GRANITIC ROCKS

Granitic rocks underlying most of the southwest corner of the quadrangle are well exposed on the higher parts of Granite Mountain. Examination of four specimens by Dr. Robert B. Forbes, Department of Geology, University of Alaska, indicates that they are granodiorite (sample sites 36, 37, and 38) and quartz monzonite (sample site 35). These rocks are in intrusive contact with the older Birch Creek Schist beyond the quadrangle boundary to the west (Péwé and Holmes, unpublished data), and to the south (Moffit, 1954). Similar plutons occur in the Tanana Valley, and in the foothills of the Alaska Range to the southwest (Moffit, 1954).

Granitic rocks immediately to the east in the Mt. Hayes D-2 quadrangle are microscopically and megascopically similar to those in Granite Mountain; the age of the former, determined by the lead-alpha method, is 105 ± 10 million years or Cretaceous (T. W. Stern, 1960, written communication). The proximity and petrographic similarity between Granite Mountain rocks and those immediately to the east suggest a close relationship in age and origin. Regional studies by Payne (1955) suggest the emplacement of Granite Mountain rocks was during Cretaceous time and syntectonic with the deformation of the Alaska Range.

SEDIMENTARY ROCKS OLDER THAN GLACIAL DEPOSITS

NENANA GRAVEL Rocks assigned to the Nenana Gravel include small patches of old, partly consolidated gravel on slopes of the northernmost promontory of Granite Mountain in the vicinity of Arrow Creek. These are clearly not related to glacial deposits and are probably remnants of more extensive gravel beds that were deposited on the eroded surface of Granite Mountain. Similar gravel deposits occur in the gorge of the Gerstle River in the southeastern corner of the quadrangle. These are exposed in a 15-foot vertical cut and are not shown on the map. Large irregular iron oxide concretions occur throughout the beds, and the upper 0.2 foot is deeply oxidized. The beds are horizontal and are overlain by till of the Delta

These deposits are similar in lithology, weathering, and consolidation to those in a large hogback of Nenana Gravel immediately south of the quadrangle boundary (Moffit, 1954, p. 147) and to a small outcrop of flat-lying Nenana Gravel on Independent Ridge, immediately to the east (Holmes and H. L. Foster, unpublished data).

In the Nenana River region, approximately 130 miles to the west Nenana Gravel in places unconformably overlies the Tertiary coal-bearing formation (Wahrhaftig, 1958, p. 11-12); the probable age of the latter is early Oligocene to early Miocene (MacNeil and others, 1961, p. 1806). The Nenana Gravel described by Wahrhaftig has yielded fossil fruits of (MacNeil and others, 1961, p. 1806).

DEPOSITS OF THE DELTA GLACIATION

Old moraines along the front of Granite Mountain and on the Gerstle River represent an advance correlated with the Delta Glaciation (Péwé, 1952) in the Delta River Valley to the west. The largest moraine of Delta age in the Mt Hayes D-3 quadrangle is along the Gerstle River in the southeastern corner of the area. This was deposited by a major glacier originating from cirques deep within the Alaska Range. Smaller moraines at the mouths of most of the canyons in the Granite Mountain uplands were deposited by local glaciers.

Moraines of Delta advance are marked by small shallow ponds, a few closed depressions, and low knobs and ridges. The moraines are covered by widely scattered, partly buried weathered boulders, gruss, and silt. Many Delta moraines are scored by channel made by meltwater streams from glaciers of a later ice advance, especially on the Granite Mountain piedmont. The Gerstle River has carved a sinuous gorge through the moraine, and streams from Granite Mountain have cut steep-sided gorges through the older drift at the mountain front. Rock fragments in the moraine are chemically altered to depths of at least 3 feet, and the till contains deeply weathered orange drift at depths exceeding 10 feet.

Outwash deposits from the Delta ice advance are well preserved. A broad sloping apron, clearly related to the Delta moraine, extends northward from the moraine on the Gerstle River and into the eastcentral section of the quadrangle. It merges with outwash of the Delta Glaciation on the Granite Mountain piedmont, and with the outwash apron of the type moraine of Delta Glaciation near the western boundary of the quadrangle.

are mapped as glacial and nonglacial gravel.

These composite deposits occur in two facies: bouldery gravel, and gravel and sand. Bouldery gravel occurs as sloping, channeled coalescent fans on the piedmont of Granite Mountain. The deposits are oxidized to a depth of at least 3 feet, which is approximately the depth to the permafrost table. The gravel and sand facies of the glacial and non-Granite Mountain to its scarp north of the Alaska Highway. with alpine colluvium.

The composition of the gravel and sand facies is not uniform Two generations of talus accumulations occur in the upper (see table), possibly reflecting various bedrock sources. The gravel has been weathered to a depth of at least 11 feet; schist and granitic rock fragments are decomposed, and quartzite and quartz pebbles and sand grains are stained. The deposits are mantled by 0.8 to 2.6 feet of silt, with greater dividing the two cirques in upper Sawmill Creek Canyon. The thickness along the Gerstle River.

DEPOSITS OF THE DONNELLY GLACIATION

Moraines correlated with the till of Donnelly Glaciation (Péwé, 1952) in the Delta River valley occur on the Gerstle River and on Granite Mountain. These moraines represent a major advance slightly less extensive than the Delta Glaciation. The largest glacier of this advance originated in the headwaters of the Gerstle River and moved almost to the northern limit of Delta Glaciation. Glaciers of Donnelly age in the larger valleys of Granite Mountain partly overrode end moraines of Delta age, but in a few smaller valleys the drift of these two glaciations is clearly separated. Glaciers did not form in Donnelly time in two valleys in the Granite Mountains that contain drift of the Delta advance.

Moraines of the Donnelly advance are rougher than moraines of the Delta advance, and have steep ridges and knobs, closely spaced kettle depressions and ponds, and somewhat greater local relief. Drainage on moraines of the Donnelly advance is poor; although most moraines have been breached by mountain streams, drainage is generally restricted to old meltwater channels or to swales formed during moraine construction. The moraines are covered by closely spaced, slightly weathered boulders which in a few areas are buried by loess and peat.

Donnelly drift contains large lenses of stratified material, including beds of large rounded boulders. Some of this stratified material occurs as channel deposits between the arcuate ridges of the moraines on the Gerstle River and is extensive enough to be shown on the map. Lithologically the younger drift closely resembles till of the Delta advance. Drift of the Donnelly advance is oxidized to depths of 1.5 to 2.0 feet; schist or granitic fragments within the weathered zone are only slightly altered.

Although glaciers of Donnelly advance on the Gerstle River and in several of the larger canyons were nearly as long as the older glaciers, they produced smaller and less discrete outwash deposits. The most distinct are in the gorge of the Gerstle River, occurring in terraces 15, 30, and 55 feet above the stream, and probably representing several positions of the ice front. These deposits are covered by silt and sandy silt as much as 3 feet thick. Most of the outwash of the Donnelly Glaciation from Granite Mountain was deposited in poorly defined, unmapped fans or channel deposits super-

imposed on older outwash and alluvium at the mountain front. Small, distinct, slightly weathered moraines in a few cirques of Granite Mountain indicate a glacial advance at some time between the maximum of the Donnelly Glaciation and the Trapa bispinosa, indicating a middle Miocene or younger age relatively recent advances of modern glaciers. These appear on the map with the same symbol as the main Donnelly moraines. Moraines of this readvance occur in both cirques of the west fork of Sawmill Creek, and in the hanging valley heading directly east of these cirques. The moraines consist of mounds or arcuate ridges marked by small closed depressions and hillocks having as much as 30 feet of relief. They are separated from end moraines of the main Donnelly moraines by bouldery, poorly sorted outwash deposits. The moraine surfaces are covered with slightly weathered boulders and gruss. The till, derived entirely from granitic rock, is coarse, and is weathered to less than 0.5 foot.

COLLUVIUM

alluvium, and till. The surface of the material on the valley stage. Silt and sand deposited during the fluctuations are sides is marked by solifluction lobes, turf-banked and stone- blown across the flood plain as loess or as sand sheets. banked terraces, stone stripes, and scattered boulders. Material on the valley floors is commonly patterned in the form of only a short distance from the mountain front. Most of the polygons and nets, vegetation rings, earth hummocks, tussocks, transport is on the flood plain, but occasionally the adjacent and scattered boulders. The debris on the valley floors is older bouldery deposits on the piedmont may be flooded. One trenched by the present streams in gorges 30 to 100 feet deep. such flood in recent years carried boulders onto and along a These materials are primarily in valleys that were filled with 9-foot terrace on one of the forks of Sawmill Creek. This ice during the Donnelly Glaciation and most, therefore, post-flood deposited 1 to 2 feet of coarse sand, gravel, and boulders, date the maximum of this advance. However, colluvium on and left pebbles leaning against or embedded in the bark of the upper valley walls may be somewhat older. Valley trees that are no more than 145 years old. fill is also older than modern alluvium, as shown by the deep

RUBBLE

trenches in the fill.

Angular granitic fragments derived from underlying bedrock rest on the gently rolling summit of Granite Mountain. Frost features are especially well developed, notably segre-Although these deposits are essentially glacial in origin, gated and unsegregated stripes, stone polygons, and nets, they merge with alluvial gravel from Granite Mountain, and vegetation rings, earth hummocks, and tussocks. A few knobs are mantled by younger glacial and alluvial gravel. The of deeply weathered granitic rock rise above the general level, lateral boundaries between the two kinds of gravel cannot be and are surrounded by patches of gruss. This rubble and delineated on a physiographic basis. Therefore, these deposits gruss, isolated from both glacial action and stream erosion, developed over a long period, extending at least as far back as the Delta Glaciation. It is still forming under present climatic and soil moisture conditions.

Angular fragments of granitic rock have accumulated as talus sheets, stripes and fans on steep bare valley or cirque glacial gravel deposits is more extensive than the bouldery walls. Unlike rubble, the material generally includes little Wahrhaftig, Clyde, 1958, Quaternary geology of the Nenana gravel and occurs as a broad plain from the piedmont of or no fine material. Talus merges downslope in many valleys

canyons: (1) large sheets and ridges of stabilized, weathered, lichen-encrusted blocks, and (2) narrow strips of fresh talus. Among the best examples of the older talus are large protalus ramparts separated by depressions from the sharp promontory protalus rampart at the north end of this promontory is composed of blocks as much as 25 feet across and has a relief of approximately 50 feet. Fresh talus is in general composed of smaller blocks, and is limited to narrow stripes. Some of these encroach upon, or are derived from, older talus sheets, or occur in narrow gullies near the ridge crests.

STREAM-TERRACE DEPOSITS

Low terrace deposits along the Gerstle River, especially in the northeast corner of the quadrangle, represent episodes of sedimentation in late glacial or postglacial time. The surface is marked by old meander scars, bogs, marshes, active drainage ways, and eolian deposits. The terrace was deposited against the terrace scarp of the extensive "glacial and non-glacial gravel" deposits which are regarded as no older than the Delta

EOLIAN SAND

Windblown sand occurs (1) as large dunes on the terrace deposits in the northeastern part of the quadrangle, (2) as small ridges and sand sheets on the gravel deposits in the center of the quadrangle, and (3) as modern sand sheets and dunes as much as 3 feet high on the lower part of the Gerstle River flood plain. The latter two types of occurrences are ot differentiated on the map.

The large area of eolian sand on the terrace deposits in the northeast part of the quadrangle consists of several narrow northwest-southeast ridges having a total length of more than 2 miles and relief as much as 50 feet. The northwestern tip of a similar feature which occurs 4 miles to the south is part of an extensive sand accumulation in the adjacent quadrangle to the east. The sand is stained yellow brown and is covered by about 2 feet of brown loess. Grass and forest vegetation cover the dunes. There is no active wind erosion, and there are no important sources of sand in the immediate vicinity. The dunes are younger than the post-Delta terrace on which they lie, and are probably younger than the maximum of the Donnelly Glaciation. The loess and forest cover and the oxidation of the sand suggest they are possibly late

Unmapped sand sheets on the glacial and nonglacial gravel in the center of the quadrangle are similarly oxidized and covered with forest vegetation. These dunes include ridges and lenticular sheets as much as 20 feet high. Perennial and intermittent ponds and dry depressions lie among the dunes.

Organic silt and peat occur in shallow swales, such as in the closed depressions on terrace deposits, in dune hollows, and in kettle holes. Organic silt, typically supporting black spruce muskeg vegetation, also accumulates on the gravel deposits flanking Granite Mountain. Scattered, unmapped deposits, including eolian silt and organic silt and peat, also cover nearly all other materials, except bare flood plains, bedrock on steep slopes, or areas exposed to strong wind.

FLOOD-PLAIN GRAVELLY ALLUVIUM

Coarse, poorly sorted alluvium lies on the flood plain of the Gerstle River and flood plains along streams draining Granite Mountain. This material is deposited and reworked by a Valley sides and floors of canyons in Granite Mountain are braided glacial stream, which is covered by icing in winter, mantled by colluvium consisting of mixtures of talus, rubble, and which is subject to diurnal and seasonal fluctuations in Alluvium in the mountain streams is bouldery, and is moved

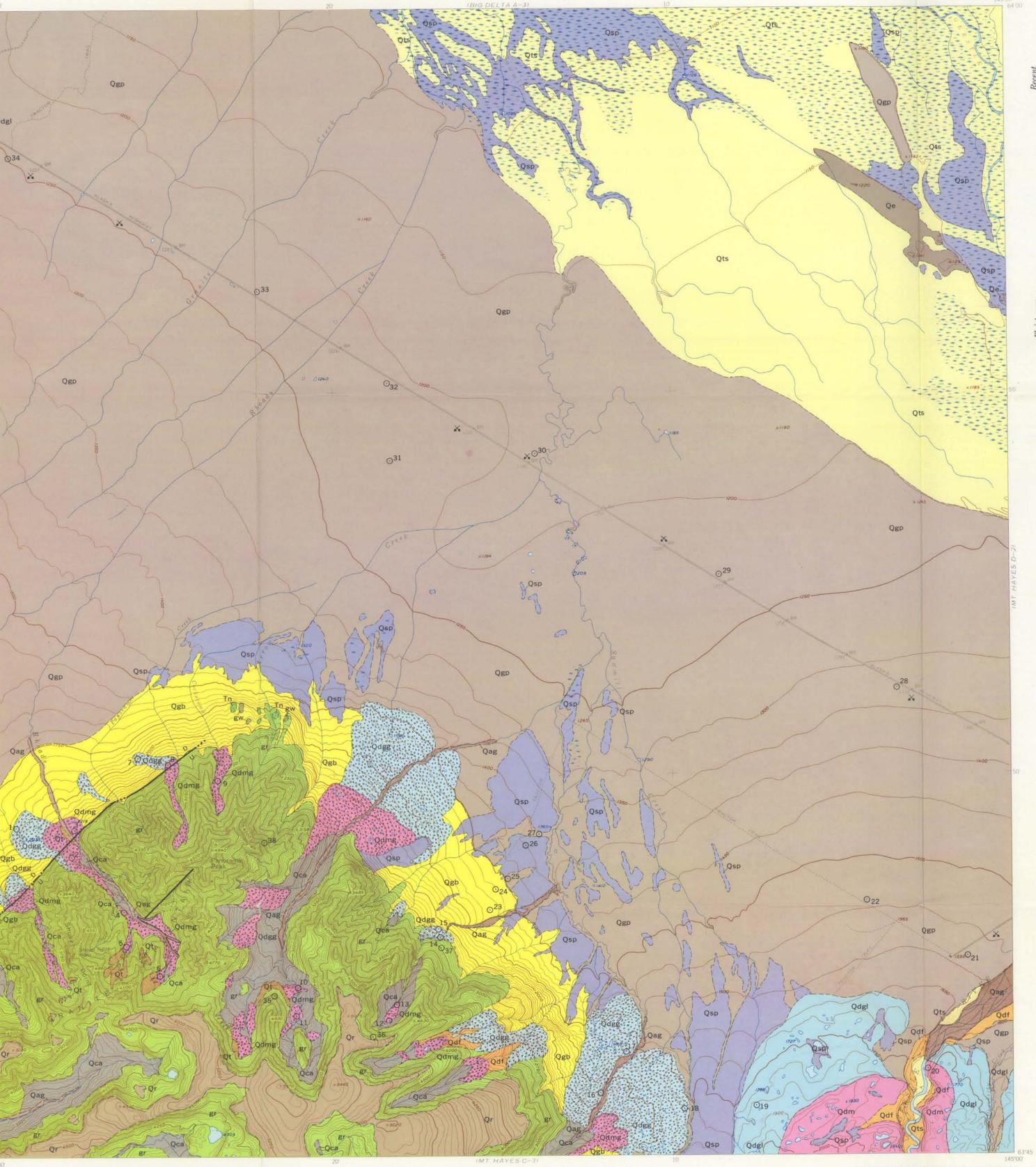
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Base by U.S. Geological Survey, 1956



ated with William S. Benninghoff in 1956, and Troy L. Pewe, assisted by M. F. Meier in 1951 and R. A. Paige in 1955 and 1956

Flood-plain gravelly alluvium

Light yellow or light gray gravel, sand and

sand and silt. Poorly sorted and poorly

stratified, with frequent changes in grain

Stream terrace deposits

Brown, dark brown, or gray silt, silty sand, or

sand in low terraces on the Gerstle River.

Mantled and interbedded with peat and

Glacio-fluvial deposits

Light yellow, faintly stratified, moderately to

poorly sorty silty or sandy gravel. Mantled

Glacial-moraine deposits

Gray to yellowish gray bouldery sandy till,

containing fragments of schist, quartzite, granitic and mafic rocks. Moraines flank-

entirely of granitic rocks

Qdm, till from the Alaska Range

Qdmg, till from Granite Mountain

Qdgl, till from the Alaska Range

Odgg, till from Granite Mountain

ing Granite Mountain are composed almost

Qdgl Qdgg

Glacial-moraine deposits

Light yellowish brown or yellowish gray

compact sandy till, containing fragments of

schist, quartzite, granitic and mafic rocks.

Moraines in the mountains are mostly

Contact

Dashed where approximately located

0

Fault

Dotted where concealed; U, upthrown

side; D, downthrown side

Gravel pit

Sample location

FTTTTTTT

Terrace scarp

Ticked on down-slope side

by variable thicknesses of silt and sand

size both laterally and vertically

organic silt

oulders, with lenses or surficial sheets of

GEOLOGIC MAP OF THE MT. HAYES D-3 QUADRANGLE, ALASKA

G. Williams Holmes and Troy L. Pewe' SCALE 1:63 360 1 .5 0 1 2 3 4 5 KILOMETERS CONTOUR INTERVAL 50 FEET DATUM IS MEAN SEA LEVEL 1965

EXPLANATION

Silt and peat

silt, typically well sorted, with little clay,

and mantled by thin (normally less than

0.5 foot) layers of peat. Moist in summer

and underlain by permafrost at 2-4 feet

Glacial and non-glacial gravel

unweathered gravel and boulders.

of the Delta Glaciation, but merge

laterally and vertically with

younger glacial and non-glacia

gravel from Granite Mountain

Qgp, gravel and sand

Qgb, bouldery gravel

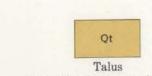
rimarily glacio-fluvial deposits

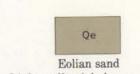
Light yellowish brown, weathered to

Angular granitic fragments derived

with a sandy or silty matrix

from underlying bedrock, in places





Angular fragments of locally Light yellowish brown, well sorted, cross-bedded sand, derived granitic rocks, deposited by gravity movement mantled by silt

Alpine colluvium derived from granitic talus Black, or mottled gray and brown, organic rubble, till and alluvium, merging downslope with mixtures of till and alluvium on

OLDER SEDIMENTARY ROCKS

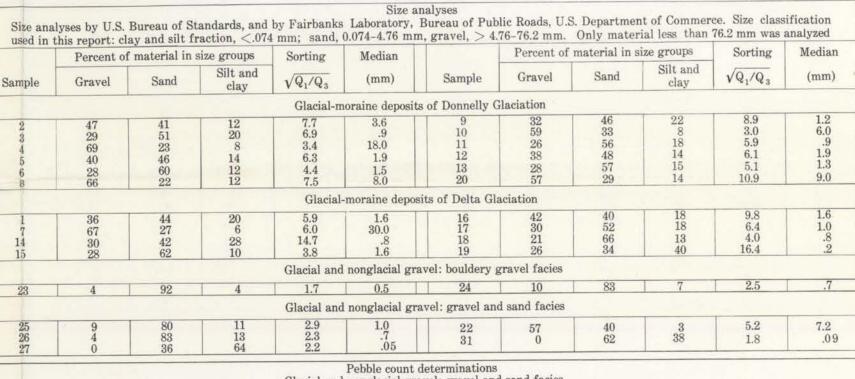
Nenana Gravel Deeply weathered, partly to well cemented gravel, composed of well-rounded quartz and quartzite pebbles and small cobbles

BEDROCK



Light gray, medium to coarse-grained granodiorite and quartz monzonite, composed of plagioclase, microperthitic potash feldspar, quartz, biotite, and accessory minerals. Chiefly hypidiomorphic, containing euhedra to subhedral plagioclase, and anhedral potash feldspar. Some quartz is anhedral but most is interstitial. Plagioclase is polysynthetically twinned and zoned, and potash feldspar displays Carlsbad twinning. Biotite and green hornblende occur as poikilitic inclusions in the feldspars and as independent grains in the matrix gw, deeply weathered granitic rocks

Analyses of samples for Mt. Hayes D-3 quadrangle



[sample locations shown on map]

Glacial and nonglacial gravel: gravel and sand facies Percentages of rock types

For sale by U.S. Geological Survey, price \$1.00