DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 85-143
SHEET 2 OF 2

Description of surficial deposits map units

Map unit symbol and title	Description of materials	Distribution and thickness	Topography and drainage	Permafrost	Susceptibilty to frost action	Suitability for construction	Special problems
al Flood-plain and low-terrace alluvium	Water-washed and deposited boulder, cobble, and pebble gravel, sand, and silt, with local organic material. Forms lenses and thin to thick beds; local imbricate structure. Large boulders and other material winnowed from glacial and glaciolacustrine deposits through which canyons have been cut; bedrock slabs and boulders added to stream deposits by lateral erosion of canyon walls; locally shale boulders disintergrate rapidly to form silty angular pebbly matrix for gravel. In general, however, sandy matrix contains less than 6% silt sized material. deposits generally coarser upstream, near glacier sources.	Distributed in floodplain and low terraces of major stream systems, including broad outwash plains in front of glaciers and modern fan deltas fronting in lakes such as Tazlina Lake. Thickness of alluvium under downcutting streams in canyons probably less than 23 ft (7 m), as modern paleo stream scour. Thickness may be greater in outwash plain and in fan-delta environment where fluvial topset beds lie above sandy foreset and silty bottomset beds.	Form narrow to broad incised floodplain and low-terrace surfaces as high as 15 to 20 ft (5 - 6 m) above the river, principally along Nelchina, Little Nelchina, Tazlina, and uppermost forks of Matanuska River, and Tyone Creek. Incised valleys bordered by low to high colluvial slopes and sheer bedrock bluffs. Alluvial surfaces well drained, but subject to river flooding at a recurrence interval ranging from about 1 in 2 years on lowest surface to a much greater interval on terraces; floods along Tazlina Lake and River from Nelchina and Tazlina Glacier discharge are much as 5 ft (2 m) above normal lake level and perhaps triple normal streamflow at irregular intervals.	Permafrost may be present locally in silty overburden of terraces, but generally appears absent in coarse-grained fluvial deposits that are warmed by heat condition from bodies of surface water and by convection from moving ground water discharging to the stream. No subsurface data available.	Generally not frost-susceptible except for silt beds and lenses that increase silt content of alluvium to more than 6% and for isolated occurrences where disintegrating shale clasts increase the silt content.	Except for flood hazard due to spring runoff and summer glacier discharge, gravel of floodplain provides level ground and good near-surface materials; however, borings should be drilled to check presence or absence of liquefiable saturated sand and silt and permafrost conditions. Low terraces are less subject to flood and also suitable for construction; local source of saw-quality timber.	Glacial streams and Tazlina Lake subject to sudden (overnight) rise in stage if as much as 5 ft (2 m) due to hot-weather glacier discharge and dumping of ice-dammed lakes. Gravel may contain coal and chert; in some areas it contains shale clasts that cause failure of suitability tests for concrete aggregate.
at Terrace, deltaic, and outwash deposits	Water-worked and deposited boulder, cobble and pebble gravel, sand, and silt, with local organic material. Forms lenses and thin to thick beds; local imbricate structure. Large boulders and other material winnowed from glacial and glaciolacustrine deposits through which the streams cut to deposit alluvium, Generally less than 6% silt, except for local silt lenses and beds; contains local concentrations of oversize material; generally becomes finer downstream in former fluvial and outwash terraces; becomes finer at depth in former deltaic deposits.	Forms terraces along stream courses generally above flood level; covered by silty organic soils that support mature spruce forest with heavy moss cover. Deposits generally as thick as maximum depth of scour - 23 ft (7 m) on major streams; deposits on former deltas may be 10 ft. (3 m) thick and lie above sandy foreset beds and silty bottomset beds. Former outwash deposits of braided channels apparently only 10-15 ft (3-4.5 m) thick at most and lie on till.	Terraces bordering modern streams generally more than 15 ft (5 m) high, broken by tributary gullies; locally covered by fan or colluvial deposits along bluff at valley margin. Well to poorly drained in thick moss, silt mantle, and dense woods. Abandoned deltas and outwash channel terraces deposits, by contrast, are generally burned over, well drained to droughty, but have a generally higher water table than the terraces bordering streams.	Permafrost probably present in high terraces along modern streams, but sporadic in distribution. Permafrost may be absent to sporadic beneath former outwash channel systems which are seasonal stream courses and discharge areas for ground water, and beneath the well-drained old deltaic deposits. Ground-ice settlement problems unlikely in these granular deposits; no subsurface data available.	Generally not frost-susceptible except for silty beds and lenses that increase silt content of material to more than 6%.	Gravelly material more deeply buried by silty and vegetation overburden than lower terraces, and greater chance for frozen ground, in deposits along river; the higher terraces offer gullied sites having good drainage and materials, access to granular borrow and water. Other sites in former outwash plains and deltas have excellent topography, materials, and water supply.	
b Beach deposits	Rounded to subangular, well sorted, accumulation of pebbles and cobbles as large as 1 inch (3 cm) in diameter, granules, coarse and medium sand. Commonly rests on or grades into wave-winnowed boulder concentrations at base of deposit and top of underlying till; may merge laterally to lag boulders at the base of wave-cut scarp.	Principally found along shoreline about 2,450 ft (747 m) above sea level marking one of the last major lake stands with a semi-stable outlet. Deposit is seldom as wide as 330ft (100 m) across series of beach ridges, and is more commonly a single poorly-developed beach ridge, 6-10 ft (2-3 m) high, and containing, perhaps 6 ft (2 m) of beach material.	Forms single to multiple elongate beach ridges less than 10 ft (3 m) high and individually about 15 ft (5 m) across, though they do occur in groups aggregating 330 ft (100 m) in width. Deposit is well drained and generally entirely above the water table; supports aspen and other forms of dry land vegetation.	Permafrost is not present within the shallow zone occupied by beach deposits, but may occur at greater depth in local areas.	Not susceptible to frost action.	Deposit is really too thin and of too limited areal extent to be considered for major construction sites. However, it is suitable to excellent foundation and drainage for small sites, with modest amounts of clean granular borrow.	Linear deposits of limited thickness useful only for road or airfield alignment or for providing small amounts of borrow.
c Colluvium	Mixed silt, sand, gravel, and broken rock derived by gullying, mudflow activity, creep, and landsliding that mix and redeposit material from bluffs to the base of the bluffs. Generally non stratified to poorly or irregularly stratified; locally mixed with organic material.	Largely concentrated along base of river bluffs and include cones, fans, creep deposits, and landslides too small to map individually. Thickness less than 33 ft (10 m), wedging out to upslope boundary and irregularly thinning downslope to toe of unit, commonly deposited on alluvium.	Localized on lower third of slopes of river bluffs and other breaks in slope, and extend out onto adjacent plains at base of slope. Relief is uneven reflecting landslide, gravity, and mudflow and rill-forming gully action. Unit drains at a steep gradient downslope through gully or rill system; rapid runoff. Soils dry and well drained in some places, wet and plastic in slumps and slides scars where water is discharged.	No information on permafrost, other than speculation that it is probably present, particularly on shaded stabilized north-facing slopes, and to a lesser extent on south-facing slopes.	Locally contains more than 6% silt which when wet is subject to frost action.	Generally not suitable for construction because of steep slopes, poor materials, local seepage sites for ground-water discharge (winter icings), and, particularly because of active slope movement, such as landsliding, soil creep, and gullying.	Unstable slopes require special design or remedial work.
e Eolian deposits	Stratified coarse to fine sand, sandy silt, and silt, organic horizons of peat, shrub, and tree remains.	Localized along tops of bluffs bordering incised rivers - usually the south facing bluff where winds off the Chugach Mountains have blown up over the cliffs to form cliffhead dunes. Deposit generally less than 10 ft (3 m) thick, but may reach as much as 33 ft (10 m) locally.	Forms low, linear ridge along top of bluff. Drainage excellent at summit, but poor on side away from bluff face, where drainage is ponded.	Growth of aspen and dry soils suggest that no permafrost occurs within the eolian deposits, except for the possibility of some minor shallow permafrost on the slopes away from the bluff face.	Probably not susceptible to frost action because of lack of water in soils that are generally sandy, although locally silty.	Fair to poor for construction because of fine-grained foundations and borrow limited on site to sand or silty sand. Risk in location adjacent to steep bluffs, which are locally subject to erosion by river and gullying. Site is dusty as material is blown up over cliff. Terrain broken by ridges and deep gullies.	
f Alluvial-fan deposits	Chiefly angular to subrounded gravel of rock type mapped upslope from upper end of fan; matrix sandy, slightly silty; boulders to granules. Poorly stratified and more poorly sorted than al and at.	Distributed along northern front of Chugach and eastern and southern front of Talkeetna Mountains and along major valleys within these mountains. Thickness unknown, but probably generally less than 33 ft (10 m), 10-15 ft (3-5 m).	In plan, a triangular or fan-shaped map unit, with apex extending up lower third of hillside, and remainder in lowlands. Considerable relief from apex to toe; perhaps 10 - 20 ft (3- 6 m) local relief at stream channels. Gravelly deposits well drained on upper and middle parts of unit, but finer material having very low slope near toe is poorly drained and locally covered by swamp and muskeg.	Permafrost probably discontinuous, and more likely to be prevalent and thickest in toe area where drainage is poor and ground-water circulation lower than other areas of coarser materials and higher ground-water gradient. Ground-ice content not known, but could locally be in excess of void spaces of fine-grained deposits at toe of some fans.	Susceptible to frost action where silt content exceeds 6% and where water is present, especially in the toe of many fans; coarser silt-free gravel not subject to frost action.	Construction limited by steep slopes and shifting stream channels; generally dry, firm foundations with minimum permafrost problems and good sources of borrow are favorable in all except wet toe area of fans where soils are fine grained. Care should be taken to avoid areas of alpine mudflows indicated by levee-bordered stream courses and silty soils.	Shifting stream channels; mudflow and potential avalanche hazard.
gm Ground moraine (till)	Nonsorted, nonstratified, inhomogeneous mixture of boulders, cobbles, pebbles, sand, silt, and some clay. Coarse material generally angular to subrounded. Well graded or poorly sorted; locally compact. Where a thin veneer, shown as gm/Vu, where overlying volcanic rocks; generally covered by lacustrine deposits that are shown as lc/gm. Crystalline glacier ice having a slow downvalley motion; buried by firn or perennial snow above about 4,500 ft (1,375 m), depending on local conditions. Carries entrained rock debris.	Widely distributed in mountains and basins above 2,450 ft (747 m) as surficial deposit, but below 2,460 ft (747 m) is commonly covered by thin lacustrine deposits (lc/gm) although landforms retain features of ground moraine. Thickness of unit reaches about 50 ft (15 m), but locally it overlies other deposits, e.g. in thick sections along Nelchina River and Tazlina River.	General topographic form is alternating low ridges and swales oriented as shown by drumlin symbol, in the direction of ice movement. Net relief of 3 - 33 ft (1- 10 m) little modified by overlying lacustrine deposits (where lc/gm). Drainage fair on ridge tops where slope is adequate to drain overland, but poor where level. Poor internal drainage in silty till.	Permafrost probably prevalent but thickness not known; probably more than maximum recorded thickness of 125 ft (38 m) locally. Thin or absent where ground temperature is affected by bodies of running or standing water. May contain ice-rich zones that would cause differential settlement upon thawing.	Silt content much greater than 6% causes high degree of frost susceptibility wherever water is available.	Generally poorly to moderately well-suited for construction; limited by lack of granular borrow, potential for thaw settlement in areas of ice-rich permafrost, poor soil drainage, and local hummocky terrain. Higher, better-drained sites are most favorable for construction.	
ice Glacier ice	Crystalline glacier ice having a slow downvalley motion; buried by firn or perennial snow at above about 450 ft (1375 m), depending upon local conditons. Carries entrained rock debris.	Distributed as névé fields and small ice caps that feed large and small valley glaciers in northern Chugach Mountains, e.g. South Fork Matanuska River glacier, Nelchina Glacier, Tazlina glacier, and the small alpine glaciers area boundary). Thickness of snow and ice not known, probably several hundred meters within map area.	Smooth appearing, gently sloping white, clear ice, broken by crevassed medial moraines along axis of glacier, and by crevassed ice falls across the glacier. Marginal crevasses, lateral moraines and terminal moraines mapped as mic where ice cored, moraines as m where not ice cored.	Glaciers below the firn line are melting and are being replenished by ice moving downvalley; yet, in a sense glaciers are perennially frozen and structures built on them are subject to thaw settlement.	Glacial ice is not a soil that is susceptible to frost heaving, although there is about 11% volume increase when water freezes.	Not satisfactory for construction because of potential for thawing of ice to cause settlement and because of glacier motion and its effect on foundations.	
ke Kame-esker deposits	Washed sand and gravel, ranging from fine sand and silt to cobble and boulder gravel. Subangular to rounded, sandy matrix, generally less than 6% silt content. Locally contains pieces of coal, lignite or shale. Where covered by thin lacustrine deposits with little alteration of landforms, mapped as lc/ke.	Distributed as kames and kame terraces in Chugach Mountains, kames and eskers bordering the Little Nelchina River and Lake Louise, and as kame-esker beneath glaciolacustrine deposits in the Late Louise-Susitna Lake area. Thickness of deposits probably less than 50 ft (15 m), more likely 10 to 20 ft (3 to 6 m).	Forms ridges of kames and elongated, serpentine eskers with intervening swales and marshy areas. Ridges are normally well drained, the swales poorly drained. Through drainage is poorly intergrated. Soil drainage of unit mantled with lake deposits (lc/ke) is poor except for unusually sharp ridge crests.	Permafrost probably present, especially in the unit mantled with lake deposits (lc/ke) but may be thin and sporadic in lateral extent near heat sources such as ponds and lakes. Thickness not known. Little or no excess ice in granular material to cause differential settlement on thawing.	Only the silt and clayey horizons subject to frost action, including the silt mantle of unit lc/ke. Remainder of unit in granular materials is generally non frost-susceptible.	Although uneven topography, foundations and materials for borrow are generally favorable for construction. Some eskers and kames provide large quantities of easily-worked, well-drained gravel. Deposits need to be checked for coal and chert before use as concrete aggregate. Many deposits of this type have abrupt lateral variation from coarse to relatively fine material, and may include local pockets of frost-susceptible or otherwise unsatisfactory materials.	
lc Glaciolacustrine deposits	Wide range of stratified to massive deposits of glacial lakes laid down as mantle over glacial deposits (lc/gm, lc/m) and kame-esker deposits (lc/ke). Range from laminated silt, sand, and clay (sand mapped as s where known), to massive or poorly stratified stony silt, silty gravel (as lenses), sand, and gravel. Much of the near-surface material is stony silt (diamicton) with angular to rounded stones, sand, and abundant silt and clay, generally poorly stratified.	Distributed widely north of Lake Louise and Little Nelchina River to altitudes as high as 3,200 feet (975 m); to the south upper limit is about 2,500 ft (762 m), the principal shoreline (mapped in unit b) being 2,450 ft (747 m). Thickness of lake-bottom deposits probably only a few m in most places where the short-lived lake covered older deposits, the landforms of which are still preserved. Along Tazlina River and elsewhere in the deeper part of the lake basin, sediments mixed with other material are more than 300 ft (100 m) thick.	Forms either a flat plain, as in eastern part of the map area, or a thin cover that has a topography that reflects that characteristic of the underlying drift or kame-esker deposits. Lacustrine deposits are poorly drained and are covered by muskeg and stunted black spruce forest having a thick moss mat.	Underlain by the most continuous and thickest permafrost in map area, probably broken only by thawed zones beneath lakes and larger streams. Permafrost thickness generally less than but may locally exceed 125 ft (38 m), the greatest known permafrost thickness. Ice wedges and masses may be found in these frozen deposits, but most of the ice content is thin layers, lenses, and veins that in many areas exceed the natural voids of the soil; this excess ice will result in ground subsidence upon thaw of the permafrost.	Highly susceptible to frost action.	Frozen, ice-rich, fine-grained deposits require special construction methods to prevent thawing of permafrost. Sources of granular borrow are remote. Poor drainage. This map unit, especially lc and lc/gm, is probably the poorest of any for construction, but where underlain by gravelly or sandy material, lc/m, lc/ke, unit has more favorable foundation, material, and permafrost conditions.	
ls Landslide deposits	Unsorted unstratified mixture of clay, silt, angular rock fragments, mainly derived from bedrock slide with incorporated overburden. Fresh slide very wet, sticky mass of material.	Formed of shale in southeastern Talkeetna Mountains, upper Matanuska River tributaries, northernmost Chugach Mountains and along Glenn Highway east of Little Nelchina River. Formed of volcanic and igneous rocks on slopes oversteepened by glaciation in Chugach Mountians. Landslides in unconsolidated deposits are small and generally incorporated in Unit c. Thickness of large, mappable slides not known, perhaps as much as 65 ft (20 m).	Form characteristic lobate deposit with steep face at lower end and ridges and cracks headward to a steep headwall, usually in rock. Seepage from rock and surface drainage generally forms creek that flows down slide; slide material partially to wholly liquefied near seepages and drainage channels.	Permafrost conditions are unknown. Although a few slides may move on permafrost table, most are shallow to deep seated slides that move on failure planes in bedrock.	Silty slide materials susceptible to frost action.	Landslide deposits are generally uneven and are locally still moving as shown by living split trees and ground cracking. In general have poor foundations as liquefied mud, broken shale, large boulders of hard rock. Poor construction sites.	Slides should be checked for current and recent movement, and adjacent areas having the same geologic conditions should be investigated to ascertain potential for future landsliding.
m End-and lateral-moraine deposits	Loose, poorly-sorted, nonstratified silty sandy gravel, similar to ground moraine (gm) but less compacted and including much stratified sand and gravel, silt, and clay pockets, beds, and lenses. Pebbles, cobbles, and boulders are angular to subrounded.	Lateral and end moraines form unmodified subparallel till and gravelly ridges on slopes and hillsides above 3,200 ft (975 m): below that level moraines are commonly mantled by lake sediments (lc/m). The most prominent moraines are northwest of Curtis Lake, west of Little Nelchina River, and between Tolsona and Tazlina Hills north of Glenn Highway. Thickness unknown, but may be as much as 100 ft (30 m).	Range from subdued to prominent subparallel ridges on slopes and in lowlands to heavily kettled massive lateral moraines like those north of Glenn Highway. Relief as much as 80 ft (25 m). Moraines are crossed by streams, but much of the drainage is internal through permeable soils.	Permafrost may be present, but deposits with excess ice and settlement potential are probably relatively limited.	Silty material is susceptible to frost action.	Construction potential limited by uneven terrain, position on side hill, and numerous local ponds. However, foundation conditions good to fair on ridges and knobs, although commonly frost-susceptible. Suitable granular borrow locally available.	
mic Debris-rich glacial ice of medial, lateral, and terminal moraines	Ice matrix enclosing largely angular rock fragments, derived from mountainsides and transported as medial and lateral moraines and deposited as ice-cored moraine. Boulders concentrated at surface by melting probably more abundant than boulders entrained in ice at depth.	Occurs as lateral and medial moraines and as part of the end moraines of Nelchina, Matanuska, Tazlina and smaller glaciers in Chugach Mountains. Thickness of deposit not known.	Crevassed and ridged glacier surface in lateral and medial moraines; hummocks and collapse pits of ice-cored terminal or end moraines. Drainage of melt water and precipitation through crevasses to subglacial and marginal drainage systems. A few glacier-surface streams lead to enlarged crevasses (moulins) through ice.	Glacier ice is subject to settlement upon thawing, as much as 100 % of thaw depth, depending on amount of rock debris.	Ice, not subject to frost action.	Generally poor for construction because of potential for subsidence on thawing of glacial ice and because of deformation of foundations by glacier movement. Not a source of materials. Rough terrain prevents use in local areas as a temporary road.	
r Talus and rubble	Angular rock fragments of pebble to boulder size embedded in silty sandy matrix; nonstratified and poorly sorted, except where locally reworked by running water.	Most commonly occurs at the foot of and on lower mountain slopes in talus cones and in avalanche chutes, in scree slopes on upper mountainsides, and in cirques where the deposits may border glaciers or merge downvalley into rock glaciers. Thickness probably less than 50 ft (15 m). Rubble deposits of flat hill summits and gentle slopes (felsenmeer) are frost-split bedrock, mixed with finer material, that is as much as 15 ft (5 m) thick.	Talus cones are features of steep mountain slopes, which attain slopes of about 100 % at the upper limit of the cones, and as little as 10 % at the lower limit, or toe. Scree slopes exceed 100 % in upper part, and are 20 - 30 % at their lower limit. Drainage percolates freely through the coarse materials, and removes fines from the upper 1.5 ft (0.5 m) as it moves downslope.	Permafrost conditions not known. Similar coarse, silty deposits in other regions have permafrost that includes ice masses formed from buried snow banks.	Silt content above 6% makes deposits frost-susceptible in many locations.	Generally not well suited for construction because of instability of slopes or occurrence of avalanches. Near-surface blocky material may, in hard rock areas in Chugach Mountains, be suitable for riprap, coarse fill, or dimension stone, but generally not suitable elsewhere. Excavation may activate slope movement in steeper parts of unit.	Slopes may be moving by gravity creep of talus.
rg Rock-glacier deposits	Nonstratified, unsorted mixture of broken angular rock fragments in silty sandy matrix. Active rock glaciers, and possibly some farther downvalley that are no longer active, contain intergranular ice or ice that contains fragments of rock that are not in contact with one another.	Located within high mountain cirques or at the toe of talus cones in the southern Talkeetna and northern Chugach Mountains. Thickness not known, but perhaps as much as 65 ft (20 m).	Bulb-shaped in plan view on cirque floor and at base of talus cones; outer margin is a near-vertical slope and surface is, in the case of actively-moving rock glaciers, a series of 6 - 15 ft. (2 - 5 m) high ridges concentric with the frontal scarp of the rock glacier. Active rock glaciers are normally those closest to the talus source in the cirque or on slopes, but those farther removed may also have interstitial ice. Movement is much less than 3 ft (1 m) per year. Normally drainage is internal through the rubble to a stream that commonly forms from seepage from beneath the frontal scarp of the rock glacier.	Permafrost probably is preserved as interstitial ice of active and semi-active rock glaciers. Ice content sufficient to cause differential settlement upon thawing of ground.	Susceptible to frost action.	Undesirable for construction because of potential for downslope movement and possibility for differential settlement upon thawing of interstitial ice.	
s Lacustrine sand	Fine to medium-coarse sand, apparently a shallow-water facies, perhaps deltaic, of the glaciolacustrine deposits (Unit lc); mapped where sand can be differentiated from glaciolacustrine deposits. Sand may grade downward into sandy foreset and silty bottomset beds; locally mantled with thin lacustrine silt.	Distributed between Old Man Lake and Lake Louise at elevation 2,450-2,500 ft (747-762 m), where sand forms flat-topped ridges, perhaps these are locally ice-block deltas in which the sand is less than 15 ft (5 m) thick on sandy foreset and silty bottomset beds.	Well-drained sand deposits are on flat-topped ridges surrounded by lowland marsh and muskeg that is underlain by fine-grained lacustrine deposits (mapped as lc).	Probably perennially frozen, but no supporting subsurface data are available.	Fine and silty sand containing more than 6% silt is frost-susceptible; medium to coarse sand generally not frost-susceptible.	Topography, drainage, and sandy foundations seem satisfactory for construction; lack of coarser granular materials and lack of data on permafrost and subjacent materials are drawbacks. Local sources of timber available.	

Description of bedrock lithology

Upper-and lower-case map symbols listed in column at left edge of table; lower-case map symbols explained in adjoining Description of Surficial Deposits Map Units. Sources of information listed at bottom of each column.

Map Unit	Rock Type		South of Glenn Highway and west of South Fork Matanuska River	South of Glenn Highway between South Fork Matanuska River and Nelchina Glacier and River	South of Glenn Highway between Nelchina Glacier and River and Tazlina Lake and Glacier	South of Glenn Highway and east of Tazlina Lake and Glacier	North of Glenn Highway
Su	Clastic Sedimentary rocks	Undiff.	Undifferentiated siltstone, sandstone, and conglomerate of Chickaloon Formation.	Undifferentiated siltstone and sandstone along fault.	Not present.	Not present.	Undifferentiated siltstone, sandstone, and conglomerate of Matanuska Formation.
Sc		Coarse	Chiefly pebbly sandstone of Cretaceous age and siltstone, sandstone, conglomerate and carbonaceous conglomerate of Tertiary age.	Conglomerate and sandstone of Talkeetna Formation and terrestrial conglomerate and sandstone of Chickaloon and coal bearing formations of Tertiary age.	Not present.	Channel sandstone and conglomerate of Cretaceous age, outlet Tazlina Lake.	Includes basal conglomerate and overlying sandstone beds and lenses of Cretaceous age; pebbly sandstone with siltstone and concretions of Tuxedni formation; fluviatile conglomerate and locally coaly sandstone of Tertiary age.
Sm		Medium	Volcanic wacke and sandstone of Talkeetna Formation.	Chiefly volcanic sandstone of Talkeetna formation and sandstone of Matanuska Formation.	Chiefly sandstone, some shale, siliceous shale, and siltstone of lower part of Matanuska Formation; also sandstone of Jurassic age.	Sandstone, lesser shale and siltstone, siliceous shale and zeolitized sandstone; limestone beds.	Fine sandstone, sandstone, and siltstone of Cretaceous age; sandstone, some siltstone of Jurassic Chinitna Formation and Naknek Formation. Calcareous sandstone of Cretaceous age. Minor shale and pebbly sandstone.
Sf		Fine	Chiefly siltstone, locally containing limestone concretions and graded sandstone beds; minor sandstone and conglomerate. Commonly claystone or marine shale.	Mudstone, marine shale, siltstone, local thin layered chert, calcareous concretions; minor sandstone and conglomerate.	Siltstone, claystone of upper part Matanuska Formation, some sandstone interbedded with lenses and beds of sandstone and conglomerate.	Siltstone, claystone, some sandstone with lenses of sandstone and conglomerate.	Thin beds siltstone, claystone, some sandstone conglomerate; local cone in cone structure and limestone concretions; hard siltstone and claystone; local graded sandstone beds. Rocks of Jurassic and Cretaceous age.
Sl	Limestone		Not present.	Not present.	Not present.	Not present.	Nelchina limestone (calcarenite)
Vu	Volcanic rocks		Andesite, andesite and dacite, basaltic andesite or undifferentiated intermediate lavas and pyroclastic rocks, with minor marine sandstone and argillite; Talkeetna Formation.	Undifferentiated volcanic rocks, tuffaceous and volcaniclastic sediments, of basalt or metabasalt; Talkeetna Formation.	Andesite and basalt flows, tuff, tuff-breccia. and marine and nonmarine volcanogenic sedimentary rocks; Talkeetna Formation.	Andesite and basalt flows, tuff, tuff-breccia, and marine and nonmarine volcanogenic sedimentary rocks; Talkeetna Formation.	Lavas and pyroclastic rocks of intermediate composition; sandstone and argillite dominantly marine; largely Talkeetna Formation.
Vpt			Andesite and tuff, lithic tuff (predominantly material other than pyroclastics), and crystal lithic tuff (non-pyroclastic material dominantly; crystals).	Ignimbrite (a consolidated ash flow or nuée ardente deposit); layered welded pyroclastic; medium to well compacted fine to very coarse grained water-laid tuff with angular fragments. In thin layers; locally hydrothermally altered.	Included within Vu unit.	Included within Vu unit.	Not present.
Ig	Intrusive igneous rocks	Felsic Inter-mediate	Quartz diorite and tonalite, locally sheared (where dotted on map); felsic intrusives such as quartz porphyry; and some intermediate plutonic rocks or mixed mafic and felsic types.	Felsic to andesitic (intermediate) plugs and dikes, locally porphyritic, quartz diorite containing plagioclase, quartz, hornblende and biotite; locally intruded by sheeted mafic dikes as thick as three meters.	Felsic to intermediate plutonic rocks, include dikes, sills, and small stocks that are mostly dacite and larger bodies of biotite-hornblende granodiorite.	Biotite-epidote granite, medium grained and biotite hornblende granodiorite; minor amount of tonalite.	Plugs and dikes of feldspar porphyry and of quartz porphyry; medium-to coarse-grained hypabyssal rocks of intermediate composition.
Ib		Mafic	Gabbronorite, fine-coarse textured, sheared (where dotted on map); diorite and tonalite/quartz diorite; pyroxenite; pyroxene-hornblende gabbronorite with undifferentiated sheared intermediate and basic/ultra-basic rocks.	Gabbro, coarse to medium, sheared (where dotted on map), pyroxenite, horblendite, gabbro and quartz diorite (undifferentiated), cut by basic and intermediate and by diabase/basalt dikes.	Mafic plutonic complex, includes layered hornblende-pyroxene gabbro and leucogabbro, minor ultramafic bodies, diorite and tonalite. Layered quartz gabbro body is a large tectonic inclusion within McHugh complex (Mo) and is surrounded by amphibolite facies rocks and orthogneiss; has quartz and only minor hornblende. Banded.	Mafic plutonic complex, includes layered hornblende-pyroxene gabbro and leucogabbro, minor ultramafic bodies, diorite and tonalite.	Not present.
Iu		Utra-mafic	Serpentinite.	Not present.	Body of serpentinized pyroxenite within mafic plutonic complex near head of Bottley Creek.	Serpentinized pyroxenite.	Not present.
Ms	Metamorphic rocks	Valdez Group	Phyllite, locally chloritic, and thin bedded metagraywacke and metagreenstone beds and lenses. Grades westward into rocks more closely like McHugh (Mo).	Schist, graywacke, quartz sericite albite chlorite schist, graphitic. Also conglomerate, sandstone, and siltstone, volcaniclastic argillite altered to epidote-amphibolite facies, locally gneissic; intruded locally by gabbro.	Marine argillite, siltstone, sandstone, and conglomerate metamorphosed to metasedimentary rocks. Lenses and layers of mafic metatuff with minor massive or weakly foliated greenstone with pillow shapes.	Not present.	Not present.
Mv		Green/blue schist	Not present.	Not present.	Greenschist and blueschist as blocks in a mélange or as continuous belt extending northeastward from Nelchina Glacier.	Greenschist and blueschist as blocks in mélange or a continuous belt northeastward from Nelchina Glacier to Klutina Lake.	Not present.
Mg		Amphibolite Orthogneiss	Not present.	Not present.	Amphibolite facies metamorphic rocks and orthogneiss of tectonic inclusion in McHugh (Unit Mo). Contains local lenses of ultramafic rocks, banded mafic amphibolite, hornblende biotite diorite, quartz diorite gneiss, gabbro, and pyroxenite. Foliation or banding is folded.	Not present.	Not present.
Mo		McHugh complex	Not present.	Not present.	McHugh Complex, a deformed diverse assemblage that has broad discontinuous shear zones, and inclusions of marble (Unit Mm where mappable). Altered and sheared quartz diorite, diorite, and gabbro, greenschist, blueschist, aligned in matrix of phyllite or argillite; chloritic argillite has wispy lenses of green tuff, thin bedded siliceous argillite, argillaceous chert, massive and pillowed greenstone, tan and marine chert and wacke sandstone. Pumpellyite-prehnite grade metamorphism.	McHugh Complex, a deformed diverse assemblage that has broad discontinuous shear zones, and inclusions of marble (Unit Mm where mappable). Altered and sheared quartz diorite, diorite, and gabbro, greenschist, blueschist, aligned in matrix of phyllite or argillite; chloritic argillite has wispy lenses of green tuff, thin bedded siliceous argillite, argillaceous chert, massive and pillowed greenstone, tan and marine chert and wacke sandstone. Pumpellyite-prehnite grade metamorphism.	Not present.
Mm		Marble	Not present.	Not present.	Marble within McHugh Complex (Unit Mo).	Marble within McHugh Complex (Unit Mo).	Not present.
TM		Tectonic melange	Tectonic mélange of blocks of intermediate, mafic, and ultramafic igneous rocks in a matrix of cataclasite (chlorite-rich, fine-grained granular crushed intermediate, mafic, and ultramafic rocks) subsequently altered by retrograde processes.	Blocks and fragments of gabbro, quartz diorite, and volcanic rocks in a matrix of crushed rock (cataclasite) in a tectonic mélange.	Tectonic mélange delimiting the Border Ranges fault; blocks and crushed matrix of serpentinized ultramafic rock, rodingite dike rocks, blocks of layered gabbro, croesite schist, pillow basalt, marble, chert. Includes conglomerate like that in Chickaloon Formation (Tertiary). Besides prominent serpentinite is also incompletely serpentinized dunite, peridotite, and pyroxenite.	Tectonic mélange delimiting the Border Ranges fault; blocks and crushed matrix of serpentinized ultramafic rock, rodingite dike rocks, blocks of layered gabbro, croesite schist, pillow basalt, marble, chert. Includes conglomerate like that in Chickaloon Formation (Tertiary). Besides prominent serpentinite is also incompletely serpentinized dunite, peridotite, and pyroxenite.	Not present.
TMg			Not present.	Tectonic mélange of metabasalt and lesser amount of pyroclastic rocks, including those of Talkeetna Formation, in crushed cataclastic matrix.	Not present.	Not present.	Not present.
	Sources of Information		Burns, 1982 Burns and others, 1983 Grantz, 1960, 1965 Pessel and others, 1981 Winkler and others, 1984 unpublished mapping	Andresen and others, 1964 Burns, 1982 Grantz, 1961b, 1965 Pessel and others, 1981 Winkler and others, 1984, unpublished mapping	Andresen and others, 1964 Burns, 1982 Winkler, Silberman, and others, 1981.	Andresen and others, 1964 Burns, 1982 Winkler, Silberman, and others, 1981.	Andresen and others, 1964 Detterman and others, 1976 Grantz, 1960, 1961a, 1961b, 1965 Hawkins, 1976 Winkler and others, 1984 unpublished mapping

Ground-water resources

Experience in developing ground-water resources along the Glenn Highway for use by residents and businesses suggests that certain general principles apply, modified by local conditions and exceptions to the rule. In general, the thin, relatively impermeable glaciolacustrine and glacial deposits and thin glaciofluvial mantle yield no water or only small supplies to dug or driven wells, but the long period of no recharge and low winter water table makes many of these wells unproductive in winter. The uppermost bedrock formation, chiefly relatively impermeable shale, siltstone, and fine, tight sandstone of the Matanuska Formation (included in map unit Sf) along the Glenn Highway has yielded little or no water to wells. Small supplies have been developed in talus deposits and alluvial fans along the slopes of Sheep Mountain, where the water is high in sulfate coming from gypsiferous deposits; this water is highly corrosive to metal pipe. Several wells in glacial drift that is more than 66 ft (20 m) thick have located water in unfrozen permeable lenses or beds. Tertiary gravel is an excellent aquifer where beneath the drift or lacustrine deposits in the valleys, e.g., well 5 (map and section A-A') on Mendeltna Creek where the base of gravel beneath the drift was 583 ft (178 m) below the surface. This aquifer may extend southward in Mendeltna Creek valley to the south side of Fish Lake where a flowing artesian well is located on the south shore (Mrs. C. R. Houston, oral commun., 1984). The aquifer may have some still-unknown relation to Mendeltna Springs.

The Copper River Basin saline aquifer lies generally below 2,000 ft (610 m) above sea level, and, for the most part, east of the map area, except for a few gas seeps and possible saline seepages near Tolsona Lake (well 11). Elsewhere most of the well water and that from Mendeltna Springs is fresh and potable. Saline springs lie immediately east of Tolsona Creek along both Glenn Highway and Tazlina River (Nichols and Yehle, 1961; Grantz and others, 1962). Connate (saline) water was found in lower Cretaceous beds in at least one oil well (4, map, and also under pressure in a well drilled by Pan American Petroleum Corp. at Glennallen east of the map area) (Alaska Geological Society, 1970; Williams, 1970, p. 55), along with methane gas, evidently derived from the coal in these sediments (Reitsema, 1979). The water and gas have migrated from bedrock upward through the unconsolidated deposits to either be discharged from springs and mud volcanoes, or to become trapped beneath an impermeable bed in the unconsolidated deposits, such as lacustrine silt. The potentiometric surface of the saline aquifer generally slopes eastward and southward toward the incised Copper and Tazlina Rivers, respectively, and its elevation away from these rivers may be above land surface, so that saline water could rise in a pipe above ground level; the problems of saline water appear limited to the lowlands below 2,000 ft (610 m) elevation along the eastern edge of the map area, extending eastward toward Glennallen and Gulkana. Further information may be obtained from the literature cited and from well inventories by Waller and Selkregg (1962) and a more recent one made by R. L. Glass and others in support of current hydrologic studies by Water Resources Division, U.S. Geological Survey (Emery and other, 1985).

Other wells among those numbered 8-25 in Waller and Selkregg (1962) are largely shallow driven points or dug wells in the thin drift that covers the relatively impermeable upper Cretaceous shale and siltstone or the much more permeable Tertiary sandstone and conglomerate. Well 19 in Waller and Selkregg is a U.S. Army well 927 ft (281 m) deep at about mile 3 (4.8 km) on the Lake Louise Road; it has a log similar to that in nearby Union Oil Tazlina Unit No. 1 (well 6, cross section AA'); the base of permafrost was 100 ft (30 m) deep in the Army well. Other dry holes at mile 130, 126, 135 Glenn Highway between Sheep Mountain and Little Nelchina River apparently bottomed in tight shale or siltstone (R. L. Glass, U.S. Geological Survey, written commun., 1984).

Subsurface data
(see also cross sections on sheet 2)

Map No.	Depth (m)	Log of well	Remarks and other information
1-6	All information on cross section A-A', sheet 2		No data on permafrost.
7-9	30.5	Chiefly glacial drift and silty sandy and gravelly material of Tertiary age, with lowermost few m possibly shale of upper Cretaceous age. Tertiary rocks exposed from drill sites 150 m up hill to summit north of highway	Frozen to about 20 m.
10		0-37 m lacustrine silt, sand, gravel (outwash or ice contact) and some basal till; 37-51 m poorly consolidated sandstone gravel, sand or sandstone, coal; 51-73 m shale(?)	Coal beds reported as thick as 1.5 m. No water at total. depth. Frozen 0-5 m.
11	68	0-21 m frozen gravelly material; 21-68 m silt and clay	Gas at base of frozen ground at 21 m.
12	79	?-79 m shale/siltstone of upper Cretaceous age; thin cover of till	Reported frozen to 24 m
13	31	0-25 m frozen gravel and muck; 25-31 m no water	Frozen to 25 m
14	78.3	0.6-5.2 m silty gravel; 5.2-13.7 m frozen silt and sand; 13.7-38.1 m frozen gravel; 38.1-78.0 m clay and hardpan; 78.0-78.3 m gravel, water	Frozen 5.2 m to 38.1 m
15	54.9	0-25.9 m glacial capping, muck and wash; 25.9-26.1 m wash gravel; 26.1-29.6 m silt; 29.6-32.3 m blue-gray gravel, quartz, basaltic lava, no sediment, few colors of gold; 32.3-35.9 m, vegetable muck, willow twigs; 35.9-36.6 m gravel; 36.6-41.1 m vegetable muck, gas-bearing (ignited); 41.1-43.5 m blue-gray gravel; 43.5-45.5 m yellow gravel; 45.5-48.5 m clean wash, no sediment 48.5-54.9 m no log	Permafrost conditions not recorded. Location on claim 19 below discovery is approximate (Chapin, 1918, p. 61).

Engineering soils

Suitability of the surficial unconsolidated deposits for contruction materials and foundations is evaluated in the description of map units on sheet 2. The basis for the evaluation is sampling and testing of soils believed reasonably representative of the map units; however, individual beds and lenses within complexly stratified and lenticular deposits cannot represent the unit as a whole, as, for example, in pit-run material taken from a vertical section consisting of many individual beds and lenses of different characteristics. Not all map units were tested. The conclusions drawn from the data, therefore, are useful only as a general guide for route selection or soil exploration, and should not supplant the usual subsurface investigations required by good engineering practice. The soil tests, including Atterberg limits and mechanical analyses needed to classify the material were made at only 20 locations, mostly in the fine-grained problem soils, and only a few in gravelly or sandy materials. Additional test results are available in reports of subsurface testing and sampling for construction or reconstruction of state highways by Alaska Department of Transportation and Public Facilities and its predecessor organizations. Basically, the soils can be divided in five groups: (1) organic silt, peat, and muck; (2) sand; (3) sand and gravel; (4) lacustrine and fluvial silt; and (5) glacial till. The soils were classified according to American Association of State Highway and Transportation Officials (AASHTO, 1982), the classification of soils and soil-aggregate mixtures for highway construction purposes. Data were collected by Joe Kubota of the U.S. Department of Agriculture during his 1952 field studies and related laboratory work (unpublished), and from samples collected by Kubota and the writer that were later analyzed by Bureau of Public Roads, U.S. Department of Commerce, and by the Alaska District, Corps of Engineers, U.S. Army, Anchorage.

Surficial silt and admixed peat and other organic material form a mantle as thick as 10 ft (3 m) in poorly drained areas not only on the lacustrine silt, but also in the undrained depressions of moraines, ground moraine, ice-contact deposits, and alluvial flood plain and terrace deposits. It is generally classified in group A-5 of AASHTO 1982 classification and has a group index for fine-grained soils that exceeds 20, indicating very poor subgrade materials, whether dried or under natural moisture conditions.

Sand, a constituent of a variety of deposits (map units al, at, b, e, ke, and s) was analyzed at three sites—a lacustrine sand exposed in a river bluff, a kame-esker or deltaic sand, and sand from beneath ground moraine on the summit of the 4,000-ft (1,219-m) hill northwest of Eureka Lodge. The AASHTO classification of these sand deposits are either group A-2-4(o), A-2, or, where silty, A-4(2).

Sand and gravel mixtures are largely within the A-la category of the AASHTO classification. Sand and rounded gravel occurs chiefly in kames and eskers (map unit ke), fluvial deposits (al, at), and beach deposits (b). Other types of gravel are either more angular, more silty, or both, and tend toward the A-4 group of the AASHTO system; these units include colluvium (map unit c), rock glacier deposits (rg), talus (t), and landslide deposits (ls). These units were not sampled and have slope stability problems that make them unsuited for many purposes. Sand and gravel, with both angular and rounded stones and increasing amounts of silt form the gravelly till or sandy till that is common in the morainal deposits (unit m), but rarer in the ground moraine (gm) and glaciolacustrine diamicton included in unit lc; some of these are in AASHTO Group A-4, are frost susceptible, and may contain segregated ice where perennially frozen.

Lacustrine and fluvial silt and clay and stone-poor diamicton (unit lc) have been classed as AASHTO Group A-4 where the deposit is of sand and silt mixtures, and A-6 or A-7 where it is of silt and clay mixtures. The Group Index (AASHTO, 1982) for fine-grained soils is greater than 20 for the very plastic varved clay and silt within unit lc in the banks of Tolsona Creek near the bridge, of Bottley Creek 15 mi (24 km) above its mouth, and of Nelchina River above the mouth of Little Nelchina River; these materials are a very poor subgrade, and, in addition, contain excess ice as lenses and veins which cause differential settlement of the material upon thawing of the permafrost. Where the Group Index is less than 20, fine-grained soils may be suitable foundations with proper compaction and drainage; however, the ice content of permafrost is likely to be so high that settlement will take place on thawing of the ground during or following construction disturbance.

Glacial till generally falls in AASHTO classification A-4, and has a generally low Group Index indicating that it may, with good drainage and proper compaction be a suitable subgrade material. The till of map unit gm and some of that of unit m falls in this category. The till-like glaciolacustrine diamicton, landslide deposits, talus, and other units may be more silty, or even more gravelly, to warrant a higher or lower AASHTO rating.

Very few engineering data have been collected on bedrock. The most common rock units along the Glenn Highway transportation corridor are shale and sandstone (units Sf, Sm), volcanic flows and pyroclastic rocks (map unit Vu), and sandstone and conglomerate (unit Sc) which contains deleterious amounts of chert and coal. The shale is baked and indurated west of Eureka Lodge and has been used extensively for road fill. To the east the shale is soft and fails in large landslides under favorable conditions on slopes that have been oversteepened by glacial erosion, as at Slide Mountain. Nearby, at the Little Nelchina River crossing some difficulty was encountered in reaching refusal of bridge piling driven in the soft shale. The rock in adjacent roadcuts is still sliding and has caused unending maintenance problems. Tests of a bulk sample of this shale from the eastern end of the old (1952) bridge by the laboratory at Alaska District U.S. Army Corps of Engineers (W. M. Knoppe, written commun., December 1952) indicated a density of 112.6 lb/ft^3, specific gravity of 2.6, moisture content of 11%, and saturated CBR of 10% at 1/10 in, and 6% at 2/10 in, and swell of 2.4%. After drying the density was 116.2 lb/ft^3, moisture content 3.1%, saturated CBR 3% at 1/10 in, 4% at 2/10 in, and swell 7.2%. Los Angeles Abrasion Test of fresh material showed grading "A", Wear 38% at 500 revolutions. Dried lumps were pulverized; the material had 60% passing the 0.075 mm size, liquid limit of 39, plasticity index of 15, and was classified as CL under the Corps of Engineers system. The pulverized shale is in Group A-6 (AASHTO, 1982) and has a Group Index of 7, probably marginal as a subgrade material if properly drained and compacted and if not frozen with excess ice to cause differential settlement upon thawing. Lumps of shale, so common in the sand and gravel of the alluvial deposits north of the Chugach Mountains have caused the alluvium to fail the magnesium-sulfate-soundness test for concrete aggregate. Similarly, the chert and coal of Tertiary rocks have been redistributed in some unconsolidated deposits and may cause the deposits to be unsuitable for concrete aggregate.

Geologic hazards and special problems

Earthquakes, proximity to active faults, slope stability problems, permafrost, avalanches, glacial lake "dumping" to raise lake levels and cause drastic increases in river discharge and stage are among the hazards and special problems.

Earthquakes

Earthquakes are common in southern Alaska, and many have been felt in the Copper River Basin. None on record was so severe as the 8.4 magnitude earthquake of March 27, 1964. The southern border of the area is only 35 mi (56 km) north of the epicenter of this earthquake. Seismic shaking, landsliding, ground cracking and other effects described by Ferrians (1966) caused slight to moderate damage to facilities. The land subsided 3 ft (1 m) at the southern edge of the area, nearest the epicenter, 2 ft (0.6 m) near Sheep Mountain, 1 ft (0.3 m) along Glenn Highway, and 0 ft along the northern border of the area (Ferrians, 1966, fig. 4). Local subsidence of the free face of fan deltas in large lakes, such as Tazlina Lake, caused large waves to cast lake ice high up on the shores. The most badly damaged building was a house that slid off its foundations toward a lake near Mile 160 Glenn Highway. Intensive ground cracking and ejection of water and fine sediment was noted on most alluvial deposits within 100 mi (161 km) of the epicenter, and cracking of lake ice was common, especially on large lakes disturbed by waves generated by slumping of deltas.

Proximity to active faults

Seismic design for the Trans-Alaska Pipeline, about 18 mi (29 km) east of the map area provided for magnitude 8.5 within the Chugach Mountains, a magnitude 7.0 in the Copper River Basin, and a magnitude 8.0 in the vicinity of the Denali fault in the Alaska Range 70 mi (113 km) north of the map area (Page and others, 1972). Westward extension of these design criteria earthquakes requires examination by earthquake specialists of the faults within the map area and their recent activity, and would seem to require a minimum design magnitude of 7.0. The western part of the area, within the upper Matanuska River valley is bordered by the Border Ranges/Eagle River fault and by the Castle Mountain/Caribou fault (see inset map). The Border Ranges fault passes through the northern Chugach Mountains as a thrust along which the Valdez Group has been moved beneath the older igneous and metasedimentary rocks (MacKevett and Plafker, 1974; Winkler, Silberman, and others, 1981). The fault cuts Tertiary rocks, but is believed to have been largely inactive in the last 10,000 yrs; however, displacement of talus and other Recent deposits has been detected along the fault by Burns and others (1983) 2.15 to 3.3 mi (3.7 to 5.1 km) east of Matanuska Glacier. Grantz (1965), Andreasen and others (1964), Detterman and others (1976), and Silberman and Grantz (1984) in mapping the Castle Mountain fault and its major branch, the Caribou fault, believe that the system is not seismically active and that movements, if any, are due to lower crust displacements, rather than to surface faulting. These faults are believed to splay into smaller faults within the Copper River Basin. Definite evidence of ground slippage in Holocene time has been noted in the Matanuska River valley west of the map area, and a possible active fault segment is located on lower Sanona Creek. No specific seismic design criteria have been established as yet for the map area.

Slope stability problems

Slope stability problems are largely a result of glacial oversteepening of slopes during the last and earlier glaciations. Slope failure, chiefly landslides and also rockfalls and avalanches, is not limited to the soft siltstone and shale of the Matanuska Formation (unit Sf, map), for other slope failures occur in gabbro, metamorphic rocks, and perhaps have resulted from failure of a rock wedge in an oversteepened slope, the base of which was cut away by the glaciers. The largest area of landslides is on the south slope of Slide Mountain, where many landslides have occurred since deglaciation; the failures are in flat-lying Matanuska Formation capped by about 50 ft (15 m) of Tertiary gravel and sand. The most recent slide reportedly took place not long before the 1946 inspection by R. F. Black (unpublished U.S. Geological Survey field notes, 1946). Smaller slides in shale are common along East Fork Matanuska River. Slides and earth flows are common in lacustrine and colluvial silt and clay and in silty till along streams and on hillsides. Rock falls and rock avalanches in narrow chutes in steep walled valleys are local hazards. Creep on steep slopes in talus and in rock glaciers makes them poor foundations.

Permafrost

Perhaps the most widespread of the geologic hazards is that of permafrost, or perennially frozen ground. In the map area, it is discontinuously distributed, but is present in most areas except beneath the larger lakes or streams, or in some cases beneath coarse gravelly material through which water percolates readily. Depth of permafrost below the land surface known from only a few wells (table) is about 80 to 100 ft (25 to 30 m), and one well in which permafrost is 125 ft (38 m) deep; these depths are compared to maximum depths of 150 to 250 ft (46 to 76 m) in river bank exposures and 100 to 200 ft (30 to 61 m) in wells (Nichols, 1956, p. 8) near Glennallen, east of the map area. Permafrost (near Glennallen) has a temperature of about 30°F (-1°C) at the level of zero annual amplitude (Nichols, 1966, p. 173), and, at that temperature, it is very easily thawed by slight changes in the ground surface temperature brought on by alteration of the surface conditions, as, for example, by clearing the vegetation. Much of the permafrost in fine-grained deposits contains excess ice as lenses, veins, and small masses, including wedges. Thawing of this excess ice causes ground settlement. The amount of subsidence depends on the quantity of ice in excess of the natural voids in the materials. The silty sediments locally are thick enough and contain enough excess ice to cause settlements of at least 3 ft (1 m); normally, however, the ice-rich material is less than 20 ft (6 m) thick, and settlement is several inches but may in some areas exceed a foot. The character of permafrost in each map unit is given in the description of surficial deposits map units.

Avalanches on talus slopes and floods on fans

In addition to rock avalanches at any time of year, many avalanche chutes above talus cones are the site of springtime avalanches of snow and rock debris which sweep all before them and commonly block passage at the foot of the hill in the accumulation area. Avalanches can be identified sometimes by the scarred, matted, and broken down appearance of the vegetation. They are particularly common in the glaciated Chugach Mountains, and less common in the more gently sloping terrain of the Talkeetna Mountains.

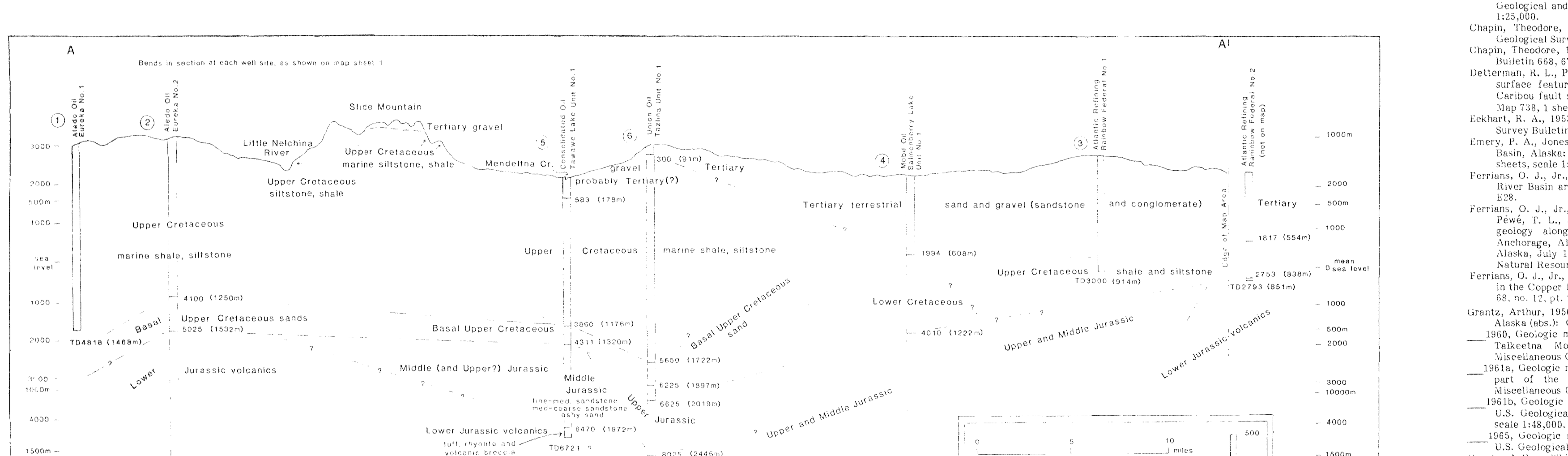
Alluvial fans in the Chugach Mountains are formed by small tributary streams which are subject to torrential floods and to frequent channel shifting following heavy rain or snowmelting. Those in the less rugged Talkeetna Mountains seem to have more stable stream courses, a lower gradient, and perhaps a greater drainage basin storage capacity in the vegetated slopes than those of the Chugach Mountains. Nevertheless, high rainfall during summer storms can cause devastating floods.

Glaciers and outburst floods

The glaciers of the Chugach Mountains within the map area are not known to be of the surging type. Nelchina and Tazlina Glaciers are each bordered by two ice-dammed lakes which drain periodically through the ice to cause outburst floods. These sudden outbursts of water carried small pieces of ice from Tazlina Glacier to the lake and raised the level of the 60 mi^2 (155 km^2) lake 5 ft (1.5 m) overnight (C. R. Houston, written commun., 1984) . These floods, as reflected in the gaging record on Tazlina River at the Richardson Highway bridge, do not happen every year, may take place twice during a year, generally happen in late July or August, and may be triple the normal summer discharge to more than 60,000 ft^3/sec (2,000 m^3/sec) (Post and Mayo, 1971). The four ice-dammed lakes drain in different sequence in different years, sometimes in pairs, as on Tazlina Glacier in 1962, or in some years not at all. Post and Mayo suggested that the peak discharge of 1962 was caused by simultaneous drainage of the two lakes bordering Tazlina Glacier; in other years, when the lakes bordering Nelchina Glacier drained, no increase in discharge correlable with an outburst flood was detected, so the gradual release of water must have been further damped by storage in Tazlina Lake. The reported 5-ft increase in level of Tazlina Lake is an increase in storage that is just about equal to the amount of water drained from the two lakes bordering Tazlina Glacier. These lakes have an aggregate area of 2.7 mi^2 (4.5 km^2) an estimated average depth over that area of 110 ft (34 m) when full. Simultaneous impact of drainage of all four lakes on the level of Tazlina Lake and the resulting peak discharge of Tazlina River might, if coincident with glacier-melt maximum discharge of the Copper River, affect structures along the Copper River downstream from the mouth of the Tazlina River. In July 1932, the railway bridge across the Copper River at Chitina was destroyed by high water augmented by a breakout flood on the Tazlina (Post and Mayo, 1971).

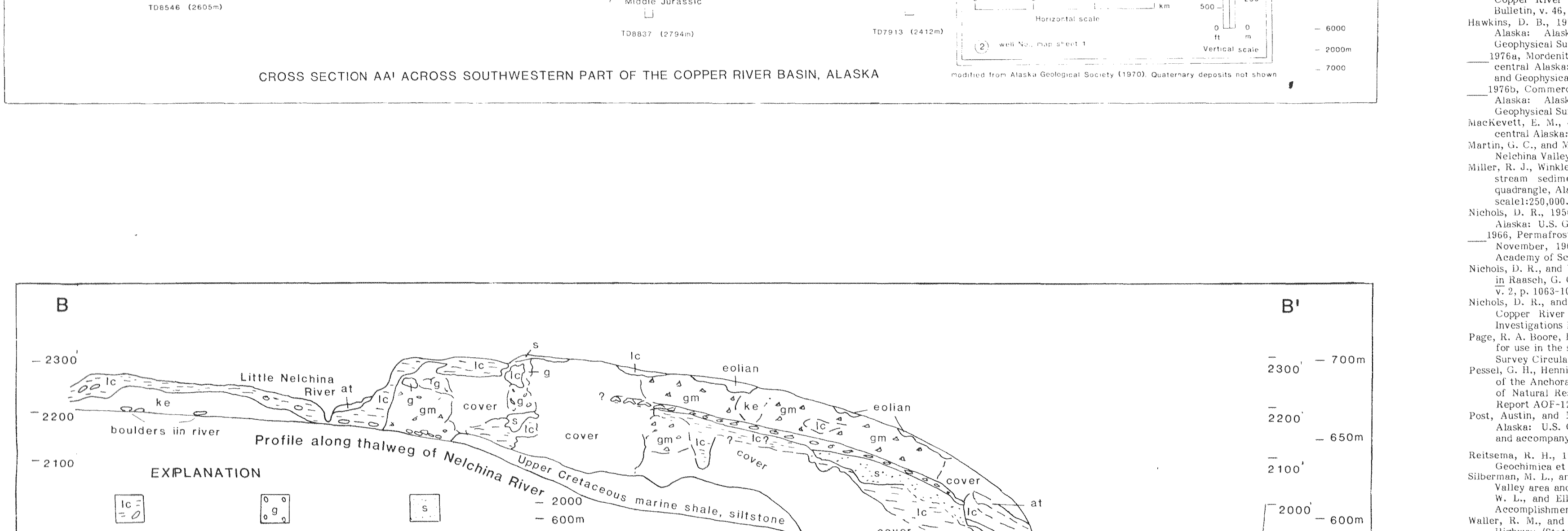
Cross sections

The cross sections on this sheet show the subsurface unconsolidated deposits and bedrock. A bedrock cross section (A-A') has been based on seven exploratory oil wells and test holes, ranging from 2,793 to 8,837 ft (851 to 2,794 m) deep. These wells have defined the local basement rocks (volcanic rocks of lower Jurassic age) over much of the section and apparently were drilled into or through the target formations of upper and middle Jurassic age without achieving success (Alaska Geological Society, 1970). A cross section (B-B') shows materials exposed in river bluffs along the Nelchina River from Eureka Creek to Tazlina Lake.



CROSS SECTION AA' ACROSS SOUTHWESTERN PART OF THE COPPER RIVER BASIN, ALASKA

modified from Alaska Geological Society (1970). Quaternary deposits not shown



CROSS SECTION BB' ALONG NELCHINA RIVER, EUREKA CREEK TO TAZLINA LAKE

References cited

Alaska Geological Society, 1970, Stratigraphic correlation sections, Copper River Basin, Alaska: Anchorage, Alaska, Alaska Geological Society Stratigraphic Committee year 1970, 3 sections, vertical scale 1 in.=400 ft.
Alaska Glacial Map Committee of the U.S. Geological Survey, 1965, Map showing extent of glaciations in Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-415, 1 sheet, scale 1:2,500,000.
American Association of State Highway and Transportation Officials (AASHTO), 1982, Recommended practice for the classification of soils and soil-aggregate mixtures for highway construction purposes, in Standard specifications for transportation materials and methods of sampling and testing, Part I, Specifications adopted by AASHTO, 13th ed., July: Washington, D.C., American Association of State Highway and Transportation Officials Designation M145-82, p. 211-217.
Andreasen, G. E., Grantz, Arthur, Zeitz, Isidore, and Barnes, D. F., 1964, Geologic interpretation of magnetic and gravity data in the Copper River Basin, Alaska: U.S. Geological Survey Professional Paper 316-H, p. 135-153, 2 pls., scale 1:250,000.
Beikman, H. M., 1974, Preliminary geologic map of the southeast quadrant of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-612, 2 sheets, scale 1:1,000,000.
Burns, L. E., 1982, Gravity and aeromagnetic modeling of a large gabbroic body near the Border Ranges Fault, southern Alaska: U.S. Geological Survey Open-File Report 82-460, 66 p., 3 pls.
Burns, L. E., Little, T. A., Newberry, R. J., Decker, J. E., and Pessel, G. H., 1983, Preliminary geologic map of parts of the Anchorage C-2, C-3, D-2, and D-3 quadrangles, Alaska: Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Report of Investigations 83-10, 3 sheets, scale 1:25,000.
Chapin, Theodore, 1915, Auriferous gravels of the Nelchina-Susitna region: U.S. Geological Survey Bulletin 622-D, p. 118-130.
Chapin, Theodore, 1918, The Nelchina-Susitna region, Alaska: U.S. Geological Survey Bulletin 668, 67 p.
Detterman, R. L., Plafker, George, Tysdal, R. G., and Hudson, Travis, 1976, Geology and surface features along part of the Talkeetna segment of the Castle Mountain-Caribou fault system, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 738, 1 sheet, scale 1:63,360.
Eckhart, R. A., 1953, Gypsiferous deposits on Sheep Mountain, Alaska: U.S. Geological Survey Bulletin 989-C, p. 39-60, 2 pls., scale 1:12,000 and 1:2,650.
Emery, P. A., Jones, S. H., and Glass, R. L., 1985, Water resources of the Copper River Basin, Alaska: U.S. Geological Survey Hydrologic Investigations Atlas HA-868, 3 sheets, scale 1:2,000,000.
Ferrians, O. J., Jr., 1966, Effects of the earthquake of March 27, 1964, in the Copper River Basin area, Alaska: U.S. Geological Survey Professional Paper 543-E, p. E1-E28.
Ferrians, O. J., Jr., Nichols, D. R., and Williams, J. R., 1983, Copper River Basin, in Péwé, T. L., and Reger, R. D., eds., Guidebook to permafrost and Quaternary geology along the Richardson and Glenn Highways between Fairbanks and Anchorage, Alaska: Fourth International Conference on Permafrost, Fairbanks, Alaska, July 18-22, 1983, Guidebook 1, Fairbanks, Alaska: Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, p. 137-175.
Ferrians, O. J., Jr., and Schmoll, H. R., 1957, Extensive proglacial lake of Wisconsin age in the Copper River Basin, Alaska (abs.): Geological Society of America Bulletin, v. 68, no. 12, pt. 2, p. 1726.
Grantz, Arthur, 1956, Possible origin of the placer gold deposits of the Nelchina area, Alaska (abs.): Geological Society of America Bulletin, v. 67, no. 12, pt. 2, p. 1807.
___1960, Geologic map of Talkeetna Mountains (A-1) quadrangle, and the south third of Talkeetna Mountains (B-1) quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-314, 1 sheet, scale 1:48,000.
___1961a, Geologic map and cross sections of the Anchorage (D-2) and northeasternmost part of the Anchorage (D-3) quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-342, 1 sheet, scale 1:48,000.
___1961b, Geologic map of the north two-thirds of Anchorage (D-1) quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-343, 1 sheet, scale 1:48,000.
___1965, Geologic map and cross sections of the Nelchina area, south-central Alaska: U.S. Geological Survey Open-File Report 255, 4 sheets, scale 1:63,360.
Grantz, Arthur, White, D. E., Whitehead, H. C., and Tagg, A. R., 1962, Saline Springs, Copper River Lowland, Alaska: American Association of Petroleum Geologists Bulletin, v. 46, no. 11, p. 1990-2002.
Hawkins, D. B., 1973, Sedimentary zeolite deposits of the upper Matanuska Valley, Alaska: Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Special Report 6.
___1976a, Mordenite deposits and zeolite zonation in the Horn Mountain area, south-central Alaska: Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Special Report 9, 9 p., 2 pls., scale 1:21,120.
___1976b, Commercial grade mordenite deposits of the Horn Mountains, south-central Alaska: Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Special Report 11, 11 p., 1 pl., scale 1:15,840.
MacKevett, E. M., Jr., and Plafker, George, 1974, The Border Ranges fault in south-central Alaska: U.S. Geological Survey Journal of Research, v. 2, no. 3, p. 323-329.
Martin, G. C., and Mertie, J. B., Jr., 1914, Mineral resources of the upper Matanuska and Nelchina Valleys: U.S. Geological Survey Bulletin 592-H, p. 273-299.
Miller, R. J., Winkler, G. R., O'Leary, R. M., and Cooley, E. F., 1982, Analyses of rock, stream sediment, and heavy-mineral concentrate samples from the Valdez quadrangle, Alaska: U.S. Geological Survey Open-File Report 82-451, 224 p., 2 pl., scale1:250,000.
Nichols, D. R., 1956, Permafrost and ground-water conditions in the Glennallen area, Alaska: U.S. Geological Survey Open-File Report, 14 p., 2 pls.
___1966, Permafrost in the Recent Epoch: Permafrost International Conference, 11-15 November, 1963, Lafayette, Indiana, Proceedings: Washington, D.C., National Academy of Sciences—National Research Council Publication 1287, p. 172-175.
Nichols, D. R., and Yehle, L. A., 1961, Mud volcanoes in the Copper River Basin, Alaska, in Raasch, G. O., ed., Geology of the Arctic: Toronto, University of Toronto Press, v. 2, p. 1063-1087.
Nichols, D. R., and Yehle, L. A., 1969, Engineering geologic map of the southeastern Copper River Basin, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-524, 1 sheet, scale 1:125,000.
Page, R. A. Boore, D. M., Joyner, W. B., and Coulter, H. W., 1972, Ground motion values for use in the seismic design of the Trans-Alaska Pipeline System: U.S. Geological Survey Circular 672, 23 p.
Pessel, G. H., Henning, M. W., and Burns, L. E., 1981, Preliminary geologic map of parts of the Anchorage C-1, C-2, D-1, and D-2 quadrangles, Alaska: Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Open-File Report AOF-121, 1 sheet, scale 1:63,360.
Post, Austin, and Mayo, L. R., 1971, Glacier-dammed lakes and outburst floods in Alaska: U.S. Geological Survey Hydrologic Investigations Atlas HA-455, 2 sheets, and accompanying text, 10 p.
Reitsema, R. H., 1979, Gases of mud volcanoes in the Copper River Basin, Alaska: Geochimica et Cosmochimica Acta, v. 43, no. 2, p. 183-187.
Silberman, M. L., and Grantz, Arthur, 1984, Paleogene volcanic rocks of the Matanuska Valley area and the displacement history of the Castle Mountain fault, in Coonrad, W. L., and Elliott, R. L., eds., The United States Geological Survey in Alaska: Accomplishments during 1981: U.S. Geological Survey Circular 868, p. 82-86.
Waller, R. M., and Selkregg, L. F., 1962, Data on wells and springs along the Glenn Highway (State 1), Alaska: U.S. Geological Survey in cooperation with Alaska Department of Health and Welfare, Basic Data Report, Water-Hydrological Data No. 15, 23 p., 1 pl.
Williams, J. R., 1970, Ground water in the permafrost regions of Alaska: U.S. Geological Survey Professional Paper 696, 83 p.
___1984, Late Wisconsin glacial retreat and lake levels, western Copper River Basin, Alaska (abs.): Geological Society of America, Cordilleran Section, 80th meeting, Anchorage, Alaska, May 30, 31, June 1, 1984, Abstracts with Programs, v. 16, no. 5, p. 340, abstract 47,109.
Williams, J. R., and Ferrians, O. J., Jr., 1961, Late Wisconsin and Recent history of the Matanuska Glacier, Alaska: Arctic, v. 14, no. 2, p. 83-90.
Williams, J. R., and Johnson, K. M., compilers, 1980, Map and description of late Tertiary and Quaternary deposits, Valdez quadrangle, Alaska: U.S. Geological Survey Open-File Report 80-892-C, 2 sheets, scale 1:250,000.
Williams, J. R., and Johnson, K. M., 1981, Surficial deposits map of the Valdez quadrangle, Alaska, in Albert, N. R. D., and Hudson, Travis, eds., The United States Geological Survey in Alaska: Accomplishments during 1979: U.S. Geological Survey Circular 823-B, p. B76-B78.
Winkler, G. R., Miller, R. J., Mackevett, E. M., Jr., and Holloway, C. D., 1981, Map and summary table describing mineral deposits in the Valdez quadrangle, southern Alaska: U.S. Geological Survey Open-File Report 80-892-B, 1 sheet, scale 1:250,000.
Winkler, G. R., Silberman, M. L., Grantz, Arthur, Miller, R. J., and MacKevett, E. M., Jr., 1981, Geologic map and summary geochronology of the Valdez quadrangle, southern Alaska: U.S. Geological Survey Open-File Report 80-892A, 2 sheets, scale 1:250,000.

ENGINEERING - GEOLOGIC MAP OF THE SOUTHWESTERN COPPER RIVER BASIN AND UPPER MATANUSKA RIVER VALLEY, ALASKA

BY

JOHN R. WILLIAMS

1985

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