Report of Investigations 95-3

PHOTOINTERPRETIVE SURFICIAL GEOLOGY OF AREAS SURROUNDING ALATNA AND ALLAKAKET, ALASKA

by

R.J. Motyka

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Tony Knowles, *Governor*

John T. Shively, *Commissioner*

Milton A. Wiltse, *Acting Director*

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SHEET
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Sheet 1. Photointerpretive surficial geology of areas surrounding Alatna and Allakaket, Alaska

PHOTOINTERPRETIVE SURFICIAL GEOLOGY OF AREAS SURROUNDING ALATNA AND ALLAKAKET, ALASKA

by
Roman J. Motyka[1]

INTRODUCTION

The accompanying geologic map (sheet 1) illustrates extents and types of unconsolidated deposits in sections 9-11, 14-16, and 21-23, Bettles C-6 Quadrangle, in and around the villages of Alatna and Allakaket. Table 1 describes map units and table 2 presents engineering geology properties. The villages were devastated by a disastrous flood in August 1994. This mapping project was undertaken in support of government efforts to help define potential sites for relocation of homes, public buildings, and infrastructure as part of a long-term recovery and mitigation plan for the area. Surficial geology was delineated by interpreting the following vertical aerial photos: 1991 1:12,000-scale color photos, 1994 1:6,000-scale black-and-white photos, and 1979 1:65,000-scale false-color infrared photos. The base contour map was prepared by Aeromap, Inc. at a scale of 1:6,000 specifically for this study. Contours in the center of the map, in and around the villages of Alatna and Allakaket, were constructed from 1994 1:6,000-scale black-and-white photos. Photo control points allowed determination of accuracy to within 2 ft, although only 10-ft contours are shown. The southeastern part of the map was constructed from 1984 1:16,800 black-and-white photos with a 4-ft contour interval. Contours in the outlying areas were determined from 1979 1:60,000 false-color infrared photos; lack of control and the large photo scale limit accuracy to 25-ft contours (Steve St. Peter, Aeromap, Inc., Anchorage, written commun., 1995). The contours are superimposed on a 1979 1:60,000 false-color infrared photo (no. 3552) enlarged as a 'best fit' to the map at 1:6,000.

The user is cautioned that this geologic map has not been verified by field observations, although the photointerpreter referred to all available ground-truth data provided in both published and unpublished reports in preparing it. Physical properties of map units were obtained from previous reports (Hamilton, 1969), from soil-boring information gathered by the Department of Transportation (Bennett, 1994) and other agencies, or are extrapolated from similar deposits in the region (Weber and Péwé, 1970); they may be later revised as a result of detailed field observations and laboratory tests. Because of the lack of fieldwork and quantitative analyses, interpretations presented in this report are preliminary and site-specific engineering studies should be required to ensure safe design and construction.

GEOLOGIC SETTING

The map area is near the northeastern end of the Yukon-Koyukuk province (Patton, 1973) (fig. 1). Terrain in the map area consists solely of unconsolidated Quaternary deposits; the nearest bedrock outcrops are about 5 mi to the north and consist of Cretaceous graywackes, mudstone, and sandstone. The area is believed to be underlain by the Koyukuk terrane, which is composed of Middle and Late Jurassic plutonic rocks, a complex of altered mafic volcanic rocks and mafic and ultramafic plutonic rocks of probable late Paleozoic or early Mesozoic age, and Upper Jurassic(?) and Lower Cretaceous andesitic volcaniclastic rocks and flows (Patton and others, 1994). Depth to bedrock in the mapped area is unknown. No major faults traverse the area. The Kobuk fault, which was active during the Quaternary, lies 20 mi north and is a potential source of earthquakes in the region (Plafker and others, 1994). The Alatna-Allakaket area was intensely glaciated during the Kobuk glaciation (Hamilton, 1969) (fig. 2), which is older than late Wisconsin. The Wisconsin-age Itkillik glaciation did not reach the Alatna-Allakaket area.

UNCONSOLIDATED DEPOSITS

Hamilton (1969) described a bluff located opposite Allakaket as consisting of 70 ft of till and outwash overlain by 55 ft of eolian, lacustrine, and organic sediments (fig. 3). The basal till is clayey and compact and overlain by sandy till that shows little compaction and contains a greater proportion of water-worn sediment. Stratified deposits between the two tills consist of well-sorted sand that coarsens upward and is succeeded by outwash gravels. Deposits overlying the upper till include eolian silt and fine sand, lacustrine organic silt, and stratified peat. River bluffs examined both upriver and downriver from Allakaket exhibited similar characteristics (Hamilton, 1969) (fig. 3). This complex deposit of till, loess, and other sediments is generally frozen and ice rich; it covers the

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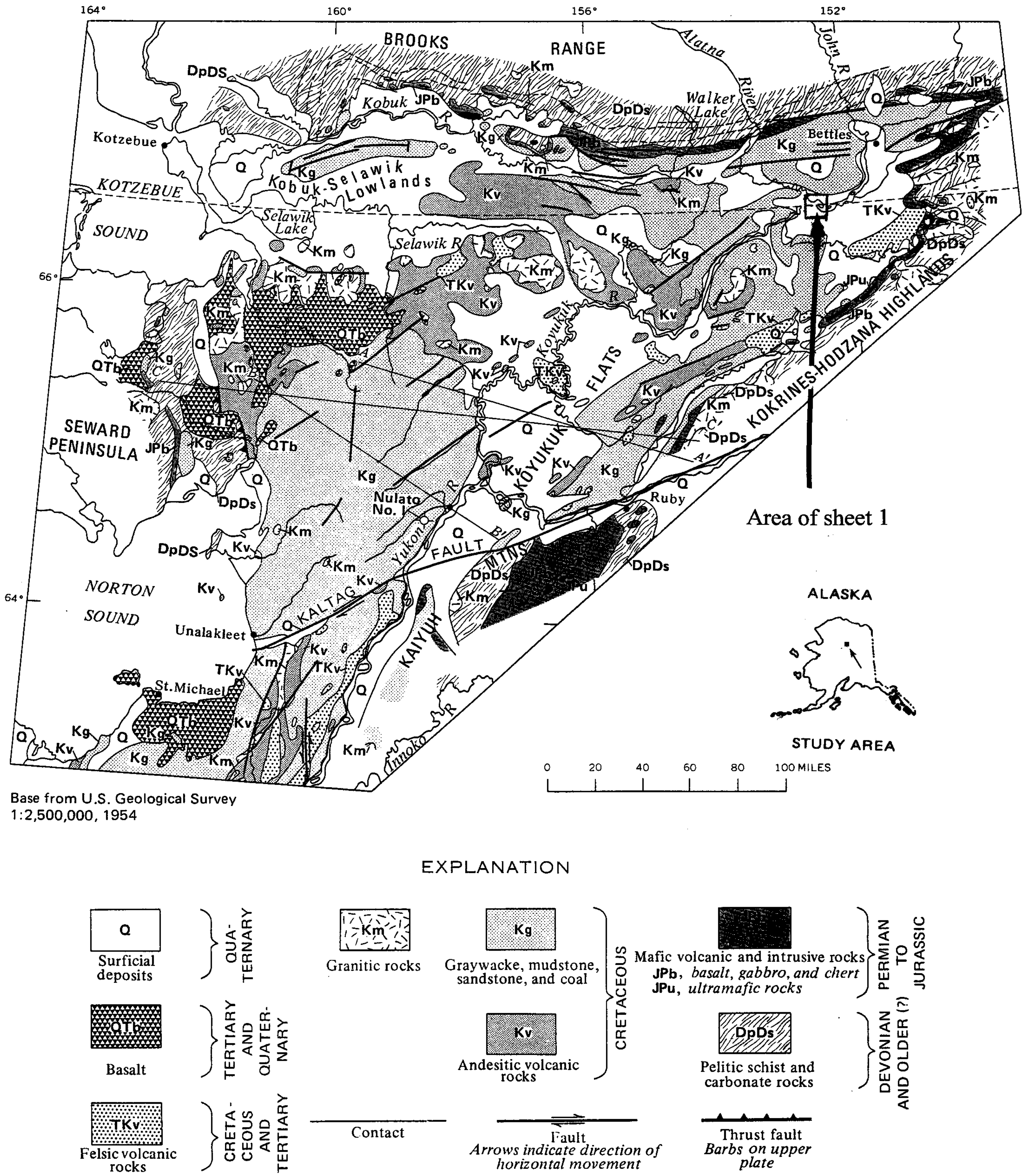

Figure 1. *Reconnaissance geologic map of northern Yukon-Koyukuk province (Patton, 1973).*

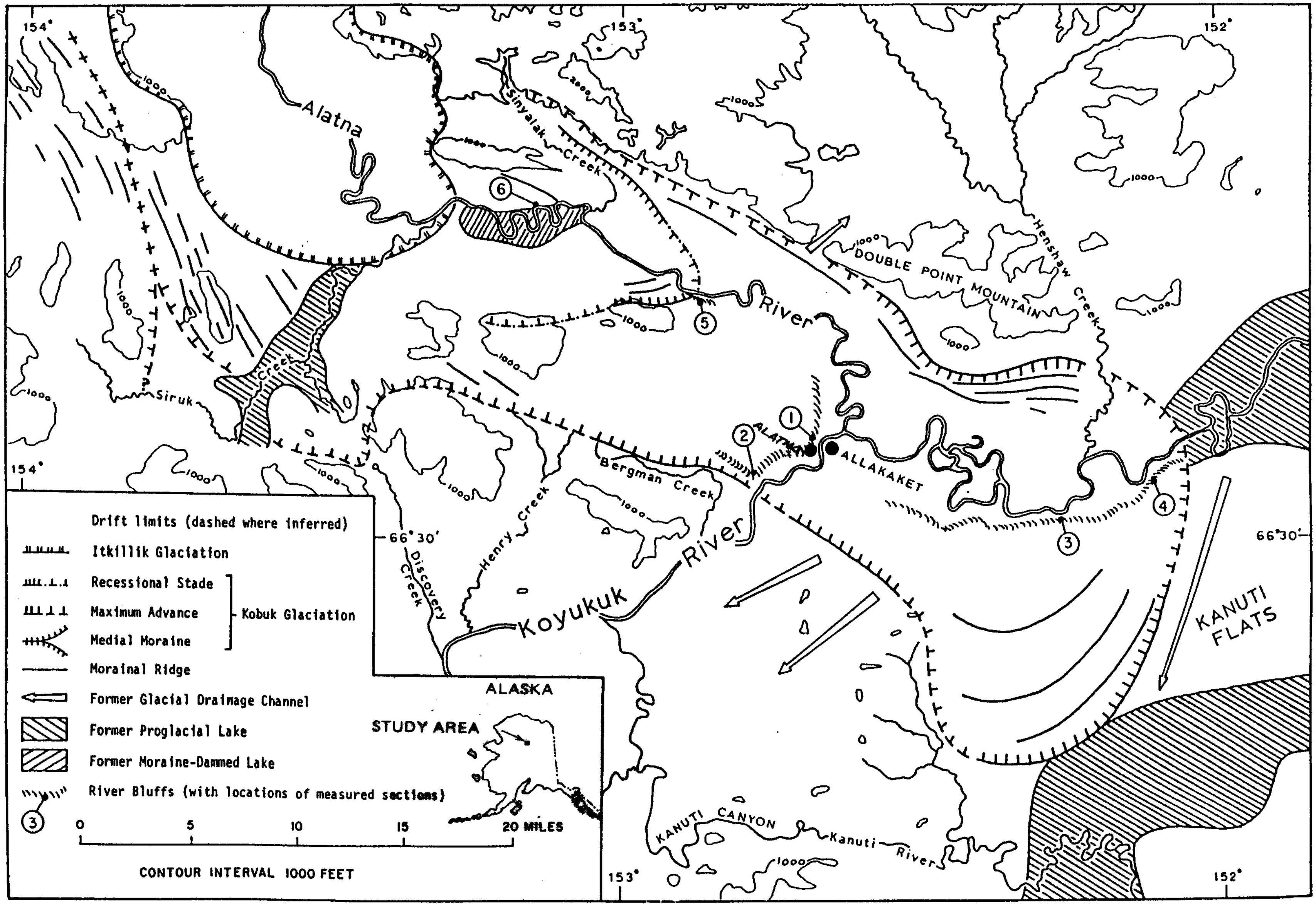

Figure 2. *Drift limits and related glacial features of middle to late Quaternary age, lower Alatna valley (Hamilton, 1969).*

uplands bordering the Koyukuk and Alatna River valleys. Thaw lakes dot the upland terrain.

Floodplain deposits of the Koyukuk and Alatna Rivers have been incised into the complex till-loess unit. Floodplain alluvium exhibits scroll-and-swale topography (Weber and Péwé, 1970). This report follows the convention established by Weber and Péwé (1970) for describing mapped floodplain alluvium.

RECENT PROCESSES

The August 1994 flood that devastated the villages of Alatna and Allakaket is considered to be a 100-year event (David Meyer, U.S. Geological Survey, Anchorage, written commun., 1995). Maximum flood height reached elevations of 499 ft and 496 ft north and south of the villages, respectively, with flood waters inundating nearly the entire floodplain (sheet 1). A map showing 100-year-flood water depths for the floodplain in the Alatna-Allakaket area has been prepared by D. Meyer (U.S. Geological Survey, Anchorage, written commun., 1995).

Recent river erosion and aggradation can be gauged by comparing 1979 stream banks, visible on the background map photo, to 1994 mapped stream bank positions and, in one case, to the 1991 photo position. Going upstream, west to east, point bars have prograded outward by a maximum of 375, 400, 500, and 250 ft, and cutbanks have been eroded back 125, 275, and 150 ft (sheet 1). Point bars have prograded at average rates of 17 to 42 ft/yr, and cutbanks have retreated at average rates of 8.3 to 18.3 ft/yr. Of particular concern for future construction is erosion at the northern edge of Allakaket, which averaged 10 ft/yr between 1979 and 1994. Erosion is likely to continue in this vicinity over the next 2 to 3 decades or more; buildings, roads, and other facilities should have adequate setbacks to accommodate future erosion. Estimates of stream erosion and point-bar progradation are discussed in detail by Palmer (1994) and D. Meyer (U.S. Geological Survey, Anchorage, written commun., 1995).

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I wish to acknowledge R.D. Reger for helpful discussions on distinguishing floodplain and other surficial deposits on air photos. Reger and R.A. Combellick reviewed an earlier version of this manuscript and provided helpful comments which improved this report.

SELECTED REFERENCES

Bennett, J.D., 1994, Allakaket airport master plan (federal project AIP 3-02-0009-03, state project 65305), Alaska Department of Transportation geotechnical report, 78 p.

Hamilton, T.D., 1969, Glacial geology of the lower Alatna Valley, Brooks Range, Alaska, *in* S.A. Schumm and W.C. Bradley, eds., United States Contributions to Quaternary Research: Geological Society of America Special Paper 123, p. 181-224.

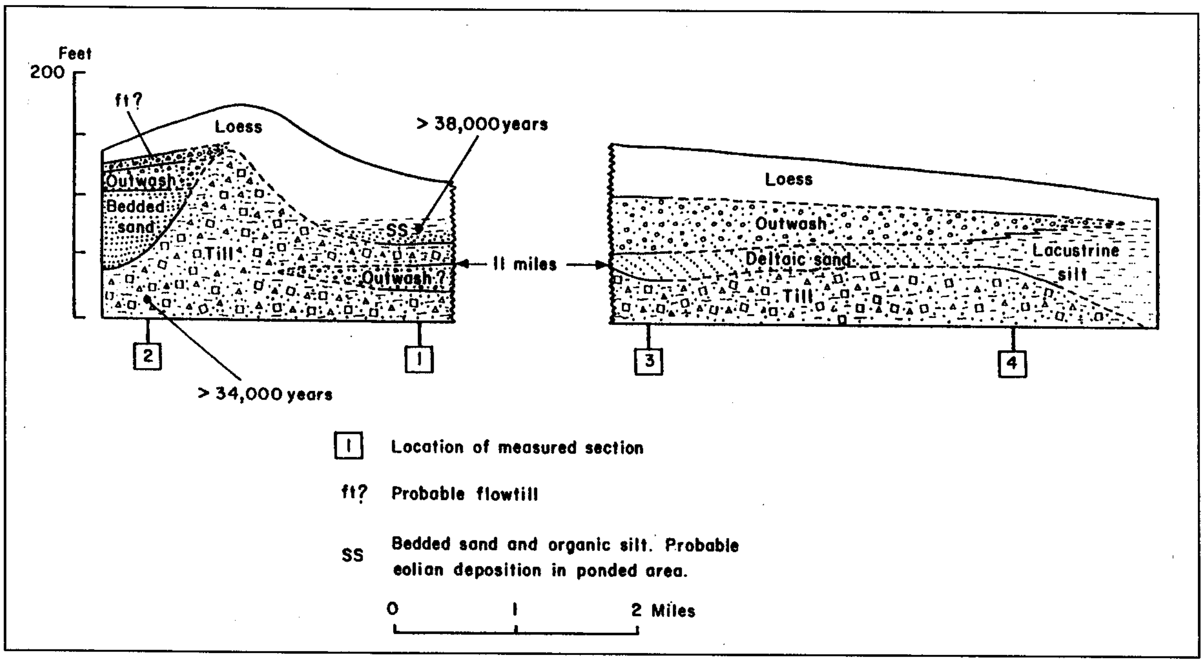

Figure 3. *Kobuk-age drift relations (maximum advance) exposed in bluffs along the Koyukuk River as inferred by Hamilton (1969). See figure 2 for locations of sections.*

Interior Housing Authority, 1991, Miscellaneous logs of borings made in the villages of Alatna and Allakaket by A.W. Murfitt Company in December, 1991, Anchorage, 22 plates.

Palmer, Leonard, 1994, Rates of channel migration at Allakaket, Alatna, and Hughes, Alaska, preliminary draft: Federal Emergency Management Administration, Koyukuk River Floods, DR-1039-AK, 11 p.

Patton, Jr., W.W., 1973, Reconnaissance geology of the northern Yukon-Koyukuk province, Alaska: U.S. Geological Survey Professional Paper 774-A, 17 p.

Patton, Jr., W.W., Box, S.E., Moll-Stalcup, E.J., and Miller, T.P., 1994, Geology of west-central Alaska, *in* George Plafker and H.C. Berg, eds., Geology of Alaska, v. 13, The Geological Society of America, Boulder, p. 241-270.

Plafker, George, Gilpin, L.M., and Lahr, J.C., 1994, Neotectonic map of Alaska, *in* Geology of Alaska, Geology of North America (GNA-G1), v. G-1, plate 12, scale 1:2,500,000.

RoEn Design Associates, 1977, Village site investigations Allakaket, Alaska: Project report, project file 6169, 20 p., 1 sheet, scale 1:360.

Weber, F.R., and Péwé, T.L., 1970, Surficial and engineering geology of the central part of the Yukon-Koyukuk lowland, Alaska: U.S. Geological Survey Miscellaneous Investigations Series, Map I-590, 2 sheets, scale 1:125,000.

Table 1. *Description of units, photointerpretive surficial geology of areas surrounding Alatna and Allakaket, Alaska*

Geologic unit	Lithology	Distribution and thickness	Vegetation	Permafrost
Floodplain alluvium, channel phase **(A0)**	Well-stratified tan to buff-colored sand and gravel with some micaceous silt. Sediments are of probable Cretaceous graywacke, sandstone and mudstone, and Devonian pelitic schist and carbonate origins. Gravel subangular to well rounded.	Lowest surface unit. Borders major streams as gravel and point bars, and flooded at any elevated river stage. Thickness unknown but probably at least equal to channel depths.	None	Absent or at depths of more than 20 ft.
Floodplain alluvium, linear phase **(A1)**	Well-stratified brown sands and gravel with some interbedded micaceous silt and organic mats; occasional cobbles to 10 in. Sediments are of probable Cretaceous graywacke, sandstone and mudstone, and Devonian Pelitic schist and carbonate origins. Gravel subangular to well rounded.	Next lowest surface unit. Borders major streams and forms most active part of floodplain. Thickness unknown but in places greater than 18 ft.	Horsetail, grasses, sphagnum moss, labrador tea, lowbush cranberries, alder, willow, cottonwood; occasional aspen, rare spruce.	Generally absent or at depths greater than 20 ft near rivers. Discontinuous lenses and layers possible at depths 2-4 ft elsewhere. No large ground-ice masses.
Floodplain alluvium, advanced phase **(A2)**	Well-stratified brown micaceous silt, sand and some gravel and some organic material.	About 4-6 ft above river level, adjoining A1. Forms abandoned channels and islands. Thickness unknown but in places greater than 13 ft.	Bunchberry, rose, willow, alder, birch, black spruce, latter up to 30 in. in diameter. Moss 4 to 8 in. thick.	Depth to permafrost 3-11 ft. Probably no large ground-ice masses.
Floodplain alluvium, coalescent phase **(A3)**	Well-stratified layers of brown and gray micaceous silt with much darker silt rich in organic material, and local peat layers 1-2 ft thick. Soils underlain by sand and gravel. Where drilled, average depth to gravely sand or sandy gravel was 10.5 ft.	Extensive areas in the higher part of the active floodplain, usually forms the cutbank of major streams and may stretch away from rivers up to 2 mi in mapped area. Thickness exceeded 33 ft at one drilled location .	Stunted black spruce and birch, 1-4 in. in diameter. Small alder and willow in damp places. White spruce and cottonwood on high ground. Ground cover consists of sphagnum moss, labrador tea, roses, lowbush cranberries, and grasses.	Depth to permafrost 18-24 in. in forest; 12-18 in. in bogs; greater than 10 feet beneath lakes. In test holes drilled in oxbow or meander cutoff lakes, permafrost not noted until depths of 18 and 32.5 ft.
Floodplain alluvium, scalloped phase **(A4)**	Well-stratified layers and lenses of brown and gray micaceous silt with large amounts of dark-colored organic silt, wood, peat, and vegetal material.	Highest part of active floodplain, 0.5 to 2 mi wide in mapped area. Adjoins terrace unit, other floodplain units, and major streams on cutbanks.	Tundra with peat moss, reindeer moss, cottongrass and other sedges, cranberry, blueberry. Tundra mat 12-24 in. thick. Also stunted black spruce, a few small birch and willows along sloughs and lake shores.	Depth to permafrost 12 in. in tundra area, slightly greater in forested areas, and more than 10 ft under lakes. Large ground-ice masses present.
Stream terrace deposits **(T)**	Well-stratified layers and lenses of micaceous silt and organic-rich silt.	Found bordering Koyukuk River floodplain as remnant ridges on low, flat areas 30 or more feet above river.	Peat moss, cottongrass tussocks and other sedges, stunted spruce, a few birch, aspen. Much tundra with thick vegetal mat.	Depth to permafrost 1 ft. Larger ground-ice masses abundant.
Marsh deposits **(M)**	Primarily fibrous and locally woody peat with organic silt and sand deposited in local basins. Underlain by sand and gravel.	Found as fill in linear lakes, ox-bow lakes, abandoned stream channels, and valley bottoms.	Sphagnum moss, sedge grasses, and willow saplings.	Depth to permafrost 1-4 ft. Large ground masses present.
Thaw lake deposits **(Lt)**	Primarily thawed silts and organic deposits.	Found at edges of perennial upland lakes formed in basins.	Sphagnum moss, sedge grasses, and willow saplings.	Depth to permafrost 1-4 ft. Large ground masses present.
Frozen complex upland silt **(Elr)**	Bottom units are tills with clayey matrix, deposited during Kobuk glaciation, with locally interstratified sand and gravel outwash deposits, overlain by eolian deposits, mainly silts but some sands, with locally interstratified peats and lacustrine deposits.	Till and loess units are typically tens of feet thick and form prominent erosion resistant bluffs along river and comprise erosional uplands above floodplains. Bluff opposite Allakakeet consists of 70 ft of till and outwash overlain by 55 ft of eolian, lacustrine, and organic sediments; tills are older than 38,000 BP (Hamilton, 1969). Peat layers 0.6-16 ft thick encountered in test holes.	Mixed stands of white spruce and birch, 1-6 in. in diameter, and stands of predominantly black spruce, 1-4 in. in diameter, aspen and willow saplings, sphagnum moss, caribou lichen, labrador tea, lowbush cranberry, and tussocks.	Depth to permafrost 1-4 ft. Test wells encountered ice-rich brown to black organic silts, locally containing ice lenses 2.5- 6 ft thick at depths of 4 to 12 ft.

Table 2. *Engineering geology properties, photointerpretive surficial geology of areas surrounding Alatna and Allakaket, Alaska*

Geologic Unit	Drainage and potential as water source	Susceptibility to river erosion	Susceptibility to flooding	Susceptibility to frost action	Bearing strength and slope stability	Suitability for foundation and construction use	Excavation and compaction
Floodplain alluvium, channel phase **(A0)**	Well drained. Source of large supply of water.	High	High	Sand and gravel unsusceptible; silt moderate to intense	Poor	Unsuitable for road foundation or structure foundation because of periodic flooding. Good source of sand and gravel. Gravel good for subgrade, base course and, if screened, road metal.	Easily excavated with power equipment. Silt difficult to compact but mixture of silt, sand, and gravel easy to compact.
Floodplain alluvium, linear phase **(A1)**	Distinct linear lakes parallel to river, no integration of drainage. Source of moderate to large supply of water.	High to moderate	High to moderate	Silt moderate to intense	High bearing strength when frozen. Sand and gravel high when thawed, silt moderate to high when thawed and welldrained, low when poorly drained. Stands in slopes of 2/3:1 to 1:1, except unfrozen sand.	Fairly good for road foundation but subject to flooding, river cutting, and icing. Gravel good for subgrade, base course and, if screened, road metal. Good foundation for structures if gravel present.	Easily excavated with power equipment except when frozen. Silt difficult to compact but mixture of silt, sand, and gravel easy to compact.
Floodplain alluvium, advanced phase **(A2)**	Linear lakes parallel to drainage trends. No integration of drainage. Lakes partly broken into segments by encroaching vegetation. Source of moderate to large supply of water.	High to moderate	High to moderate	Silt moderate to intense	High bearing strength when frozen. Sand and gravel high when thawed, silt moderate to high when thawed and welldrained, low when poorly drained. Stands in slopes of 2/3:1 to 1:1, except unfrozen sand.	Fair for road foundation if gravel and sand present. Silt poor because susceptible to frost heaving. Subject to flooding and river cutting. Gravel good for subgrade, base course and, if screened, road metal. Good foundation for structures if gravel present.	Easily excavated with power equipment except when frozen. Silt difficult to compact but mixture of silt, sand, and gravel easy to compact.
Floodplain alluvium, coalescent phase **(A3)**	Numerous linear lakes and swamps modified by cave-in coalescence. Lakes lie at various angles to flow of major river. No integrated drainage. Low potential as water source.	Moderate to low	Moderate to low	Intense	High bearing strength when frozen or dry; low when wet or thawed unless welldrained. Organic silt with high moisture flows as sludge when thawed. When drained, silt stable at 2/3:1 to 1:1.	Poor for road foundation. Intense frost heaving, subsidence on thawing of permafrost, poor surface drainage, subject to river cutting and flooding. Unsurfaced road unstable -- powdery when dry, sticky when wet. Poor foundation for structures.	Easily excavated with power equipment except when frozen. Difficult to compact.
Floodplain alluvium, scalloped phase **(A4)**	Numerous lakes and swamps with scalloped and irregular borders, small circular cave-in lakes. Some integration of drainage form lake to lake and along a few through streams. Low potential as water source.	Low to very low	Low to very low	Intense	High bearing strength when frozen or dry; low when wet or thawed unless welldrained. Organic silt with high moisture flows as sludge when thawed. When drained, silt stable at 2/3:1 to 1:1	Poor for road foundation. Intense frost heaving, subsidence on thawing of permafrost, poor surface drainage, subject to river cutting and flooding. Unsurfaced road unstable -- powdery when dry, sticky when wet. Poor foundation for structures.	Easily excavated with power equipment except when frozen. Difficult to compact.
Stream terrace deposits **(T)**	Impermeable substratum of permafrost creates poor drainage. Drainage good on terrace scarps where permafrost absent. Poor potential for water source.	Low to very low	Low to very low	Intense	High bearing strength when frozen or dry. Silt is subject to sloughing and landsliding when thawed and poorly drained.	Very poor for road foundation and structure foundations. Intense frost heaving, great subsidence on thawing of permafrost. Unsurfaced road unstable -- powdery when dry, sticky when wet. If clear, forms a summer quagmire.	Easily excavated with power equipment except when frozen. Difficult to compact
Marsh deposits **(M)**	Poor drainage. Low potential for water source.	Low	High to moderate	Intense	Poor bearing strength and stability.	Very poor for foundations because of shallow water table, low bearing capacity, and large thaw consolidation. Good source of peat.	Easily excavated except moderately difficult where frozen and tightly bound. Easily compacted.
Thaw lake deposits **(Lt)**	Poor drainage. Moderate to low potential for water source.	Very low	High to moderate	Intense	Poor bearing strength and stability.	Very poor for foundations because of shallow water table, low bearing capacity, and large thaw consolidation.	Easily excavated except moderately difficult where frozen and tightly bound. Difficult to compact.
Frozen complex upland silt **(Elr)**	Welldrained on upper slopes and scarps, impermeable substratum of permafrost creates poorer drainage on lower slopes. Poor potential for water source.	Low to very low	Very Low	Loess on higher hills unsusceptible to moderately susceptible. Moderately susceptible elsewhere.	High bearing strength when frozen or dry. Silt is subject to sloughing and landsliding when thawed and poorly drained.	Poor to very poor for road foundations and structure foundations. Intense frost heaving, great sudsidence on thawing of permafrost and ice lenses. Unsurfaced road unstable -- powdery when dry, sticky when wet. Road cuts in slopes subject to flowing in spring and icing in winter. Easily gullied.	Easily excavated with power equipment except when frozen. Difficult to compact