

\*In Gulkana B-3 quadrangle

\*\*(Volatile free, normalized to 100%)

Figure 1. Mount Sanford as viewed from airport at Gulkana, located about 66 km to west.

Open arrow, west Sanford eruptive center; closed arrow, north Sanford eruptive center.

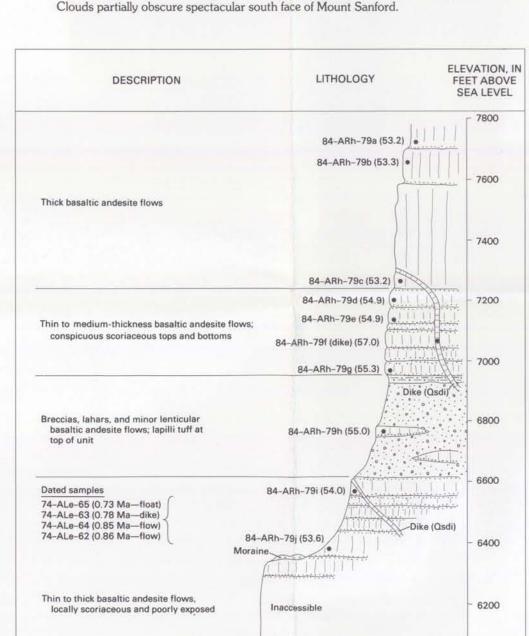


Figure 2. Sanford intracaldera(?) section (section C on map sheet), showing location of samples that were analyzed and dated. All samples are from unit Qsl except dikes, which are from unit Qsdi (see map sheet for unit descriptions). Samples that were chemically analyzed (dots) were collected along line of section C; sample number refers to table 3; silica content (in weight percent; analyses normalized to 100 percent, volatile free) shown in parentheses. Samples that were radiometrically dated by potassium-argon method (bracketed) were collected on bench near moraine (loc. 44 on map sheet); sample number refers to table 1; age and lithologic description shown in parentheses.

Showing dip where known. U, upthrown block; D, downthrown block

84-ARh-791 (53.2)

84-ARh-79k (53.1)

Sanford Glacier

Contact—Known and inferred; queried where uncertain

Strike and dip of bedding and flow layering

Strike and dip of schistosity—Shown in unit Pd

-> 5 Approximate trend and plunge of lava flowage

eruption of Mount Drum

\_\_\_t \_\_ Tephra deposit—Shown in units Qwa, Qsl, and QTf

Limonite staining—Shown in units Qod and QTf

Sample localities—Numbers refer to tables 1, 2, and 3

Petrographic sample that was chemically analyzed

A44 Petrographic sample that was radiometrically dated

cross section

section only

Section C Section line—See figures 2 and 4

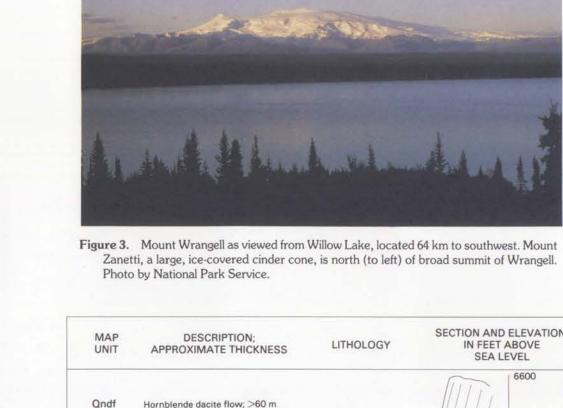
Petrographic sample

outboard on the southern flank of Sanford.

Slide block—Sawteeth on block

--- Postulated caldera margin

.\_.. Local angular unconformity



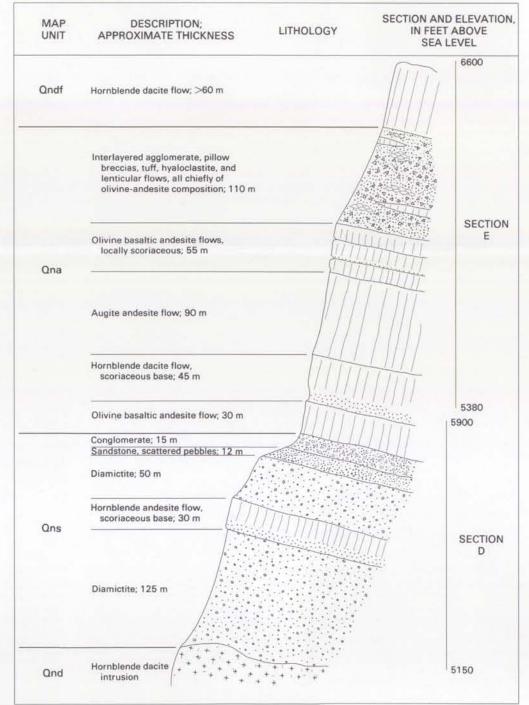
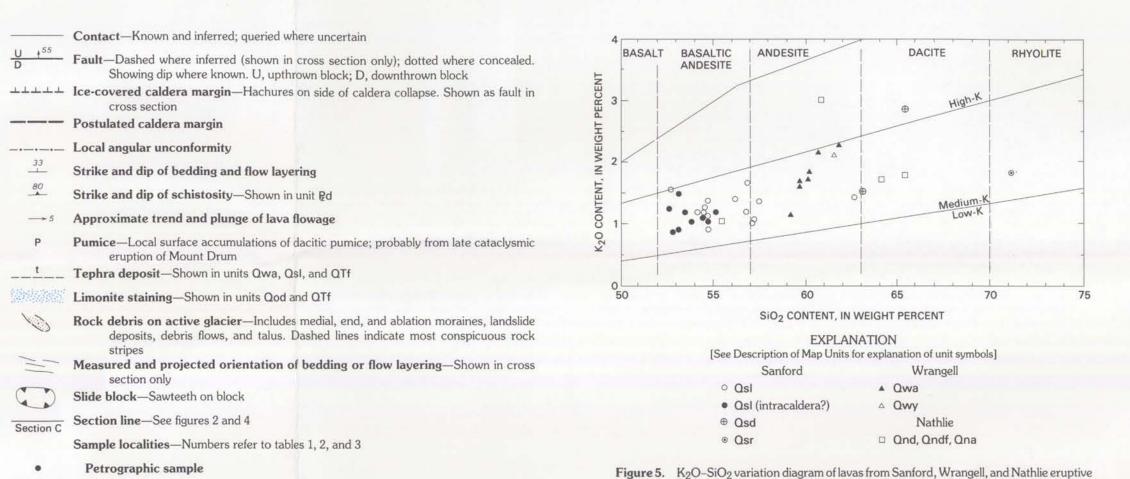


Figure 4. Nathlie Mountain tilted section, composite of two sections (section D and E on map sheet) at different elevations. Layers strike approximately N. 38° W. and dip 20° to 30° NE



centers, showing rock nomenclature used in this report. Compositional-field boundaries (dashed lines) from Le Bas and others (1986); potassium (K) discriminant boundaries (solid lines) from Peccerillo and Taylor (1976). Chemical analyses given in tables 2 and 3.

Petrographic sample that was both chemically analyzed and radiometrically

The Gulkana A-1 quadrangle is in the northwest part of the extensive (>10,000 km²) Wrangell volcanic field, which is of late Oligocene (26 Ma) to Holocene age (Richter and others, 1990), in the Wrangell Mountains of south-central Alaska. The quadrangle includes the northwest flank of Mount Wrangell and most of Mount Sanford, two very large shield volcanoes; Nathlie Mountain, a small volcanic center; and the extreme east flank of Mount Drum, a large disrupted cone or shield. Lavas from these volcanoes overlie a series of late Pliocene to early Pleistocene lavas whose sources are mostly unknown. Mount Sanford (fig. 1), highest (16,237 ft [4,949 m]) of the western Wrangell volcanoes, is a large complex andesitic shield volcano whose volume probably exceeds 900 km3. Most of the volcano above about 2,400 m is covered by glacial ice; the exceptions are its spectacular, near-vertical, 2,500-m-high south face and a few other smaller cirques. These windows into the volcano are generally inaccessible and can only be viewed from afar or by helicopter traverses that are mostly confined by aircraft limitations to elevations below 3,600 m. The broad, domelike main edifice of Sanford (fig. 1) is a relatively young (<0.7 Ma) feature apparently built on, and possibly in part contemporaneous with, flows from at least three subsidiary eruptive centers, herein referred to as the north, west, and south Sanford eruptive centers, that range in age from approximately 0.89 to 0.53 Ma (table 1). Flank lavas as young as about 0.32 Ma erupted from fissures not spatially associated with any of the known eruptive centers and are observed only on the north and northeast flanks of Sanford north of the quadrangle. The three subsidiary centers may be located along a postulated caldera margin that is now buried by lavas from both the subsidiary centers and the central vent. A detailed traverse through 500 m of vertical section, undertaken as close as possible to the south face of Sanford (fig. 2; see also, section C on map sheet), reveals a section of flat-lying basaltic andesites (caldera fill?) that are chemically and mineralogically unlike and are possibly somewhat younger (about 0.86-0.73 Ma; table 1) than topographically higher flows (about 0.89 Ma; table 1) exposed further

Mount Wrangell (fig. 3), a volcanic shield of approximately the same volume as Sanford volcano (>900 km³), contains an ice-filled summit caldera that is 6 km long by 4 km wide. North crater and two other postcaldera craters, all located along the caldera margin, are geothermally active and have been the site of minor phreatic activity throughout historic time (since about A.D. 1800). Although caldera formation may be as young as Holocene (Benson and Motyka, 1978), the bulk of the Wrangell shield was probably built between about 0.6 and 0.4 Ma. Mount Zanetti, a large, ice-covered cinder(?) cone on the northwest flank of Mount Wrangell, may have formed following major Pleistocene glaciation. Nathlie Mountain, a small Pleistocene volcanic center between Mount Drum and Mount Sanford, consists chiefly of a shallow subvolcanic pluton that intruded and tilted a sequence of lava flows, breccia, and sedimentary rocks (fig. 4). Some flows in the tilted sequence may have erupted from the Nathlie volcanic center; most are probably from Mount Sanford. The west side of Nathlie Mountain consists of more than 600 m of massive, columnar-jointed, flat-lying andesite flows (Qwa) from Wrangell volcano that apparently ponded against a buttress formed by both the Nathlie Mountain uplift and glacial ice in the Sanford River valley. Age of the center is probably about 0.5 to 0.7 Ma, as it predates the two-pyroxene andesite (Qwa) from Wrangell volcano and apparently postdates some of the younger lava flows (QsI)

from Sanford volcano. Mount Drum, westernmost of the Wrangell volcanoes, is about 30 km southwest of Mount Sanford in the contiguous Gulkana A-2 quadrangle. It was constructed between about 0.2 and 0.7 Ma during two cycles of cone or shield building and ring-dome emplacement (Richter and others, 1979). The small part of Drum exposed in the quadrangle includes three dacite domes and some early cone or shield lavas. The southernmost dome, consisting mostly of dacitic rubble, is the probable source of the Sanford volcanic debris flow that is exposed locally along the Copper River as far as 50 km from the collapsed dome (Richter and others, 1988).

Some of the older late Pliocene to early Pleistocene volcanic rocks exposed in the quadrangle may be products of the Chetaslina eruptive center (Nye, 1983), whose principal vent is located 5 km to the south in the contiguous Valdez D-1 quadrangle. Whole-rock K-Ar ages on andesite flows from the Chetaslina vent area indicate that the volcano was active at least between about 0.98 and 1.68 Ma (Nve. 1983). The source for many of these older flows, breccias, and mudflows, however, is not known with certainty as most are covered by younger lavas from Wrangell, Sanford, and Drum. Dacitic subvolcanic bodies that intrude the older lavas are locally pyritized and hydrothermally altered. Most Sanford, Wrangell, and Nathlie lavas show medium-K calc-alkaline affinities typical of volcanic systems along convergent plate margins (fig. 5; chemical analyses given in tables 2 and 3). Predominant rock types are plagioclase-phyric two-pyroxene andesites and basaltic andesites. Quaternary alpine and Copper River basin glaciers have extensively modified most of the volcanic landforms in the quadrangle. Present-day glacial ice mantles most of the bedrock above 2,500 m, hiding contact relations between volcanic centers and other features such as caldera margins. REFERENCES CITED

Geophysical Institute Annual Report 1977-1978: Fairbanks, University of Alaska Geophysical Institute, p. 1-25. Hurst, J.I., 1968, The reconnaissance petrology of andesites from the Mt. Wrangell caldera, Alaska: Fairbanks, University of Alaska, M.S. thesis, 83 p. Le Bas, M.J., Le Maitre, R.W., Streckeisen, A., and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, p. 745-50. Lowe, P.C., Richter, D.H., Smith, R.L., and Schmoll, H.R., 1982, Geologic map of the Nabesna B-5 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ-1566, scale Nye, C.J., 1983, Petrology and geochemistry of Okmok and Wrangell volcanoes, Alaska: Santa Cruz,

Benson, C.S., and Motyka, R.J., 1978, Glacier-volcano interactions on Mt. Wrangell, Alaska, in

University of California, Ph.D. dissertation, 208 p. Peccerillo, Angelo, and Taylor, S.R., 1976, Geochemistry of Eocene calc-alkaline volcanic rocks from the Kastamonu area, northern Turkey: Contributions to Mineralogy and Petrology, v. 58, p. 63-81. Plafker, George, Nokleberg, W.J., and Lull, J.S., 1989, Bedrock geology and tectonic evolution of the Wrangellia, Peninsular, and Chugach terranes along the Trans-Alaska Crustal Transect in the Chugach Mountains and southern Copper River Basin, Alaska: Journal of Geophysical Research, v. 94, p. 4255-95. Richter, D.H., and Schmoll, H.R., 1973, Geologic map of the Nabesna C-5 quadrangle, Alaska: U.S.

Geological Survey Geologic Quadrangle Map GQ-1062, scale 1:63,360. Richter, D.H., Schmoll, H.R., and Bove, D.J., 1988, Source of the Sanford volcanic debris flow south-central Alaska, in Galloway, J.P., and Hamilton, T.D., eds., Geologic Studies in Alaska by the U.S. Geological Survey during 1987: U.S. Geological Survey Circular 1016, p.114-16. Richter, D.H., Smith, J.G., Lanphere, M.A., Dalrymple, G.B., Reed, B.L., and Shew, Nora, 1990, Age and progression of volcanism, Wrangell volcanic field, Alaska: Bulletin of Volcanology, v. 53, Richter, D.H., Smith, J.G., Schmoll, H.R., and Smith, R.L., 1993, Geologic map of the Nabesna B-6

quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ-1688, scale Richter, D.H., Smith, R.L., Yehle, L.A., and Miller, T.P., 1979, Geologic map of the Gulkana A-2

quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ-1520, scale

## SOUTH-CENTRAL ALASKA

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