel Cook Inlet shores and are thought to be former beach ridges. A minimum age of about 9,000 years for these deposits is provided by the age of overlying peat at radiocarbon locality 7, table 1.

OTHER SURFICIAL DEPOSITS

Nonglacial alluvium, colluvium (including landslide deposits), pond and bog deposits, and estuarine deposits are the other principal types of deposits mapped. Alluvium occurs in the valley bottoms along principal streams, and is subdivided on the basis of texture, morphology, and relative age. It consists of gravel and sand along major streams, but commonly is finer grained where small streams meander across the Bootlegger Cove platform. Along the Beluga and Chitna Rivers alluvium of the active floodplain is mapped separately; along the lower course of the Beluga River, these deposits are especially subject to rapid and extensive change in configuration at times of episodic major flooding caused by breakout of glacier-dammed Strandline Lake or other lakes adjacent to Triumvirate Glacier (fig. 1; Sturm, 1989).

Alluvium is discontinuously preserved in terraces mainly along the Beluga and Chuitna Rivers where three terrace levels above the lowest terraces are distinguished. Along the lower course of the Beluga River the many mid-valley terrace remnants may reflect numerous and rapid changes in the course of the river because of repeated major flooding. There is no certainty that the terrace deposits similarly numbered along each river necessarily correlate. For example, the second-highest terrace along the Chuitna River is easily traceable to a locality near Ladd, north of the river's mouth (fig. 2), where a radiocarbon age of about 6,700 yr has been obtained for basal peat overlying this unit (radiocarbon locality 9, table 1). The similarly mapped terrace along the Beluga River has yielded a radiocarbon age for basal peat of about 10,000 yr (locality 5, table 1). Because both dates furnish only minimum ages for the terrace deposits, they could be coeval, or the Chuitna River deposits could be younger. In any case, deposits of one or both of the two highest terraces at least along the Beluga River may be very late Pleistocene in age; most nonglacial alluvium in the map area, however, is Holocene in age.

Colluvium is mapped mainly along the steep walls of the incised valleys of the Beluga and Chuitna Rivers and along several glacier-meltwater channels that transect the moraine deposits; it also occurs on the bluffs bordering Cook Inlet. The valley-wall and sea-bluff colluvium is subdivided into (1) that which is derived mostly from moraine deposits and which commonly conceals bedrock, especially in the lower part of the slopes on which it occurs, and (2) that which is derived mostly from the Viapan Lake and Hood Lake deposits and which may conceal the Bootlegger Cove Formation in the lower slopes.

Landslide deposits, which we regard as a type of colluvium, occur mainly in association with the valley-wall and sea-bluff colluvium. Two large slides are located at the north edge of the western map area, one along the Beluga River and the other along Coffee Creek. A prominent linear slide occurs along the Cook Inlet bluffs near Viapan Lake. Although at the site of an earlier slide, the present configuration of the slide deposits there probably resulted from movements of fine-grained material in the Bootlegger Cove Formation during the 1964 earthquake. As reported in Foster and Karlstrom (1967), however, only about 0.4 m displacement here resulted from the 1964 event, suggesting that much of the presently-evident slide deposits formed prior to that event.

We have not dated any of the colluvial deposits directly, and most of them are presumed to be Holocene in age, but some, especially those developed along glacial meltwater channels, well may have begun to form during late Pleistocene time.

The shallow depressions in the generally irregular surface of most moraine deposits, as well as large areas on the BC channel and on the Bootlegger Cove platform, are, or have been, occupied by ponds in various stages of infill by growth of vegetation. The resulting bogs consist mainly of peat and vary considerably in degree of wetness, both seasonally and at any given time. Those bogs, or parts thereof, that are commonly wetter or drier than most are mapped separately. The bogs also include many variably continuous beds of mostly ash-size tephra from volcanoes to the northwest, west, and southwest. Although three of the volcanic ash beds have been dated at about 3,700, 6,300, and 9,250 yr B.P. (localities 9, 1, and 5, respectively, table 1), we have not correlated these beds with any of those reported by Riehle (1985). The bog deposits are mainly Holocene in age, but four bogs (localities 1, 2, 4, and 5, table 1) have yielded basal ages in the range of 10,000-13,000 yr B.P., placing the lowest beds of at least some bogs within the latest Pleistocene.

The relatively thick accumulations of peat containing thin interbedded tephra in the areas mapped as bog and pond deposits grade laterally away from the bogs into a complex of tephra deposits with thin organic beds. This complex constitutes a ubiquitous blanket 1 m or less in thickness that, although not mapped, covers all of the glacial deposits and, to an extent roughly commensurate with age, covers older alluvium and colluvium as well.

Estuarine deposits occupy the small area of the Alexander plain in the easternmost part of the map area and are subdivided mainly into (1) modern deposits that are alternatively submerged and subaerially exposed by the twice-daily rise and fall of the tide, and (2) older deposits that no longer are affected by tide water. Other subdivisions of the deposits reflect the general degree of wetness of an area or some modification to the deposits.

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