### ENVIRONMENTAL GEOLOGY AND FOUNDATION PROBLEMS

In the Fairbanks area, the effects of development on the geologic environment must be considered in determining proper land use. Persons concerned with the land, especially land planners, developers, public officials, engineers, architects, financial advisors, and educators, must be aware of recognizable geologic features that may prove hazardous; only then can proper and economical land usage be insured.

To provide a background for people concerned with the land, basic data from the Geologic map of the Fairbanks D-2 NW quadrangle (Péwé and others, 1975), the Map showing distribution of permafrost in the Fairbanks D-2 NW quadrangle (Péwé and Bell, 1975a), and the Map showing ground-water conditions in the Fairbanks D-2 NW quadrangle (Péwé and Bell, 1975b) have been recast into this foundation map. The description of units outlines in simple and basic terms the major problems and the various foundation conditions found in the quadrangle.

Not only do conventional foundation and constructional problems occur, but unique problems related to permafrost and seasonal frost action complicate otherwise normal land use. The bedrock is, in general, a solid foundation that presents no major problem. Most of the unconsolidated sediments would provide fair to good foundations in more temperate latitudes. In the Fairbanks area, however, the widespread blanket of silt is very susceptible to intense seasonal frost action, especially where poorly drained. Theoretical frost-heaving forces are given below. To prevent frost heaving, special precautions must be taken in the construction of roads, air fields, bridges, unheated buildings, and structures on piers or pilings. In some places, the silt can be removed; in others, drainage must be improved. It is also possible to anchor structures in the underlying permafrost to eliminate the effects of frost heaving.

Permafrost is critical in evaluating land use. Permafrost, or perennially frozen ground, is defined as soil or bedrock that remains at or below 32°F for two or more years. In this area, as well as in other parts of the North, many types of structures have been extensively damaged because the existence and nature of the frozen ground were little

The first step in preparing the land for construction or farming is usually the stripping of the vegetative cover, an operation that disturbs the natural thermal equilibrium, causing thawing of the permafrost if present. As the ground thaws, the ground surface (and anything on it) settles differentially, sometimes producing severe damage. The type and extent of permafrost vary, and the consequences of building on ice-rich ground vary as well.

The foundation map presents as much data as possible on engineering problems that would be found in any particular area. Information is presented on frost heaving and permafrost and on general ground stability and soil properties. Six foundation units are defined: I, bedrock; II, tailings; III, loess; IV, muck; V, peat muck; VI, peat. Each unit poses different foundation problems depending upon the presence and type of permafrost, the mechanical properties of the material, whether or not it is consolidated, and its characteristics upon thawing. The conditions within a unit are generalized and may vary locally, especially near contacts.

The most critical foundation problem is the existence of large, massive ground-ice masses in the reworked valley-bottom silts (units IV, V, and VI).

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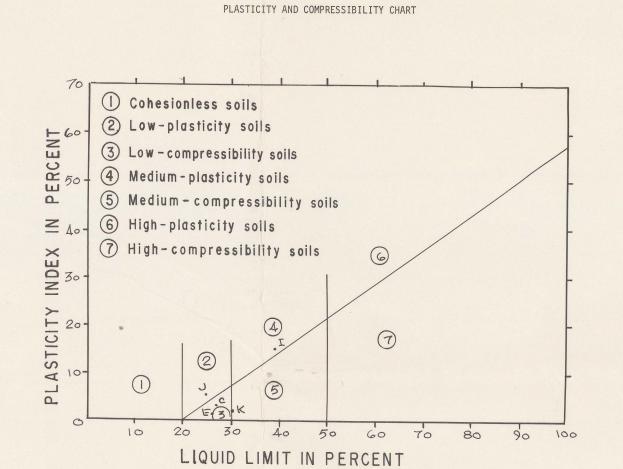
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	The graph shows the frequency of occurrence of particles the Fairbanks D-2 NW quadrangle. The slope of a curve ir slope, the higher the degree of sorting.	of various sizes in several types of foundation materials from dicates the degree of sorting of the materialthe steeper the

CUMULATIVE FREQUENCY CURVES OF SORTING OF REPRESENTATIVE SAMPLES



Relation of plasticity and compressibility to plasticity index and liquid limit for samples (indicated by letters) in the Fairbanks D-2 NW quadrangle. Although none of the samples fall into groups 4, 6, or 7, it does not necessarily mean that these groups are absent from the area. After Legget (1967, fig. 5).

# ANALYSES OF SAMPLES FOR FAIRBANKS D-2 NW QUADRANGLE

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#### Depth of frost Maximum force Date penetration, pushing upward, in feet in pounds 21,600 November 1 December 1 1.5 32,400 January 1 43,200 64,800 February 1 March 1 86,400 April 1 4.5 97,200

Hypothetical example of seasonal frost penetration

POSSIBLE EFFECTS OF FROST HEAVING

into silt in central Alaska and possible upward push on 40-inch-perimeter pile (ground temperature constant) (Pewe and Paige, 1963, table 6)

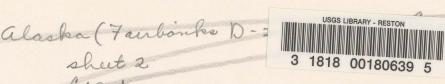
# DECODIDATION OF MAD HAUTO

			DESCRIPT	ION OF MAP	UNITS			
MAP UNIT	DISTRIBUTION AND THICKNESS	TERRAIN AND NATURAL SLOPES	DRAINAGE AND PERMEABILITY	PERMAFROST	SUSCEPTIBILITY TO FROST ACTION	BEARING STRENGTH AND SLOPE STABILITY	EXCAVATION AND COMPACTION	POSSIBLE USE
Bedrock (I)	Exposed on hilltops and steep slopes where loess cover less than 3 ft thick. Upper weathered layer 1-3 ft thick on upper slopes; more than 75 ft thick on lower slopes.	Rounded gently rolling topography; moderately steep north-facing slopes common in some areas.	Surface drainage good to excellent. Joints, faults, fracture cleavage, and foliation result in poor to fair permea- bility. Upper weathered layer has low permeability.	Locally perennially frozen under muck and tailings in creek valley bottoms and on north-facing slopes, Depth to permafrost on north-facing slopes 1-4 ft; locally 1-100 ft thick. Low ice content as interstitial ice in unweathered bedrock; low to moderate ice content as seams and interstitial ice in weathered bedrock. Water table generally deep.	Moderately susceptible in weathered bedrock.	High bearing strength in fresh bedrock; generally high in weathered bedrock if ice content low or absent. Highest bearing strength on horizontal or vertical dipping beds. Susceptible to sliding and slumping along joint, cleavage, and foliation planes, especially micaladen planes.	Weathered bedrock easily excavated with hand or power tools, except where frozen. Unweathered schist is generally easily excavated with only little to moderate blasting; some varieties, especially the quartzite facies and vein quartz, may require additional blasting. Resistant layers more easily excavated where interbedded with schistose rocks. Weathered granite easily excavated with power tools; unweathered granite requires blasting. Difficult to moderately difficult to compact both weathered and unweathered bedrock.	Schist varieties good for unclassified embankment fill; fair for selected use such as base course if processed; breaks down to silt with repeated traffic and frost action. Harder varieties, such as the quartzite facies and vein quartz, good for rip rap and ballast, and coarse aggregate; if processed, good for base course and road metal. Many varieties, especially the marble facies, are good as decorative rocks.
Tailings (II)	Placer mine dredge tailings at Sheep Creek. Thickness 3 to more than 75 ft.	Steep, imbricate, parabolic, symmetrical gravel piles forming rough terrain with some undrained depressions. Leveled in places.	Material loose, porous, and slightly compacted. Excellent drainage and permeability except where locally perennially frozen.	Locally perennially frozen; low ice content; primarily interstitial.	Unsusceptible.	High bearing strength. Slopes generally stable at 1:1.	Easily excavated by power tools, except where frozen. Realtively easily compacted.	Good foundation for any structure if tailing piles leveled. Good for subgrade, ballast, rip rap, pervious fill, and if crushed and screened, good for base course and aggregate. Possible sites for sanitary landfill.
Loess (III)	Widespread on middle and upper slopes and on lower hilltops. Thickness ranges from 3 ft on upper slopes to a maximum of over 200 ft on middle slopes. Not mapped where less than 3 ft thick.	Cently rolling terrain with low rounded hills. Old, slightly subdued parallel gullies and ridges at right angles to contours; characteristic of most upper slopes.	Good surface drainage. Laterul permea- bility poor to fair; vertical permea- bility good.	Generally permafrost free. Permafrost may be present on north-facing slopes with little or no ice content. Water table deep.	Moderate to unsusceptible; locally high if drainage poor.	High bearing strength when dry and in original position; very low when wet. Will stand in nearly vertical slopes. Extremely susceptible to gullying; freshly exposed surfaces susceptible to wind erosion.	Easily excavated with hand tools, except where frozen. Difficult to compact.	Source of fine-grained sediment, possible source of impervious fill, and unclassified embankment fill. Good foundation for heated structures if protection is provided against gullying. Unsurfaced roads unstable; powdery when dry, plastic and sticky when wet. Good agricultural soil if fertilized. Possible sites for sanitary landfill.
Muck (IV)	Widespread on lower slopes and valley bottoms. Thickness 3-30 ft.	Very gently sloping alluvial fans and colluvial slopes; broad alluviated creek valley bottoms with small lakes.	Impermeable substratum of permafrost, especially in valley bottoms, creates poor drainage; marshy and undrained in summer. Land clearing and lowering of permafrost table improves drainage near contact with loess; produces quagmire in valley bottoms. Permeability low to moderate.	Depth to permafrost 1½-3 ft on lower slopes and valley bottoms; 5-20 ft near the contact with the loess; 10-25 ft under½ leared areas. Seasonal frost layer 1½-3 ft thick. Permafrost 3-30 ft; pinches out upslope; continuous except under lakes and near contact with the loess. Ice content high as seams and leness; content high in underlying unit V as seams, lenses, and large foliated ice masses arranged in polygonal pattern. Water table below permafrost. Permafrost temperature averages 31-32°F. Pingos occur locally.	High.	High bearing strength when frozen or dry; very low when wet or thawed. May stand in nearly vertical shallow cuts near contact with the loess. Subject to sloughing and sliding upon thawing; when drained stable at 2/3:1. Very susceptible to gullying.	Very difficult to excavate unless thawed; blasting only moderately successful. When thawed, viscous sediment slides into excavation, except near contact with loess or on low hills. Difficult to compact.  Great differential subsidence when thawed.	Poor foundation for construction. Upon thawing of permafrost, thermokarst mounds 10-50 ft in diameter and 1-10 ft high and pits 3-30 ft in diameter and 5-20 ft deep form on the surface. Condition may improve near contact with the loses where permafrost table is lower and permafrost sporadic. Can serve as solid foundation if permafrost prevented from thawing and structures designed to absorb frost-heaving effects. Source of fine-grained sediment; possible source of impervious fill. Poor to fair for agriculture if fertilized. Unsatisfactory for sanitary landfill sites unless permafrost prevented from thawing or landfill frozen.
Peat-muck (V)	Occurs in valley bottoms. Thickness 10 to more than 300 ft.	Flat fans with small steep-sided cave- in lakes and a pattern of trenches 1-4 ft deep and 2-5 ft wide in polygonal network.	Impermeable substratum of permafrost and organic material creates very poor drainage; marshy and undrained in summer.  Land clearing produces summer quagmire. Permeability poor.	Depth to permafrost 1½-3 ft. Seasonal frost layer 1½-3 ft. Permafrost 1-140 ft thick; continuous except under lakes. Ground ice content high as seams, lenses, and large foliated ice masses 1½-10 ft below the surface. Water table below permafrost. Pingos occur locally.	High.	High bearing strength when frozen; very low when thawed. Slopes in cuts subject to sloughing and sliding upon thawing.	Very difficult to excavate unless thawed; blasting only moderately successful. When thawed, viscous sediment slides into excavation. Difficult to compact. Great differential subsidence when thawed.	Very poor foundation for construction of any sort. Thawing of permafrost results in formation of thermokarst mounds 1-10 ft high and 10-50 ft in diameter and pits 3-30 ft in diameter and 5-20 ft deep. Can serve as solid foundation only if permafrost prevented from thawing and the structures designed to absorb frost-heaving effects. Poor for agriculture. Poor for sanitary landfill sites. Good for mosquito studies!!!
Peat (VI)	Occurs in broad oval-shaped areas in valley bottoms. Thickness 3 to more than 20 ft.	Flat peat-filled lake basins.	Impermeable substratum of permafrost and organic silt creates very poor drainage; marshy and undrained in summer. Land clearing produces summer quagmire. Permeability poor.	Depth to permafrost $1\frac{1}{2}-3$ ft. Seasonal frost layer $1\frac{1}{2}-3$ ft. Permafrost more than 20 ft thick; continuous except under lakes. Ice content high as seams and lenses; large foliated ice masses in underlying silt. Water table below permafrost.	High.	High bearing strength when frozen; very low when thawed, Slopes in cuts subject to sloughing and sliding upon thawing.	Very difficult to excavate unless thawed, blasting only moderately successful. When thawed, viscous sediment slides into excavation. Difficult to compact. Great differential subsidence when thawed.	Very poor foundation for construction of any sort, Good source of raw peat in thawed areas; excavation pits generally need dewatering for peat excavation.  Poor for agriculture. Poor for sanitary landfill sites.

SUPPLEMENTARY DATA TO ACCOMPANY

MAP SHOWING FOUNDATION CONDITIONS IN THE FAIRBANKS D-2 NW QUADRANGLE, ALASKA

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♥U.S. GOVERNMENT PRINTING OFFICE: 1975-0-690-036/57

