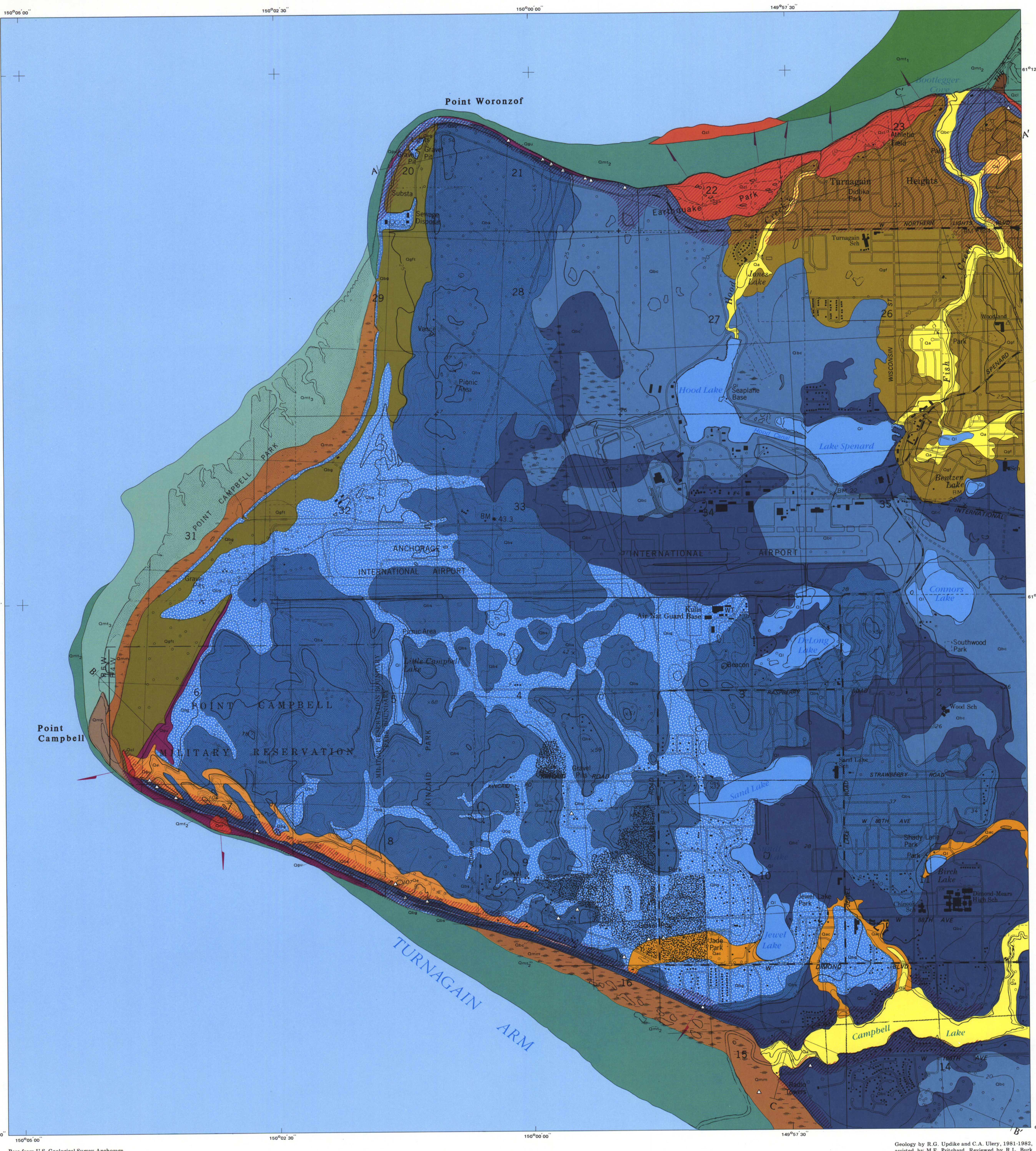
ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
PREPARED IN COOPERATION WITH THE U.S. GEOLOGICAL SURVEY OFFICE OF EARTHQUAKE STUDIES



Base from U.S. Geological Survey Anchorage A-8 (NW) and Tyonek A-1 (NE) Quadrangles, Alaska; modified by L.C. Schell, 1983.

Scale 1:15,840

1 0.5 0 1 2 kilometers

½ 0 1 mile

Contour interval 5 meters
National geodetic vertical datum of 1929
Vertical exaggeration 10x in cross sections

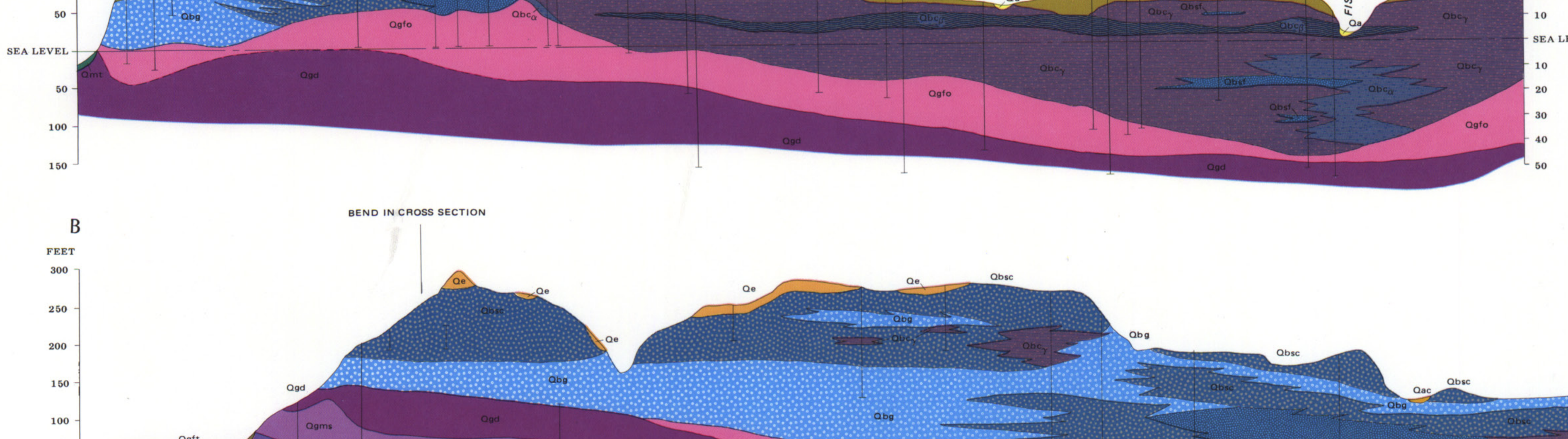
True North
Magnetic N
25°

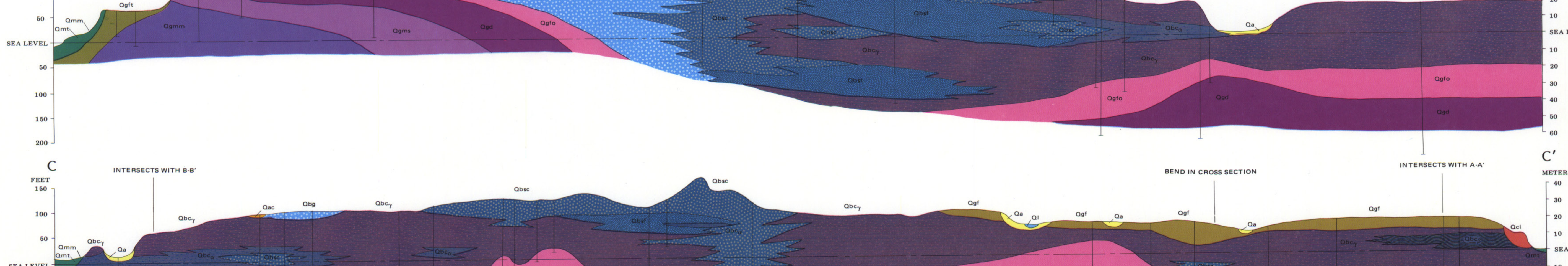
Approximate mean declination, 1979

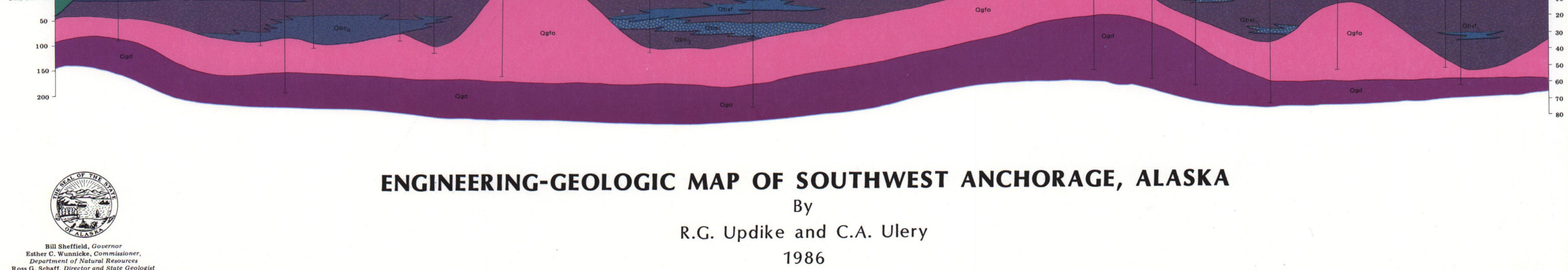
Geology by R.G. Updike and C.A. Ulery, 1981-1982, assisted by M.E. Pritchard. Reviewed by R.L. Burk (Golder and Associates) and R.A. Combellick and R.D. Reger (DGGS). Cartography by G.M. Laird assisted by B.A. Harte.

MAP SYMBOLS

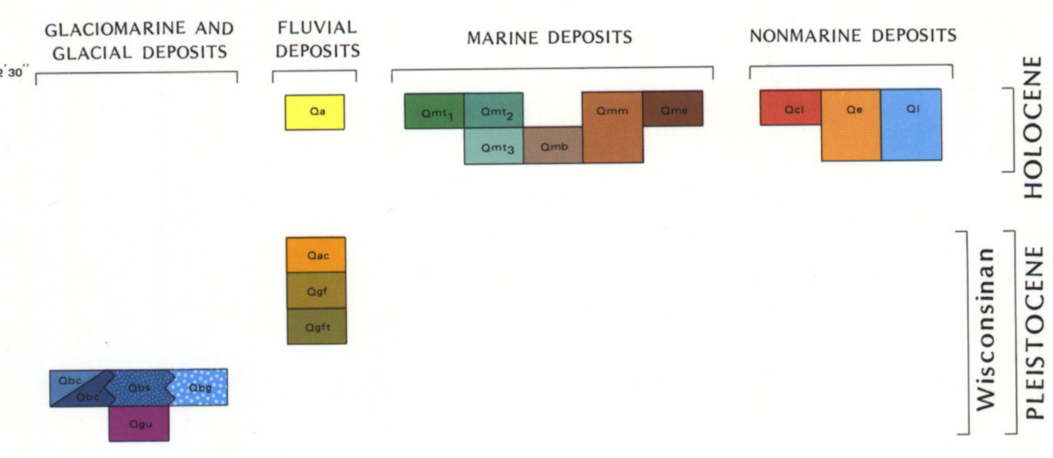
- Contact
- Stratigraphic-section location
- Area subject to major ground failure during earthquakes
- Direction of landslide movement
- Borehole location (alphanumeric code on file at DGGS); boreholes that do not appear to intersect ground surface are in topographically low areas near cross-section B-B′
- Gravel pit



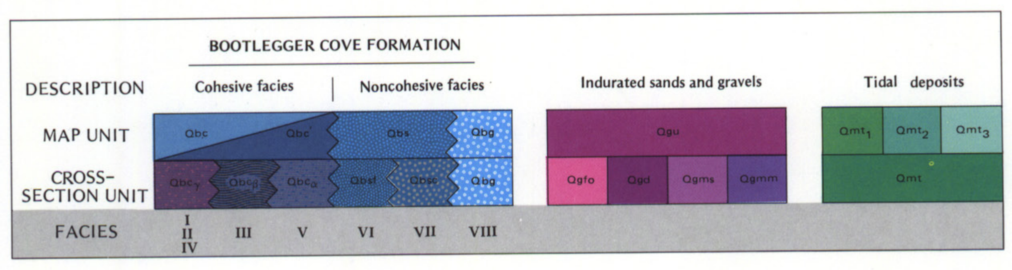




CORRELATION OF MAP UNITS



CORRELATION OF MAP UNITS WITH CROSS-SECTION UNITS



DESCRIPTION OF UNITS

(man-induced redistribution of map units is common and is not distinguished)

- Qa — MODERN ALLUVIUM—Stratified sand and gravel, with lesser amounts of silt.
- Qmt — TIDAL DEPOSITS—Dominantly sand and silt, with minor gravel associated with modern shorelines.*
  - Qmt_1 — MODERN LOW-TIDE DEPOSITS—Silt and fine sand.**
  - Qmt_2 — MODERN HIGH-TIDE DEPOSITS—Silt, sand, and gravel.**
  - Qmt_3 — ABANDONED TIDAL DEPOSITS—Silt and sand.**
- Qmb — MARINE-BAR DEPOSITS—Sand and gravel.
- Qmm — MODERN TIDAL-MARSH DEPOSITS—Silt and organic beds.
- Qme — MODERN ESTUARINE DEPOSITS—Silt and organic beds.
- Qcl — LANDSLIDE DEPOSITS—Heterogeneous mixture of gravel, sand, and silt.
- Qe — EOLIAN DEPOSITS—Silty fine sand with occasional organic beds.
- Ql — LACUSTRINE DEPOSITS—Silt and clay.
- Qac — ABANDONED STREAM-CHANNEL DEPOSITS—Silt, sand, and gravel in stratified discontinuous beds.
- Qgf — GLACIOFLUVIAL DEPOSITS—Gray, stratified sand and gravel; overlies Bootlegger Cove Formation.
- Qgft — GLACIOFLUVIAL TERRACE DEPOSITS—Dominantly sand and gravel in discontinuous beds, with ice-contact features, cross-beds, and cut-and-fill channels.
- Qbc / Qbc′ — BOOTLEGGER COVE FORMATION (FACIES I-V)—Cohesive silty clay or clayey silt, or both, with occasional sand layers and random stones. Qbc′ denotes >3 m of overburden that consists of peat and loess; indicated only for these units**
  - Qbc_γ — BOOTLEGGER COVE FORMATION (FACIES I, II, AND IV)—Silty clay or clayey silt, or both, with sand layers.*
  - Qbc_β — BOOTLEGGER COVE FORMATION (FACIES III)—Silty clay or clayey silt, or both (sensitive).*
  - Qbc_α — BOOTLEGGER COVE FORMATION (FACIES V)—Silty clay or clayey silt, or both, with random pebbles, cobbles, and boulders.*
- Qbs — BOOTLEGGER COVE FORMATION (FACIES VI AND VII)—Deltaic silty fine to medium sand, with gravel, silt, and clay layers.**
  - Qbsf — BOOTLEGGER COVE FORMATION (FACIES VI)—Deltaic silty fine sand, with silt and clay layers.*
  - Qbsc — BOOTLEGGER COVE FORMATION (FACIES VII)—Deltaic fine to medium sand, with layers of silt and gravel.*
- Qbg — BOOTLEGGER COVE FORMATION (FACIES VIII)—Deltaic sandy gravel and gravelly sand, with discontinous layers of silt and fine sand.
- Qgu — PRE-LATE NAPTOWNE GLACIAL, GLACIOMARINE, AND GLACIOFLUVIAL DEPOSITS**
  - Qgfo — GLACIOFLUVIAL DEPOSITS, INCLUDING ICE-CONTACT DEPOSITS—Dominantly sand and gravel; weakly to moderately indurated, stratified.*
  - Qgd — TILL—Heterogeneous mixture of clay, silt, sand, gravel, and boulders; firmly indurated, weakly layered.*
  - Qgms — GLACIOMARINE DIAMICTON, STRATIFIED PHASE—Buff, tan, and yellow-orange sand and silt, with random stones and discontinuous sandy gravel beds.*
  - Qgmm — GLACIOFLUVIAL DIAMICTON, MASSIVE PHASE—Gray, tan, and yellow nonstratified silt and sand, with gravel and boulders, and occasional stratified beds; firmly indurated.*

**Map only
*Cross section only

INTRODUCTION

This study is based on aerial-photograph[1] interpretation, field mapping, and previous investigations by Miller and Dobrovolny (1959), Karlstrom (1964), and Schmoll and Dobrovolny (1972). Subsurface control was obtained by cataloging and correlating more than 950 geotechnical and water-well boreholes drilled from 1955 to 1981. This borehole information allowed us to interpret the stratigraphy and physical parameters of the mapped units and thus extend our stratigraphic interpretations to approximately 50 m (164 ft) below sea level.

GEOLOGIC SUMMARY

Stratigraphic and geomorphologic relationships in the study area indicate four episodes of geologic activity. The earliest episode is represented by a gray to buff to yellow, firmly indurated diamicton that consists of two units: 1) a lower section that is generally nonstratified sandy silt with random stones that range up to small boulders, and 2) a stratified sequence that consists of thin laminar beds of silt and sand with scattered pebbles and cobbles. Both units exhibit broad flexures with amplitudes of up to 3 m (3.3 ft), low-angle reverse intraformational faults, load-cast structures, and high-angle microfaults. These deformational features suggest a subaqueous, ice-marginal environment in which low-angle slope failures and ice-shove and sediment-loading activities were interactive. The sequence, which is interpreted as a glaciomarine till (Qgmm) overlain by interbedded flow-till and fan-delta materials (Qgms), was deposited by a glacier that apparently extended across the map area; flow direction and source are not ascertainable from the borehole data. Although radiometric dates have not been obtained for this glaciation, it probably represents an early Wisconsinan (late Knik) event. The considerable relief on the upper surface of these deposits indicates erosional modification before the younger, overlying sediments were deposited.

The second episode of geologic activity is represented in an outcrop exposed near Point Campbell. There, interbedded ice-contact and stratified glaciofluvial sands and gravels that are firmly indurated (Qgfo) overlie a densely packed, bouldery till (Qgd) and a 15- to 30-cm-thick (6 to 12 in.) silt and peat bed. The eastern extent and stratigraphic relationships of this glacial sequence are concealed and are not distinguishable in boreholes. However, an obvious hiatus exists between this sequence and older and younger deposits. The dips of stratified beds and ice-shove deformation indicate that the glacier that deposited these materials apparently entered the map area from the west or northwest; the eastern extent of the unit has not been defined. The presence of ice-contact deposits below the till suggests that the ice was at a stillstand in the area and subsequently advanced across its stagnation deposits. Although radiometric dates have not been obtained for this glaciation, it probably represents a late Wisconsinan (early Naptowne) event.

The third episode of geologic activity is represented by the advance (from the northwest) of the Matanuska ice lobe, which terminated along a north-south line through the center of the map area. The terminus of this glacier fronted to the east in marine or brackish water that resulted from entrapment of water between the Chugach Mountains (to the east) and the Knik ice lobe (to the north), the Matanuska ice lobe (to the west), and the Turnagain ice lobe (to the south). The water body may have intermittently maintained a restricted communication with open marine waters to the south. Ablation of the Matanuska lobe produced a fan delta that prograded westward into deeper waters of the restricted embayment. Although considerable fluctuations probably occurred during fan building, sands and gravels that were deposited near the ice front graded eastward into sands, silts, and clays that accumulated to form the previously named Bootlegger Cove Clay (Miller and Dobrovolny, 1959); this unit was subsequently renamed the Bootlegger Cove Formation (Updike and others, 1982). This unit was formerly defined primarily on the basis of the cohesive units (Qbc and Qbc′, facies F.I-V; Ulery and Updike, 1983). Our mapping of the fan-delta deposits suggests that the noncohesive silts, sands, and gravels (Qbs and Qbg, facies F.VI-VIII; Ulery and Updike, 1983) are additional facies in the same depositional system. Although the units are distinguished by texture on the map and cross-section, we believe they represent deltaic and deep-water facies of the same formation in spatially and texturally gradational depositional regimes. This interpretation was confirmed in the field and by information from closely spaced borehole logs. Thus, the Bootlegger Cove Formation is extended to include both the cohesive and noncohesive facies of the glacial fan-delta - lacustrine sequence.

Recent investigations by Updike and others (1982), Ulery and Updike (1983), Updike (1986), and Updike and Carpenter (1986) indicate that the Bootlegger Cove Formation consists of several distinct geologic facies that can be mapped in three dimensions. The facies concept is expanded here to include the fan-delta deposits (facies F.VI-VIII).

Cohesive Facies

Facies F.I	Clay, with very minor silt and sand
Facies F.II	Silty clay, clayey silt, or both
Facies F.III	Silty clay, clayey silt, or both (sensitive)
Facies F.IV	Silty clay, clayey silt, or both, with thin silt and sand lenses
Facies F.V	Silty clay, clayey silt, or both, with random pebbles, cobbles, and boulders

Noncohesive Facies

Facies F.VI	Silty fine sand, with silt and clay layers
Facies F.VII	Fine to medium sand, with traces of silt and gravel
Facies F.VIII	Sandy gravel and gravelly sand, with discontinuous layers of silt and fine sand

Generally, the noncohesive facies (F.VI-F.VIII) are the dominant units in the western half of the map area, and the cohesive facies (F.I-V) are most abundant in the east. Landslides that were triggered by the 1964 Great Alaska Earthquake in the Turnagain Heights area were attributed to liquefaction or sensitive-clay failures (or both) in this formation (facies F.VI and F.III, respectively).

During the early fan-building phase, facies F.VIII began to accumulate near the active ice front, and therefore ice-contact sedimentary features characterize the unit. Facies F.V is typical of the lower Bootlegger Cove Formation in the eastern part of the map area, where ice calving along the glacier front caused random dispersal of ice-rafted stones and coarse sand in the silts and clays that accumulated in the basin. Glaciodeltaic deposition continued while an ice front existed to the west. As the glacier retreated, an outwash terrace was eroded between it and the abandoned fan-delta deposits. A similar terrace occurs on Fire Island (Schmoll, Dobrovolny, and Gardner, 1981), and together these outwash terraces may represent the remnants of an outwash flood plain that drained to the south from the retreating glacier. As the glacier retreated, ice blocks that were buried during progradation of the delta melted to produce kettles and poorly integrated drainage ways. The surface embayment drained, and material from the irregular dissection of the fan delta was transported to the east onto the cohesive-facies surface where it was deposited as channels and fans of medium to coarse sand and gravel. Similarly, retransported deltaic sediments were deposited on the outwash terrace to the west. Drainage channels that are now abandoned or contain underfit streams (for example, channels that enter the Campbell Creek drainage from the north) developed as the embayment drained and the stranded ice melted. We correlate this episode of late Wisconsinan glaciation to the early phase of the late Naptowne Glaciation; on the basis of stratigraphic relationships and ^{14}C dating, it predates the very late Wisconsinan Elmendorf advance (latest Naptowne). Outwash associated with the Elmendorf advance (to the northeast) was deposited over the cohesive facies of the Bootlegger Cove Formation in the northeast corner of the study area. Aggregate is mined in the Sand Lake area from the coarse facies of the fan delta and the retransported channel deposits in marginal segments of the delta.

The fourth episode of geologic activity encompasses the Holocene Epoch. During this time, the area has been subjected to vertical adjustments in response to isostatic rebound, tectonic activity, and fluctuations in sea level that have resulted in the development of erosional bluffs along Knik and Turnagain Arms and along streams that drain into Cook Inlet. Continuous scarp retreat caused by mass movement along these bluffs over the last several hundred years is graphically demonstrated by the 1964 Turnagain landslide and other smaller failures. Coastal erosion and deposition encourage the development of tidal deposits that consist predominantly of silt with organic beds and include sand and gravel at Point Woronzof and Point Campbell. Fluvially retransported silt and sand, lacustrine and marshland peat, and wind-transported silt and sand have buried Pleistocene deposits from a few centimeters to several meters below modern upland surfaces. Where these Holocene deposits were mapped, they overlie the adjacent Pleistocene deposits.

ACKNOWLEDGMENTS

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[1] 1:12,000-scale photographs (Air Photo Tech, Inc., September 10, 1980) supplemented by high-altitude, color-infrared (78-119-25AUG78) and low-altitude reconnaissance photographs (ARD-U.S. Army M-64-76-4APR64).

ENGINEERING-GEOLOGIC MAP OF SOUTHWEST ANCHORAGE, ALASKA

By

R.G. Updike and C.A. Ulery

1986

Bill Sheffield, *Governor*
Esther C. Wunnicke, *Commissioner*, *Department of Natural Resources*
Ross G. Schaff, *Director and State Geologist*

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