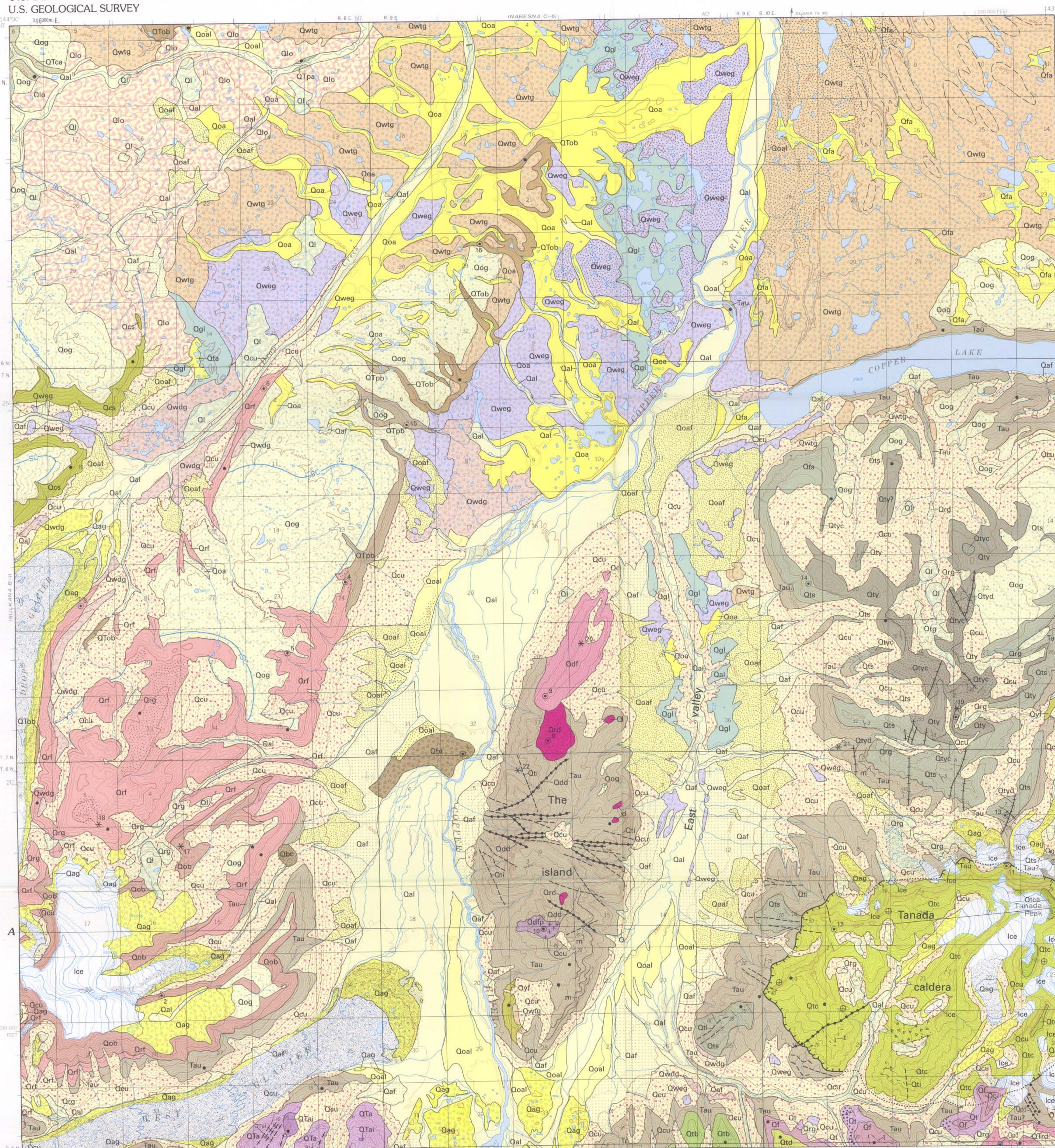


Base from U.S. Geologic Survey 1960
10,000-foot grid based on Alaska Coordinate system, zone 2
1000-meter Universal Transverse Mercator grid ticks, zone 7, shown in blue

APPROXIMATE MEAN DECLINATION, 1993

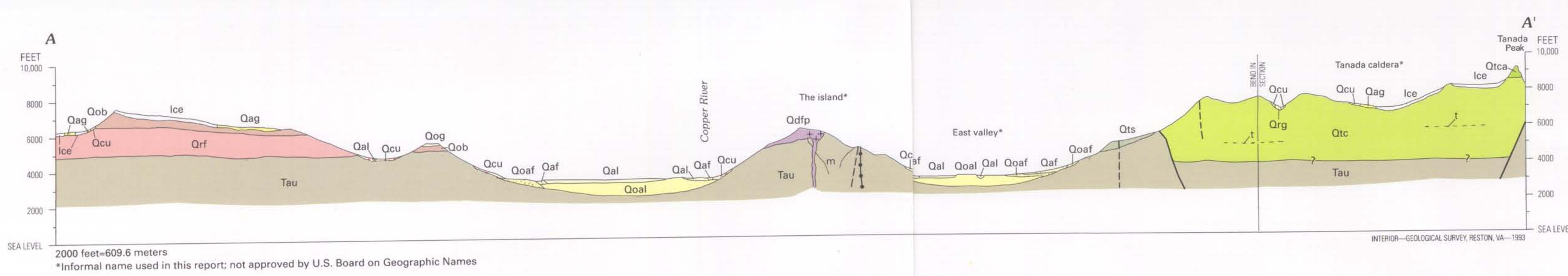
SCALE 1:63 360

CONTOUR INTERVAL 100 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

Bedrock geology mapped by D.H. Richter, 1973, 1981-82; J.G. Smith, 1981; R.L. Smith, 1973; J.C. Ratté, 1982, in 12 helicopter-supported days. Glacial and surficial geology mapped by H.R. Schmoll chiefly by air-photo interpretation

Manuscript approved for publication October 16, 1989
Edited by Julia Thomas; Cartography by Janet Goodman



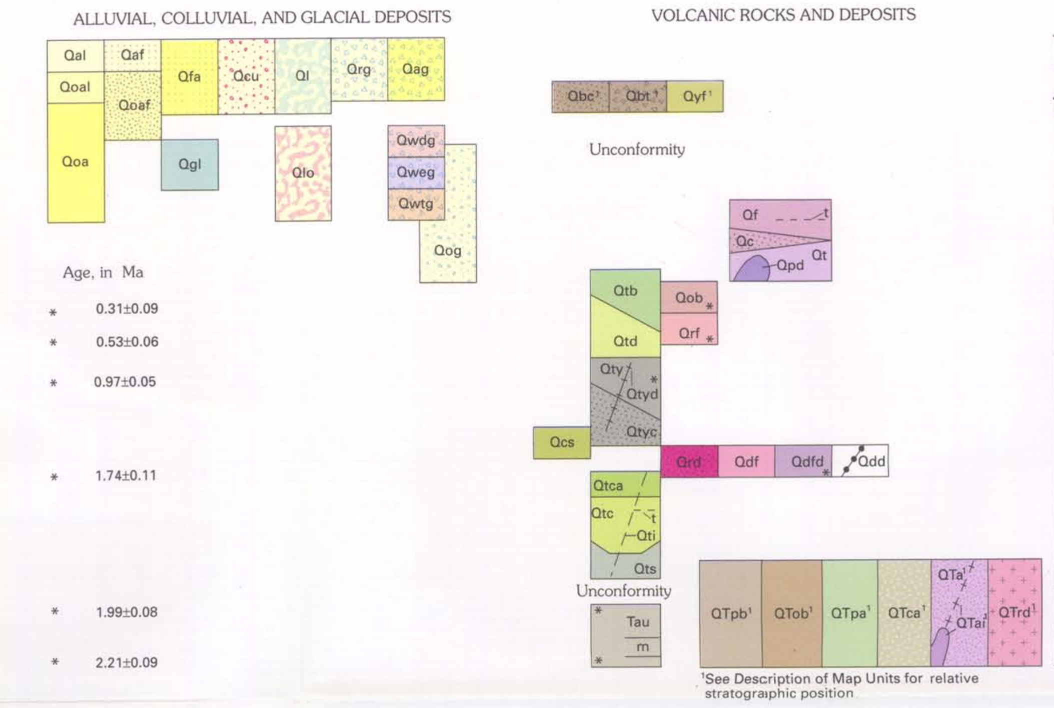
2000 feet=609.6 meters
*Informal name used in this report; not approved by U.S. Board on Geographic Names

GEOLOGIC MAP OF THE NABESNA B-6 QUADRANGLE, SOUTH-CENTRAL ALASKA

By
D.H. Richter, J.G. Smith, H.R. Schmoll and R.L. Smith

1993

CORRELATION OF MAP UNITS



[1]See Description of Map Units for relative stratographic position

DESCRIPTION OF MAP UNITS

ALLUVIAL, COLLUVIAL, AND GLACIAL DEPOSITS

Alluvial deposits (Holocene and Pleistocene)

Qal **Alluvium in streams (Holocene)**—Mainly in active flood plains and lowermost terraces of major and some minor streams. Chiefly sand and gravel with local cobbles and boulders

Qaf **Alluvium in fans (Holocene)**—Mainly large, broad, locally active fans and cones on mountain slopes chiefly along major streams. Sand, gravel, and boulders

Qfa **Fine-grained alluvium (Holocene and Pleistocene)**—Mainly silt and sand along small streams and in pond deposits mostly on drift of Tanada Creek (unit Qwtg). Includes fine-grained alluvium in complex of fan and stream deposits at west end of Copper Lake

Qoal **Older alluvium in streams (Holocene)**—Mainly in principal terraces of major streams. Chiefly outwash related to older phase of Alaskan glaciation. Stipple denotes areas of alluvium containing interbedded stratiform pumice-rich deposits derived from basalt tuff cone (unit Qbt) in the Copper River valley. Sand, gravel, and boulders

Qoaf **Older alluvium in fans (Holocene and Pleistocene)**—Includes large inactive fans and cones on mountain slopes principally along major streams and a few broad fans in low-lying areas. Chiefly sand, gravel, and boulders

Qoa **Oldest alluvium in streams (Pleistocene)**—In fossil drainages in low relief terrain underlain by Wisconsin and older glacial deposits. Consists mainly of outwash related to drifts of Drop Creek, East valley (informal name), and Tanada Creek , which in north-central part of quadrangle is graded to various levels of glacial Lake Boomerang (informal name). Chiefly sand and gravel

Qgl **Glaciolacustrine deposits (Pleistocene)**—Mainly deposits of glacial Lake Boomerang, an extensive, shallow lake that covered a large area of drifts of East valley and Tanada Creek (units Qweg and Qwtg) in the north-central part of the quadrangle, and deposits of a smaller and higher glacial lake in East valley. Unit also includes deposits in kame fans and terraces related to drift of Drop Creek in the northwestern part of the quadrangle and to drift of East valley in East valley. Chiefly silt and sand in glacial lake deposits; includes coarse sand and some gravel in kame fans

Colluvial deposits (Holocene and Pleistocene)

Qcu **Colluvium, undifferentiated (Holocene and Pleistocene)**—Chiefly talus but includes deposits of small landslides, rock glaciers, and other mass-wasting processes. Generally includes a large proportion of alluvium in small fans and cones. Also includes remnants of morainal deposits especially along major streams. Shown mainly where deposits cover volcanic bedrock; colluvium on moraines and landslide deposits is generally not distinguished. Chiefly poorly sorted silt, sand, gravel, and boulders

Ql **Landslide deposits (Holocene and Pleistocene)**—Includes large slump and block-glide deposits and some larger debris avalanches in volcanic bedrock, glacial deposits, and older landslide deposits

Qlo **Older landslide deposits (Pleistocene)**—Large, probable debris avalanche complex in Wisconsin and older glacial deposits in northwestern part of quadrangle; interpreted largely from air photos. Deposits probably range from blocky to fluidal in nature and include some fluvial and colluvial reworking. Chiefly diamicton

Glacial deposits (Holocene and Pleistocene)

Qrg **Rock glacier deposits (Holocene)**—Includes deposits in active rock glaciers, that have well-defined lobate and tongue-shaped forms, small coalescing rock glaciers which form linear ridges along bases of steep slopes, and inactive rock glaciers which have smooth forms. Chiefly angular blocks and diamicton

Qag **Drift of Alaskan glaciation (Holocene)**—Includes end and lateral moraines of the younger (Tunnel) phase of Alaskan glaciation, deposited after recession of existing glaciers, and end moraines of older (Tustamena?) phase of Alaskan glaciation. Diamicton; local gravel and sand

Drift of younger (Wisconsin?) glaciation (Pleistocene)—Chiefly diamicton and rubble; local gravel and sand

Qwdg **Drift of Drop Creek**—End, lateral, and ground moraines and locally outwash

Qweg **Drift of East valley**—End, lateral, and ground moraine locally modified by alluvial and colluvial processes. Stipple denotes area modified by glacial Lake Boomerang

Qwtg **Drift of Tanada Creek**—Lateral and ground moraine locally extensively modified by mass slumping and other colluvial and alluvial processes. Stipple denotes area modified by glacial Lake Boomerang. Dashed lines enclose prominent drumlinoid features. Tanada Creek deposits may be up-valley equivalent of Cobb Lake drift described as deposited by Copper River basin glaciers (south and west source) in the adjacent Gulkana B-1 quadrangle (Richter and others, 1989). In this part of the basin the deposits merge and the distinction between basin glacier deposits and valley glacier deposits, as recognized in the Gulkana B-1 quadrangle and elsewhere down-valley, is much less relevant

Qog **Older glacier deposits (Pleistocene)**—Includes lateral and ground moraines of the Boulder Creek (Schmoll, 1984) and Sanford-Copper drift from ice sources to the south and west in the Copper River basin, the boundaries of which are denoted by blue line, and possibly older ground moraines. Also includes esker, kame, channel, valley-fill, and outwash deposits related to these moraines. At the margin of the broad, gently north sloping surface in secs. 14, 22, and 23, along east side of quadrangle south of Copper Lake, boulder-gravel outwash, as thick as 15m is locally exposed. Deposits generally extensively modified by stream action and by colluvial processes including massive downslope movement, debris flow, solifluction, and creep. Chiefly diamicton and rubble; local silt, sand, and gravel

VOLCANIC ROCKS AND DEPOSITS

Qbc **Basalt cinder cones (Holocene or Pleistocene)**—Two small cones, showing some original constructional form, consisting of reddish-brown olivine basalt cinder and scoria. Exposed in valley in sec. 11, T. 6 N., R. 8 E. and in sec. 35, T. 6 N., R. 10 E.; evidently formed after retreat of Wisconsin glaciers

Qbt **Basalt tuff cone (Holocene or Pleistocene)**—Grayish-brown to yellowish-brown, bedded and locally palagonitic ash plus variable amounts of pumice, cinder, and glassy bombs as much as 1 m in diameter. Thin beds of accretionary lapilli common locally. All ejecta are of olivine basalt composition. Dark-gray bombs contain phenocrysts of plagioclase (4-5 percent, 0.5 mm) and fresh olivine (2-3 percent, 2-3 mm) in a glassy groundmass. Major element chemistry for sample 73-ARh-86 (map locality 1), a glassy bomb, is shown in table 1. Cone has been partly eroded by Copper River but has not been overridden by active glacial ice. Apparently erupted either through ice during waning (stagnant) stage of Wisconsin glaciation or through water or water-saturated sediments following Wisconsin glaciation

Qyf **Young andesite flows (Holocene or Pleistocene)**—Massive, grayish-black, conspicuously porphyritic flows containing phenocrysts of plagioclase (10 percent, 5-10 mm), clinopyroxene (2-3 percent, 2-4 mm), hypersthene (1 percent, 2-3 mm), and traces of opaque minerals and corroded olivine in a glassy to cryptocrystalline groundmass. Observed only at south end of The island (informal name for large erosional remnant in the Copper River valley) and in valley in sec. 35, T. 7 N., R. 10 E. May represent sub-ice flows; source unknown

Andesite intrusive rocks, flows, cinder, and tuff (Pleistocene)—Extrusive rocks fill irregular erosion surface and partly cover the wall of Tanada caldera in extreme southeast corner of quadrangle. Principal source is probably area underlain by cinders (unit Qc) in sec. 34, T. 6 N., R. 10 E.

Qf **Olivine andesite flows**—Medium-gray, medium to thick (3-10 m) flows exhibiting scoriaceous tops and bottoms. Sparsely porphyritic containing phenocrysts of plagioclase (trace to 1 percent, 1-2 mm) and olivine (trace to 2 percent, 1 mm) in a pilotaxitic groundmass of plagioclase, clinopyroxene, and opaque minerals. Interlayered section of lapilli tuff, about 30 m thick, denoted by dashed line labeled t. Maximum thickness about 360 m

Qc **Olivine andesite cinder**—Reddish-gray to medium-gray cinder, scoria, and bombs on remnant cinder cone. Composition similar to olivine andesite flows (unit Qf)

Qt **Tuffs and mudflows**—Pale-yellowish-brown to dusky-yellow layered lapilli tuffs containing locally abundant cinder, blocks, and bombs of olivine andesite. Tuffs irregularly overlie massive drab-colored mudflows (coarse stipple). Maximum thickness about 300 m

Qpd **Andesite plug and dikes**—Dark gray, equigranular (0.5 mm), containing plagioclase (70-80 percent), hypersthene (20-25 percent), and opaque minerals (2-5 percent). Rocks have distinctly different mineralogy from spatially associated extrusive rocks and may not be genetically related

Basalt and dacite flows (Pleistocene)—Source is eruptive center at head of Tumble Creek, 5-6 km south in the Nabesna A-6 quadrangle

Qtb **Olivine basalt flows**—Medium-dark-gray, porphyritic basalt containing phenocrysts of plagioclase (4-10 percent, as large as 1 cm), olivine (3-4 percent, 1-5 mm), clinopyroxene (trace to 2 percent, 1-3 mm), and rare hypersthene in a pilotaxitic to intergranular groundmass of plagioclase, clinopyroxene, olivine, and opaque minerals

Qtd **Dacite flow**—Light-gray to pale-yellowish-brown massive flow, as thick as 300 m, containing phenocrysts of plagioclase (2-4 percent, 2-3 mm), oxyhornblende (1-2 percent, as long as 5 mm), and traces of clinopyroxene and opaque minerals in a trachytic groundmass consisting chiefly of feldspar

Qob **Olivine basalt and andesite flows (Pleistocene)**—Flows are 2-6 m thick and exhibit conspicuous reddish-brown scoriaceous flow tops and bottoms. Dense flow interiors are medium to dark gray and sparsely porphyritic containing phenocrysts of plagioclase (2-5 percent, 3-4 mm) and olivine (1-3 percent, 0.5-1 mm) in an intersertal to pilotaxitic groundmass of plagioclase, pyroxene, opaque minerals, and glass. Rarely, flows contain as much as 3 percent phenocrystic hypersthene. Flows probably erupted from rift a few kilometers west in the Gulkana B-1 quadrangle and tend to be more silicic than some of the flows included in the map unit in Gulkana B-1 quadrangle (Richter and others, 1989). Major element chemistry for sample 73-ARh-81 (map locality 2) is shown in table 1. Whole rock K-Ar age of sample 73-ARh-87 (map locality 17) is 0.32±0.09 Ma (table 2). Aggregate maximum thickness about 360 m

Qrf **Rhyodacite flow (Pleistocene)**—Massive to platy and locally vesicular; possibly single flow about 18 km long, 7 km wide, and as much as 350 m thick. Rock is light gray to medium light gray, and moderately porphyritic containing phenocrysts of sodic plagioclase (4-7 percent, 1-5 mm), rounded green clinopyroxene (trace to 2 percent, generally less than 1 mm), and rare potassium feldspar and hornblende in a groundmass of micro- to cryptocrystalline felty aggregates (vapor phase crystallization?) dusted with opaque minerals. A dark-gray to brownish-black massive vitrophyre phase (indicated by stipple), showing spectacular swirly columnar joints, occurs at base and locally at top of flow. Source is probably dome along west side of the north Sanford eruptive center in the adjacent Gulkana B-1 quadrangle (Richter and others, 1989). Major element chemistry for samples 81-ASj-73, 73-ARh-84, 81-ASj-63, and 81-ASj-66 (map localities 3, 4, 5, and 6, respectively) are shown in table 1. Whole-rock K-Ar age of sample 74-ALe-29 (map locality 18) is 0.53±0.06 Ma (table 2). Volume and composition of the lava may be unique for the Wrangell volcanic field. Using an average thickness of 150 m, the dimensions indicate a volume of more than 20 km^3 which is unusually large for a single flow of remarkably uniform composition. However, there is no evidence to suggest that the lava was not emplaced as a normal lava flow. Although the flow is referred to as rhyodacite because of its mineralogy, it does plot in the rhyolite field in the K_2O/SiO_2 variation diagram of figure 1 and the high K_2O content places it well within the high-K field

Young basalts and basaltic andesites (Pleistocene)—Erupted from a vent, or group of vents, on the north flank of Tanada shield volcano. Contact between these rocks and Tanada shield lavas (unit Qts) and older flows (unit Tau) south of Copper Lake is generally obscured by colluvium and heavy brush. Maximum thickness about 300 m

Qtyd **Dikes**—Medium- to dark-gray, north-trending dikes. Porphyritic, containing plagioclase phenocrysts (5-20 percent, as much as 2 cm) in a pilotaxitic groundmass of plagioclase, olivine, clinopyroxene, and opaque minerals. Mineralogy suggests dikes are probably more silicic than associated lavas and cinder

Qty **Flows**—Chiefly dark-gray to grayish-black, thin to medium (2-5 m), olivine basalt and basaltic andesite flows. Rocks are mostly porphyritic containing phenocrysts of plagioclase (trace to 10 percent, 0.5 mm-1 cm) and olivine (trace to 5 percent, 0.5-1 mm) in a pilotaxitic to intersertal groundmass of plagioclase, clinopyroxene, olivine, opaque minerals, and glass. Major-element chemistry for sample 81-ARh-42 (map locality 7) is shown in table 1. Whole- rock K-Ar age of sample 81-ASj-86 (map locality 19) is 0.97±0.05 Ma (table 2)

Qtyc **Cinder, scoria, and bombs**—Reddish-gray to grayish-black, locally glassy ejecta compositionally similar to associated flows (unit Qty)

Qcs **Capital volcano flows (Pleistocene)**—Chiefly gray to dark-gray flows of porphyritic hypersthene andesite; includes olivine- and clinopyroxene-bearing andesites and basaltic andesites. Exposed along west boundary of quadrangle; occurs in adjacent Gulkana B-1 quadrangle where unit forms the broad shield of the 1 Ma Capital volcano (Richter and others, 1989)

Silicic lavas and dikes (Pleistocene)—These rocks occur mostly on The island where they intrude and unconformably overlie old andesites (unit Tau). May be contemporary with Tanada volcano but radiometric ages and field relations are not definitive

Qrd **Crystal-poor rhyolite dome**—Pale-red, yellowish-gray to light-gray rhyolite generally exhibiting very fine and extremely contorted flow laminations. Contains traces of sodic plagioclase, less than 1 mm in diameter, in a cryptocrystalline groundmass. Includes a number of small exposures of rhyolite to the south and east of the main mass. May have been fed from multiple vents. Major-element chemistry for sample 73-ARh-94 (map locality 8) is shown in table 1

Qdf **Crystal-rich dacite flow**—Light-gray, locally streaked reddish-gray, massive to flow-laminated, moderately crystal rich dacite containing phenocrysts of sodic plagioclase (5-10 percent, 2-5 mm) that are locally resorbed, biotite (1-3 percent, 1-3 mm), rounded quartz (trace to 1 percent, 2 mm), and traces of opaque minerals in a microtrachytic groundmass. Possibly late flow from rhyolite dome (unit Qrd). K-Ar age of biotite from sample 81-ASj-72 (map locality 20) is 1.74±0.11 Ma (table 2). Major-element chemistry for sample 81-ARh-26 (map locality 9) is shown in table 1

Qdfp **Dacite flow-dome and plug**—Pale-red to light-gray massive flow dome exhibiting a columnar-jointed base and a crackled and brecciated, medium-gray glassy plug(?) (shown by crosses). Rock is porphyritic containing phenocrysts of plagioclase (12-15 percent, as large as 3 mm), oxyhornblende (2-3 percent, 2 mm), hypersthene (trace to 1 percent, 2 mm), and traces of opaque minerals in a cryptocrystalline matrix. Major-element chemistry for sample 81-ARh-19 (map locality 10) is shown in table 1

Qdd **Dacite dikes**—Light-colored, generally porphyritic rocks containing phenocrysts of plagioclase (2-35 percent, as large as 5 mm), oxyhornblende (traces to 2 percent, 3 mm), and traces of clinopyroxene and opaque minerals in a micro- to cryptocrystalline groundmass. Dikes are generally vertical and as wide as 10 m and as long as 4 km; they are chiefly confined to a crude swarm trending roughly east-west across the middle of The island

Tanada volcano (Pleistocene)—Andesitic shield volcano of probably early Pleistocene age that may have covered an area of more than 400 km^2, containing an oval-shaped summit caldera 8.1 km long by 5.6 km wide. Much of the original shield has been stripped away by glacial erosion leaving intracaldera lavas on the presently high topographic features (Tanada Peak) of the structure (fig. 1). The shield remnants consist chiefly of andesitic lava flows and minor laharic and pyroclastic deposits that dip 1°-20° away from the summit area. The caldera is filled with more than 1,200 m of, flat-lying andesitic flows and dacitic agglutinates (5-50 m thick). Most of the exposed caldera wall consists of pre-Tanada volcanic rocks (unit Tau). Shield lavas are only exposed in the caldera wall of the volcano where erosion has been less extreme. The exposed caldera wall is probably chiefly topographic; it dips 20°-50° inward and is mantled locally by thin pyroclastic beds and rubbly breccias (not mapped separately)

Qti **Andesite dikes**—Medium- to dark-gray, equigranular to sparsely porphyritic. Equigranular varieties contain plagioclase, hypersthene, and clinopyroxene; porphyritic varieties generally contain plagioclase and hypersthene phenocrysts in a pilotaxitic groundmass. Mostly related to Tanada volcano but probably includes dikes associated with other eruptive centers

Qtca **Intracaldera agglutinates**—Thick (as much as 50 m), medium-gray to greenish-gray remobilized agglutinate probably of dacitic composition. Probably last products of intracaldera activity; exposed only on four highest points within caldera and observed only from helicopter. Maximum thickness about 150 m

Qtc **Intracaldera flows**—Medium to thick (5-30 m), dark-gray to greenish-gray, porphyritic andesite flows. Chiefly augite-olivine andesites containing phenocrysts of plagioclase (5-20 percent, 1-10 mm), augite (trace to 3 percent, 1-2 mm), and olivine (trace to 2 percent, 3-5 mm) in a pilotaxitic to intergranular groundmass. Mafic minerals generally altered to clay minerals and serpentine; vesicles mostly filled with celadonite and calcite. Pyroclastic deposits, shown by dashed line labeled t, are chiefly bedded andesitic lapilli airfall tuffs. An area of brecciation, hydrothermal alteration, and small dikes, shown by small triangles, occurs in the south-central part of the caldera and may mark the locus of long-lived post-caldera eruptive and thermal activity. Major-element chemistry for samples BCM-13 and BCM-15 (map localities 11 and 12) is shown in table 1. Thickness greater than 1,000 m; base not exposed

Qts **Shield lavas**—Chiefly dark-gray to medium-gray, thin to medium (2-10 m) flows of sparsely porphyritic andesite and basaltic andesite and minor intercalated laharic and pyroclastic deposits. Flows contain phenocrysts of plagioclase (1-2 percent, 1-5 mm), augite (0-1 percent, 1-2 mm), and traces of hypersthene, olivine, and opaque minerals in a microfelty to pilotaxitic groundmass. Major-element chemistry for samples BCM-14 and 81-ARh-33 (map localities 13 and 14) is shown in table 1. In the adjacent Nabesna B-5 quadrangle (Lowe and others, 1982) the andesite and basaltic andesite flows of their unit QTaf are mostly equivalent to Tanada shield lavas. Thickness about 500 m

Mafic to intermediate flows (Pleistocene or Pliocene)—Poorly exposed lava flows in lowlands in northwest quarter of quadrangle. Sources and ages mostly unknown

QTpb **Plagioclase-olivine basaltic andesites**—Medium-gray, medium to thick (3-10 m) flows containing phenocrysts of plagioclase (8-15 percent, 3-4 mm), olivine (1-2 percent, 0.5-1 mm), and traces of opaque minerals in an intergranular groundmass. Major-element chemistry for sample 81-ASj-64 (map locality 15) is shown in table 1

QTob **Olivine basalts**—Thick (greater than 5 m), medium-gray to medium-dark-gray, sparsely porphyritic flows containing phenocrysts of fresh olivine (trace to 5 percent, 0.5-2 mm) in an intergranular to intersertal groundmass of plagioclase, olivine, clinopyroxene, and locally glass. Major element chemistry for sample 81-ASj-76 (map locality 16) is shown in table 1. Source for northernmost flows is apparently a small eroded shield volcano 2-3 km north in Nabesna C-6 quadrangle

QTpa **Plagioclase andesites**—Medium-dark-gray, strikingly porphyritic flows containing phenocrysts of plagioclase (15-20 percent, 3-5 mm) in an intergranular groundmass of plagioclase, clinopyroxene, and opaque minerals

QTca **Plagioclase-clinopyroxene andesites**—Medium-gray, fine-grained to sparsely porphyritic lavas containing a few percent phenocrysts of plagioclase, clinopyroxene, and possibly olivine. Equivalent to old andesite flows (unit QTof) in adjacent Gulkana B-1 quadrangle (Richter and others, 1989)

Andesitic mudflows, tephra, dikes, and plugs (Pleistocene or Pliocene)—450-m-thick sequence of andesitic mudflows, tephra, and minor interlayered flows and flow breccias cut by andesitic dikes and plugs. Younger than, or partly contemporaneous with, undifferentiated older andesite (unit Tau) between West Glacier and the Copper Rivers

QTai **Andesite dikes and plugs**—Dikes are medium gray to medium dark gray, holocrystalline to porphyritic; porphyritic variants contain phenocrysts of plagioclase (1-10 percent, as long as 2 cm), hypersthene (1 percent, 1 mm), and olivine (1-2 percent, 1 mm) in an intergranular to microcrystalline groundmass. Dikes generally less than 3 m wide and 1 km long. Plugs are dark gray, brecciated, and coarsely porphyritic containing abundant (10-20 percent) large (2 cm) phenocrysts of plagioclase and minor (1-2 percent) smaller hypersthene in a pilotaxitic groundmass

QTa **Andesite mudflows and tephra**—Crudely layered brownish-gray mudflows with unsorted clasts of andesite, as much as 1 m in diameter, in a palagonitized mud matrix. Mudflows overlain by bedded, brown, tan, and gray, locally palagonitized, air-fall tuff containing andesitic debris ranging from walnut-sized lapilli to fine ash. Locally contains reworked mud and sand lenses. Andesite flows, locally coarsely porphyritic, are scattered through the section

QTrd **Rhyolite dome (Pleistocene or Pliocene)**—Light-olive-gray to medium-gray, sparsely to moderately porphyritic rhyolite containing phenocrysts of sodic plagioclase (1-12 percent, 1-5 mm), altered hornblende (trace to 2 percent, 1 mm), and traces of clinopyroxene and hypersthene in a trachytic to hyalopilitic groundmass. Exposed chiefly in Nabesna A-5 quadrangle; contains 71.4 percent SiO_2 (Richter and Smith, 1976)

Tau m **Older andesites, undifferentiated (Pliocene)**—Chiefly flat lying to gently dipping, medium to thick (3-20 m) flows, exhibiting scoriaceous tops and bottoms, and rare to locally common intercalated mudflows, breccias, and bedded tephra. Flows range from medium gray and dark gray to olive gray in color, are locally amygdaloidal and generally porphyritic containing 5-25 percent phenocrysts. Principal types include hypersthene andesite, hypersthene-augite andesite, hypersthene-olivine andesite, and olivine andesite. Typical hypersthene andesite contains phenocrysts of plagioclase (10 percent, 1-5 mm), hypersthene (trace to 4 percent, 1-4 mm), and opaque minerals (trace, 1 mm) in a pilotaxitic groundmass of plagioclase, clinopyroxene, and opaque minerals. Some thick, prominent mudflow units shown by m where mapped. Unit originates from a number of mostly unidentified sources, one of which may be at south end of The island where breccias and mudflows are steeply dipping. In vicinity of Copper Lake, unit may include younger flows of Tanada volcano (unit Qts) and young basalts and basaltic andesites of Tanada (unit Qty). Whole-rock K-Ar ages of samples 81-ASj-77B (map locality 21) and 81-ASj-85 (map locality 22) are 1.99±0.08 Ma and 2.21±0.09 Ma, respectively. Thickness greater than 900 m; base not exposed

Contact—Known, approximate, or inferred

30 **Caldera wall, showing dip**—Dotted where concealed. Hachures on caldera collapse side. Wall mostly topographic, however, symbol and dip may locally reflect structural (ring-fault) parts of wall

Glacial boundaries—Generalized upper limits of glacial deposits related to the following moraines

—BC— **Boulder Creek**—Youngest and lowest

—SC— **Sanford-Copper**—Oldest and highest

Attitude of bedding and flow layering

40 **Inclined**

⊕ **Horizontal**

• ⊙ ✳ **Petrographic sample locality**—Dot indicates sample locality; circle indicates sample has been chemically analyzed; asterisk indicates K-Ar date. Numbers refer to tables 1 and 2

GEOLOGIC NOTE

The Nabesna B-6 quadrangle is in the northwest part of the large (>10,000 km^2 (3,800mi^2)) Wrangell volcanic field of Miocene to Holocene age in south-central Alaska. The quadrangle includes most of Tanada volcano and the extreme east flank of Sanford volcano; both are large Pleistocene andesitic shield volcanoes. The two volcanoes are built on a series of older (Late Pliocene to Pleistocene) lavas whose source (or sources) is poorly constrained. Two late Pleistocene or Holocene basalt cinder-lava cones and a basalt tuff cone are the youngest eruptive rocks in the quadrangle.

Tanada volcano (fig. 1) is the dissected remnant of a large shield that originally may have covered as much as 400 km^2 (155 mi^2). It has an oval-shaped summit collapse caldera, about 8 km long by 6 km wide, filled with a minimum of 1,200 m of flat-lying intracaldera flows, which now form the highest topographic features of the volcano. Both the shield and intracaldera lavas are principally augite-olivine and augite andesites; the uppermost intracaldera lavas are agglutinates, probably of dacitic composition. Much of the north flank of the Tanada shield is mantled by a group of basaltic andesite cinder-lava cones, and a part of the south caldera wall is buried by younger andesite lava, cinder, and tuff.

The east flank of Sanford volcano is composed of an exceptionally large rhyodacite flow and a series of overlying olivine basalt and basaltic andesite flows. These lavas were erupted from vents in the north Sanford eruptive center to the west in the adjacent Gulkana B-1 quadrangle (Richter and others, 1989).

Most of the Tanada, Sanford, and older and younger lavas show calc-alkaline affinities typical of volcanic rocks erupted along convergent plate margins (fig. 2). A few silicic lavas, such as the large Sanford rhyodacite flow, have pronounced high-K tendencies suggesting that magma differentiation has been affected by local subvolcanic processes.

Quaternary alpine glaciers and Copper River basin glaciers have extensively modified most of the volcanic landforms in the quadrangle. A young Holocene or Pleistocene basalt tuff cone in the bottom of the Copper River valley is one of the few volcanic units that apparently erupted after major Pleistocene glaciation.

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Figure 1. View of Tanada volcano from the north. Tanada Peak (2,853 m (9,358 ft) is high point at left end of high ridge. High ridge is composed of flat lying intracaldera agglutinates and flows (map units Qtca, Qtc). Caldera wall is exposed locally at break in slope along base of massif. Gentler slopes in middle foreground are underlain by young basalts and basaltic andesites of Tanada (map units Qty, Qtyc) at the extreme right of figure, Tanada shield lavas (map unit Qts), and older undifferentiated andesites (map unit Tau).

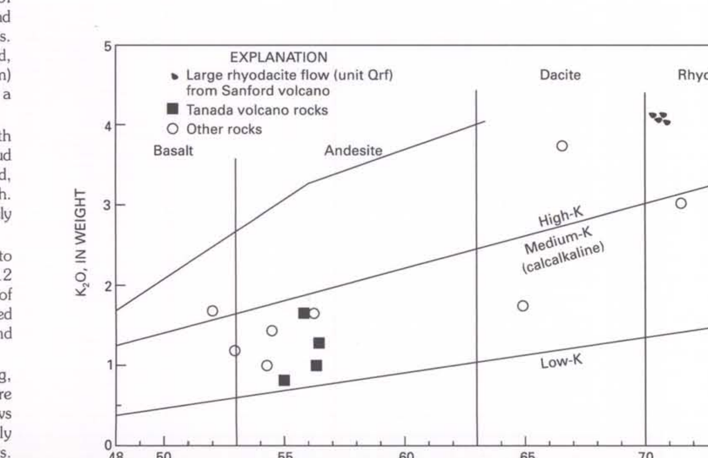

Figure 2. K_2O - SiO_2 variation diagram of Wrangell Lava from the Nabesna B-6 quadrangle, Alaska. Discriminant lines after Peccerillo and Taylor (1976). K_2O and SiO_2 values reflect volatile-free rock compositions.

Table 1. *Chemical analyses of the Wrangell Lava from the Nabesna B-6 quadrangle, Alaska*

[Analyses by U.S.G.S. X-ray spectroscopy methods, analysts, J. Baker, A. J. Bartel, K. Stewart, J. Taggart, and J.S. Wahlberg, and rapid rock methods (FeO, H20+, H20-, CO2), analysts, H.G. Heiman, G. Mason, C. Stone, H. Smith, and W. Crandell]

Rock Unit	Qbt	Qob	Qrf				Qty	Qrd	Qdf	Qdfp	Qtc		Qts		QTpb	QTob
Map Locality No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sample No.	73-ARh-86	73-ARh-81	81-ASj-73	73-ARh-84	81-ASj-63	81-ASj-66	81-ARh-42	73-ARh-94	81-ARh-26	81-ARh-19	BCM-13	BCM-15	BCM-14	81-ARh-33	81-ASj-64	81-ASj-76
SiO_2	54.6	56.2	69.9	69.9	70.3	69.9	53.1	71.0	65.4	64.5	55.0	55.5	54.4	56.3	54.6	52.1
Al_2O_3	16.6	18.2	14.5	14.6	14.5	14.5	17.6	15.4	15.3	16.7	18.0	17.9	18.4	17.6	17.2	16.6
Fe_2O_3	1.88	2.61	2.78	2.43	2.04	1.29	2.69	1.83	1.63	3.02	3.91	3.08	3.67	2.24	2.76	3.55
FeO	5.6	4.4	0.56	0.88	1.2	2.0	5.3	0.12	1.8	1.2	2.74	3.59	3.77	5.2	5.5	7.0
MgO	7.51	3.56	0.14	0.17	0.14	0.24	6.61	0.24	2.09	2.47	4.47	4.13	5.23	4.26	4.63	4.26
CaO	7.94	7.31	0.83	0.92	0.89	1.06	8.43	1.18	3.73	4.97	7.98	7.64	8.50	7.27	7.32	7.41
Na_2O	3.52	4.01	5.41	5.70	5.81	5.68	3.43	5.75	3.36	3.98	3.52	3.71	3.34	3.71	3.85	3.60
K_2O	0.99	1.60	4.11	4.04	4.03	4.09	1.15	3.00	3.72	1.69	0.87	1.25	0.71	1.59	1.38	1.61
H_2O+	0.52	0.10	0.08	0.17	0.16	0.42	0.27	0.24	1.3	0.05	1.65	0.50	0.83	0.20	0.41	0.54
H_2O-	0.06	0.05	0.03	0.02	0.04	0.07	0.02	0.21	0.13	0.02	0.12	0.73	0.64	0.08	0.03	0.06
TiO_2	0.98	1.25	0.25	0.29	0.26	0.29	1.08	0.24	0.58	0.53	0.91	1.04	0.91	1.19	1.49	2.23
P_2O_5	0.21	0.34	<0.05	0.05	<0.05	<0.05	0.32	0.07	0.21	0.15	0.26	0.32	0.22	0.34	0.37	0.68
MnO	0.13	0.11	0.12	0.12	0.12	0.12	0.14	0.10	0.06	0.08	0.09	0.13	0.10	0.12	0.14	0.16
CO_2	0.02	0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.03	0.01	<0.01	<0.01	<0.01	<0.01
Total	100.56	99.75	98.71	99.30	99.49	99.66	100.14	99.39	99.31	99.36	99.55	99.53	100.72	100.10	99.68	99.78
SiO_2 (volatile-free, normalized to 100%)	54.6	56.4	70.9	70.4	70.8	70.5	53.2	71.8	66.8	65.0	56.3	56.5	55.0	56.4	55.0	52.5

Table 2. *K-Ar ages and analytical data on samples from the Nabesna B-6 quadrangle, Alaska*

[Potassium analyses by P.R. Klock and S.T. Neil. Argon analyses by G.S. Elliott, S.E. Kollman, M. Olea, L.B.G. Pickthorn, D.R. St. Aubin, J.G. Smith, and J.C. von Essen. Ages calculated using the following constants: $\lambda_\varepsilon = 0.581 \times 10^{-10}$, $\lambda_\beta = 4.962 \times 10^{-10} yr^{-1}$, and, $^{40}K/K = 1.167 \times 10^{-4}$ atom percent]

Map locality No. and rock unit	Sample No.	Location Latitude (North)	Location Longitude (West)	Material dated and treatment[1]	Potassium analyses (weight percent oxide) First	Second	Average	Radiogenic ^{40}Ar Moles/g	Radiogenic ^{40}Ar Percent	Age (Ma)
17 (Qob)	73-ARh-87	62°10.00′	143°55.5′	Wr	0.939	0.957	0.948	4.354E-13	3.8	0.318±0.088
18 (Qrf)	74-ALe-29	62°19.40′	143°55.7′	Wr	3.800	3.790	3.795	2.923E-12	12.2	0.534±0.057
19 (Qty)	81-ASj-86	62°21.20′	143°33.1′	Wr, nit	1.259	1.241	1.250	1.749E-12	15.2	0.972±0.049
20 (Qdf)	81-ASj-72	62°21.70′	143°43.79′	Biotite	8.330	—	—	2.089E-11	8.0	1.74±0.11
21 (Tau)	81-ASj-77B	62°20.27′	143°33.26′	Wr, nit	1.229	1.226	1.228	2.883E-12	14.9	1.63±0.07
	81-ASj-77B			Wr, nit, hf[2]	1.238	1.225	1.232	3.531E-12	33.1	1.99±0.08
22 (Tau)	81-ASj-85	62°20.02′	143°45.6′	Wr, nit, hf	1.526	1.564	1.545	4.920E-12	14.9	2.21±0.09

[1]Wr = whole rock, nit = nitric acid treated, hf = hydrofluoric acid treated.

[2]Sample 81-ASj-77B contained 25 to 35 percent fresh glass which was largely removed by crushing the sample, splitting it and treating one half with 5 percent hydrofluoric acid for 2 minutes. Volcanic glass is susceptible to gain or loss of potassium or radiogenic argon. The age of the nearly glass-free hydrofluoric acid fraction is believed to be close to the emplacement age of the rock.

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