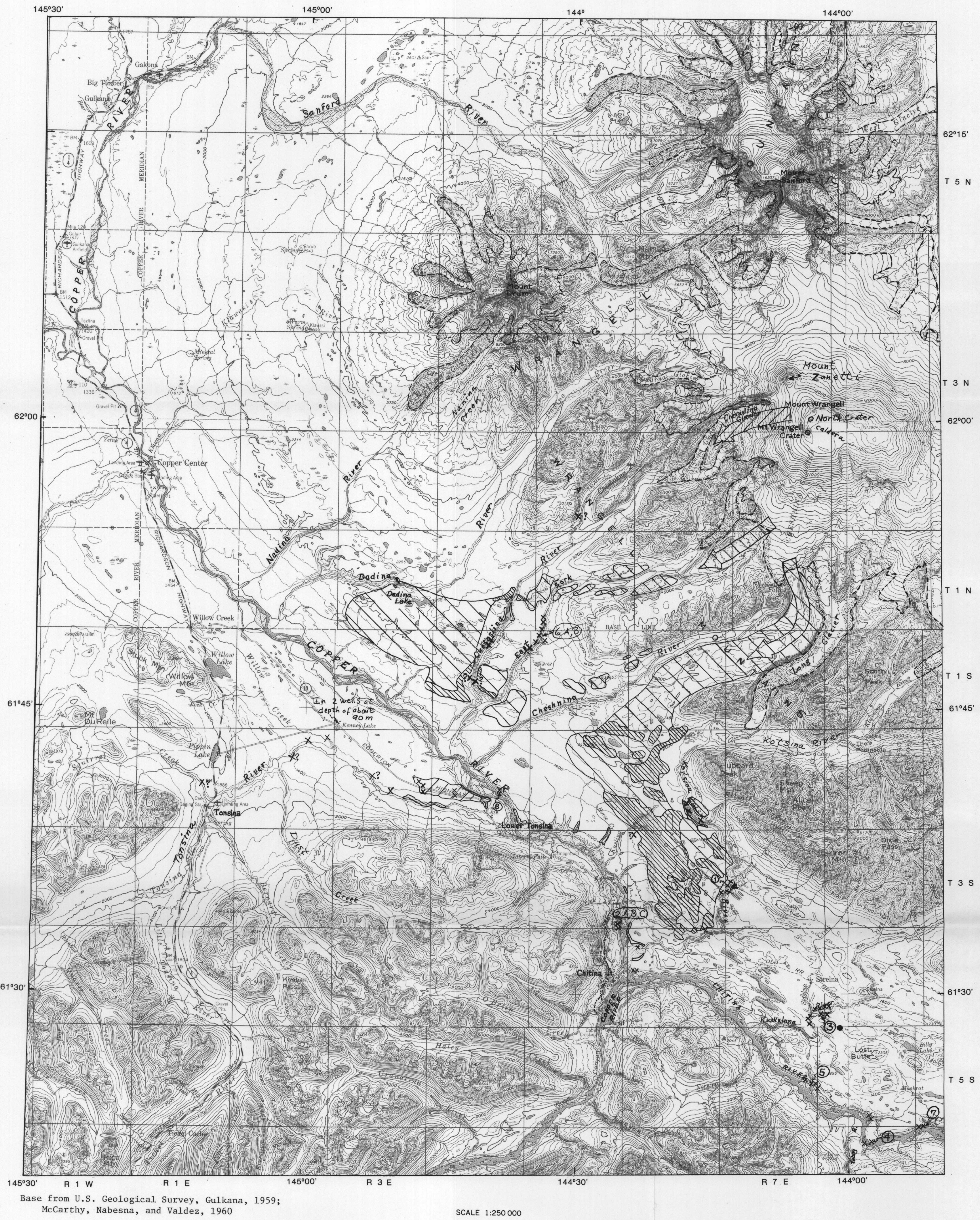
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1209
CHETASLINA VOLCANIC DEBRIS FLOW, ALASKA



Base from U.S. Geological Survey, Gulkana, 1959;
McCarthy, Nabesna, and Valdez, 1960

SCALE 1:250 000

CONTOUR INTERVAL 200 FT (61 M)
DATUM IS MEAN SEA LEVEL

RECONNAISSANCE MAP AND DESCRIPTION OF THE CHETASLINA VOLCANIC DEBRIS FLOW (NEW NAME), SOUTHEASTERN COPPER RIVER BASIN AND ADJACENT AREAS, SOUTH-CENTRAL ALASKA

By

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EXPLANATION

- X? ① ISOLATED EXPOSURE OF CHETASLINA VOLCANIC DEBRIS FLOW--Queried where thought to be present. Numbers refer to analyzed samples (see fig. 1 and table 1)
- ▲ K-AR-DATED ANDESITE SAMPLES--Age no older than about 200,000 years at the 95-percent confidence level (J. D. Obradovich, written commun., 1979; U.S. Geological Survey samples 3763 and 3810)
- ▨ AREA OF CLOSELY SPACED EXPOSURES OF CHETASLINA VOLCANIC DEBRIS FLOW--Ruled where concealed or inferred
- ▨ LAVA FLOWS--Probably overwhelmingly andesite. Wide ruled where inferred
- ⇦ POSSIBLE PRINCIPAL ROUTE OF CHETASLINA VOLCANIC DEBRIS FLOW ON UPPER PART OF MOUNT WRANGELL
- ⇦ POSSIBLE PRINCIPAL ROUTE OF LAVA FLOWS THAT PRESUMABLY OVERLIE THE CHETASLINA VOLCANIC DEBRIS FLOW
- ------ MARGIN OF ICEFIELDS AND LARGE GLACIERS
- .... ABANDONED CHANNEL OF ANCESTRAL COPPER RIVER

DISCUSSION

Introduction

The volcanoes comprising most of the glacier-clad Wrangell Mountains form a prominent part of the landscape of south-central Alaska. The volcanoes in the western part of the Wrangell Mountains flank the Copper River basin and Chitina River valley and have been the source of widespread outpourings of lava, volcaniclastic materials, and tephra. Debris-flow deposits probably ranging in type from avalanches to mudflows (lahars) are among the numerous deposits of volcaniclastic materials.

The term, debris flow, is used in the sense of Sharp and Nobles (1953) to designate any rapid flowage involving debris of various kinds and conditions.

One volcanic debris-flow deposit, thought to originate from Mount Wrangell, is largely buried and discontinuous but is clearly unique, because it contains multihued clasts, some of very large size; many clasts seem to be derived from hydrothermally altered volcanic rocks. The deposit, part of which was described earlier as volcanic rubble (Nichols and Yehle, 1969), is here-named informally the Chetaslina volcanic debris flow after excellent, although discontinuous, exposures in bluffs along the middle reaches of the Chetaslina and East Fork Chetaslina Rivers. The debris flow was observed at numerous other localities in the map area during the course of reconnaissance geologic mapping by us and others (Schrader and Spencer, 1901; D. R. Nichols, written commun., 1954-58; L. A. Yehle, written commun., 1960-62, 1966; Nichols and Yehle, 1969; Miller and Smith, 1976; K. M. Johnson, oral commun., 1979; T. P. Miller, R. L. Smith, D. H. Richter, M. A. Lanphere, and G. B. Dalrymple, written commun., 1979; Yehle, 1980).

The only other extensive volcanic debris-flow deposit described in the map area is the Sanford volcanic mudflow named for exposures along the Sanford River (Ferrians and others, 1958; Ferrians and Nichols, 1965, p. 104). The Sanford mudflow is well exposed along the Copper River in bluffs which are 45 km upstream from the nearest known deposits of the Chetaslina volcanic debris flow.

Other volcanic debris-flow exposures in the map area include the volcanic avalanche deposits of Nadina valley exposed southwest of Mount Drum (Richter and others, 1979), deposits exposed along the middle reach of the Nadina River (D. R. Nichols, written commun., 1956), along the Copper River near the mouths of the Nadina and Dadina Rivers (D. R. Nichols, written communs., 1956, 1958), and about 7 km northeast of the mouth of the Klawasi River (D. R. Nichols, written commun., 1955). The relationship of these deposits to the Chetaslina volcanic debris flow is not known. Some multicolored cobbles and boulders of volcanic rocks were observed in the upper part of a mid-bluff diamicton deposit, apparently of glacial origin, along the Chetaslina River. The deposit is interpreted to be a local influx of different volcanic material from Mount Wrangell upon glaciers within the Chetaslina River drainage basin. The event probably occurred a substantial time before the emplacement of the Chetaslina volcanic debris flow as evidenced by the large stratigraphic separation between the diamicton and the debris flow.

We acknowledge the help of U.S. Geological Survey colleagues H. C. Starkey and Fred Hildebrand for X-ray analyses, R. L. Smith for petrographic analyses, and R. H. Bennett and Eric Smirnow for mechanical size analyses of unconsolidated deposits.

Geographic setting of Mount Wrangell and the area of deposition

The volcanoes of the Wrangell Mountains, several of which rise to altitudes of over 4900 m, are mostly andesitic, and probably began developing in Miocene time (Deininger, 1972, p. 19). Among the volcanoes, only Mount Wrangell, one of the world's largest andesite volcanoes (4317 m high) (Furst, 1968, p. 13), is known to exhibit any volcanic activity. In 1974, North Crater[1] on the north part of the top of Mount Wrangell, warmed up considerably and melted large quantities of nearby ice (Benson and Motyka, 1976, 1977, 1979). North and Wrangell Craters are the most prominent examples of modern-day activity and form part of a discontinuous group of small craters that extend around part of the rim of the glacier-filled Mount Wrangell caldera. The caldera about 16.5 km² in area is partly breached on its south side, and tributaries of Long Glacier are enlarging the breach. On the western flank of the upper part of the volcano, there are several small fumaroles (Mendenhall, 1903, p. 400, 403; Dunn, 1909, p. 501, 503; Furst, 1968, p. 3; D. R. Nichols, written commun., 1958).

Terrain flanking much of the western and southwestern part of the Wrangell Mountains generally slopes downward away from the mountains and toward the Copper River basin and its southeastward-trending extension, the Chitina River valley. Major streams have cut as deeply as about 200 m into the floor of the basin and have exposed a complex of geologic materials, largely unconsolidated, that includes remnants of the Chetaslina volcanic debris flow as well as deposits representing possibly as many as four glacial advances (Nichols, 1965).

General description of deposits

The Chetaslina volcanic debris-flow deposits generally are unconsolidated to partly consolidated diamictons having a strong bimodality in size of clasts versus size of fragments in the matrix. A matrix is almost totally lacking in some exposures, which gives an openwork aspect to the debris-flow deposits. The deposits are unsorted, unstratified, and apparently ungraded.

The matrix component of the debris flow commonly is pinkish tan to pink to pinkish gray and is composed of variably sized fragments of volcanic material ranging from pebbly sand to silt. Size analyses of eight representative samples (fig. 1) from six widely separated localities indicate the median size of the matrix is 0.8 phi (within coarse sand size), ranging from -0.8 to 3.0 phi; the median size of the twenty-fifth quartile is -2.3 phi (within pebble size), and the median size of the seventy-fifth quartile is 3.6 phi (with very fine sand size). None of the size analyses were from material that had been obviously hydrothermally altered; three samples (Nos. 1, 2A, and 2B) were from deposits which resembled diamicton of possible glacial origin. Although the matrix of the Chetaslina debris flow has not been studied mineralogically on a systematic basis, a few samples of matrix material that appeared to be hydrothermally altered were analyzed by X-ray diffraction techniques (table 1). A distinctive aspect of the mineralogical analyses is a very high percent of clay minerals in the clay- and silt-sized fractions; montmorillonite predominates.

The clast component of the debris flow is characterized by an overwhelmingly high percentage of volcanic materials. These materials probably vary somewhat in mineralogical composition, and are known to vary greatly in size, angularity, hardness, and color. Many clasts are blocks and masses 20-25 m in maximum dimension and a few are as large as 90 m in maximum dimension. Even 50 km southwest from the caldera, one block 40 m in at least one dimension was noted 3 km south of the Chitina municipal airfield. Clasts are angular to subrounded and composed commonly of several types of volcanic rocks probably largely andesite; numerous clasts have multiple hues. Types of clasts include: (1) slightly fractured unaltered, hard, dense black andesite, (2) slightly fractured red andesite, (3) highly fractured red andesite, (4) variably fractured brown andesite, (5) soft, yellow to orange-yellow largely clayey masses of hydrothermally altered andesite, (6) highly fractured green or light-purple andesite, and (7) pumice. In some localities there are substantial numbers of boulder-sized clasts of a diamicton thought to be of glacial origin. No large concentrations of breadcrusted volcanic rocks, bombs, and cobble- or larger sized pumice fragments were observed. However, Miller and Smith (1976) and T. P. Miller and others (written commun. 1979), do report bombs in some exposures of volcanic material they term an ash flow. The ash flow may overlie a lateral equivalent of part of the Chetaslina volcanic debris flow. We have found no wood or charcoal fragments directly associated with the debris flow, possibly because vegetation may have been very sparse on the terrain crossed by the flow. Although paleomagnetic studies have not been made on the seemingly autobrecciated volcanic masses in the deposit, such studies may be of value in determining the emplacement temperatures of some of the volcanic clasts (Hoblitt and Kellogg, 1979). Paleomagnetic studies of selected volcanic clasts in the deposit along the East Fork Chetaslina River are underway (K. M. Johnson, oral commun., 1979).

In some places more than half of the deposit is made up of rounded to subrounded pebbles and cobbles of nonvolcanic rock types; striated pebbles and cobbles are present in some of these exposures.

Distribution of the deposits

Present known distribution of the remnants of the Chetaslina debris flow, as determined largely from stream-bluff exposures, some ground-surface exposures, and a few test wells, is shown on the map. Below altitudes of about 915 m the remnants are widely distributed southwest of Mount Wrangell and locally along the lower Chitina River valley over an area measuring approximately 12 km northeast-southwest by 70 km northwest-southeast for a total of 840 km².

Thickness of the Chetaslina volcanic debris-flow deposits below altitudes of about 915 m varies greatly. A very rough estimate of the average thickness is about 15 m; the greatest thicknesses are along (1) the southwest side of the Copper River near the mouth of the Tonsina River (115 m), (2) the north side of the lower reach of the Tonsina River (137 m) and (3) the middle reach of the Chetaslina River valley (50 m). At many other locations the flow remnants are no more than 5-10 m thick.

The volume of the Chetaslina volcanic debris flow can only be very roughly estimated. However, considering the areal distribution of the flow remnants as 840 km², and the average thickness as 0.015 km, the volume of the debris flow below 915 m altitude may be about 12.6 km³.

Stratigraphic relations

Geologic materials overlying and underlying the Chetaslina debris flow are generally poorly exposed, especially the underlying materials. This is unfortunate because the conclusion that the debris flow is largely a valley-filling event cannot be more than partly substantiated. A variety of fluvial sediments (chiefly tan-colored silty fine sand and some nonvolcanic-rich pebble gravel) seems to be the most common material underlying the flow near the southeasternmost remnants along the Chitina River. In addition to the sand and gravel, a clast-sparse diamicton is exposed below the debris flow at a few places along the Kuskulana River. Sandy gravel lies beneath the flow at the few exposures of underlying material along the Tonsina River.

A wider variety of materials overlies the debris flow. Along much of the middle reach of the Kotsina River, and at some places along the Chetaslina River, a lava flow, part of the Wrangell Lava (Mendenhall, 1905), appears to directly overlie the debris flow (Schrader and Spencer, 1901, p. 59). The lava is described as a generally dark gray to black hypersthene andesite as much as 45 m thick (Mendenhall, 1905, p. 57; H. L. Foster, oral commun., 1965). Locally the lava flow may be of basaltic composition, (Miller and Smith, 1976; T. P. Miller and others, written commun., 1979). At one locality along the north side of the Kotsina River near the mouth of Loraine Creek, an openwork volcanic rubble separates the debris flow from the overlying andesite flow. Volcanic-rich cobble- and boulder-gravel deposits overlie the debris flow at various places along the Chitina River, along the middle reach of the Chetaslina River, and along the Tonsina River near the mouth of Dust Creek. Elsewhere, deposits that overlie the debris flow include (1) sand, (2) diamicton presumably of glacial origin, and (3) sand and gravel composed of mostly nonvolcanic rocks.

The generalized distribution of the andesite flow as shown on the map is based largely on geomorphology and river alinements. In addition to spreading out in the upper valley of the East Fork Chetaslina River and the upland area between the upper Cheshnina River and Long Glacier, the lava probably spread westward beyond Dadina Lake, and possibly spread (1) southwestward to the Copper River and locally to the Tonsina River, and (2) southward along the west side of the Copper River to the Chitina area.

Speculation on the origin of the Chetaslina volcanic debris flow as a mudflow

Many cycles of volcanic activity have affected the Wrangell Mountains during Quaternary time; in the Mount Drum area, where many K-Ar dates have been determined, two major cycles of activity have been identified as occurring about 525,000 and 325,000 years ago (Richter and others, 1979; T. P. Miller and others, written commun., 1979). The relationship of only a few Quaternary volcanic events to regional glacial events is known. At least three and possibly four glacial events are represented in river bluff exposures along the Copper River and some of its major tributaries (Ferrians and Nichols, 1965; Nichols, 1965). Reworking of deposits representing these glacial events and a mixing of the deposits with products of fluvial and volcanic events has produced a complex geologic record. The record becomes more complex as the distance from volcanic and glacial source areas increases.

No single characteristic of the Chetaslina volcanic debris flow is clearly indicative of its origin. However, observations above about 915 m altitude were very reconnaissance in nature, and critical exposures may have been missed.

From a general consideration of the character of the Chetaslina volcanic debris flow and its apparent association with Mount Wrangell, and our examination of geologic literature describing recognition of types of volcanic debris flows (Crandell, 1971; Crandell and Mullineaux, 1976; Sparks, 1976; and references contained therein), it is concluded that the debris flow is best categorized as a volcanic mudflow that locally picked up and incorporated a large variety of other geologic materials. Principal attributes of the debris flow are (1) the widespread distribution, (2) the great size variation and heterogeneity of its volcanic rock types, (3) the high percentage of soft, hydrothermally altered material that probably facilitated progressive weakening of the crest of the ancestral volcano, landsliding, and flowage, and (4) the locally high percentage of nonvolcanic materials.

Suggested sequence of volcanic and related events involving principally the Chetaslina volcanic debris flow

As an initial consideration, a simple series of events is tentatively proposed to account for the deposition of the Chetaslina volcanic debris flow and the occurrence of related volcanic activities. However, it is plausible that subsequent work will show that these events are the products of a much more complex and possibly multiple series of volcanic events. It is tentatively suggested that a large phreatic explosion and (or) collapse of the top of ancestral Mount Wrangell may have begun the series of events that initiated the massive, widespread Chetaslina volcanic debris flow (see also Miller and Smith, 1976). Any large-scale explosive and (or) collapse event could have mobilized huge quantities of debris. Hydrogen sulfide gas emanations and clay deposits at existing active small craters along the rim of the caldera (Benson, 1968, p. 146) exemplify the type of hydrothermal activity that probably produced the soft, clay-rich altered volcanic rock so widely prevalent in the debris flow. The clayey material would have facilitated flowage of the abundant fragments of rock down the volcano. Heated volcanic debris would have been able to melt ice and snow during its descent from the crest of the volcano (we envision regional glaciers and icecaps similar in size to those of today). The resulting water would further facilitate travel of material down glacier and stream valleys. Another factor that promoted mobility of the debris was the relatively steep gradient of 85 m/km between the caldera and the axis of the Copper River basin.

Blockage of streams by the Chetaslina debris flow may have caused sizable temporary lakes. Volcaniclast-laden cobble and boulder gravel that overlies the flow material near the mouth of the Tebay River and the mouth of Dust Creek on the Tonsina River implies powerful discharge from blocked streams. Likewise, along the west side of the Chetaslina River, the farthest upstream exposure of the debris flow is in part directly overlain by volcanic-rich boulder and cobble gravels. Deposits reflecting blockage of the ancestral Copper River have not been found possibly because of removal by erosion or because the ancestral course of the Copper River was southwest of its current alinement and partly coincident with the present lower course of the Tonsina River.

Possibly the final major event in this proposed sequence of events is the eruption of mostly andesitic lava from several different vents along the caldera rim and possibly from auxiliary vents elsewhere. We believe the lava spread outward from Mount Wrangell into tributaries of the Copper and lower Chitina Rivers since there is no geomorphic evidence of low-lying vents at the base of the mountains or in the adjacent southeastern part of the Copper River basin. In places the lava flow probably extended beyond presently observed outcrops, and subsequently, was eroded differentially by streams and glaciers. Distribution of andesite flows possibly may have determined the present courses of parts of the Tonsina, Dadina, East Fork Chetaslina, and Kotsina Rivers, as well as the Copper River in the area between about Lower Tonsina and Chitina. The alinement of these rivers was probably influenced also by the Chetaslina debris flow. If the lava flow temporarily blocked the Copper River, the flow may have forced the river westward to cut or reoccupy the bedrock channel in which Chitina is located.

If later volcanic events occurred, they probably resulted in much more localized lava flows, debris flows, or tephra falls. Some examples of young-looking volcanic features are the lava-covered highland south of the glacier which heads the East Fork Chetaslina River (J. R. Williams, oral commun., 1979) and the Mount Zanetti cinder(?) cone northwest of the Mount Wrangell caldera. Both features give the appearance of youthfulness, and might be several thousands of years old or less. The present volcanic activity of Mount Wrangell that continues at several localities near the top of the volcano includes active fumaroles and a few active cinder cones that emit some gases and tephra; a locally high heat flow melts ice and snow in some localities (Benson and Motyka, 1979).

Age of the debris flow

The absolute ages of the Chetaslina volcanic debris flow, and volcanic features like the overlying lava flow has not been determined. It is relatively clear, however, that the debris flow did not occur during a major glaciation because most of the deposits observed underlying the debris-flow deposits are indicative of a fluvial environment. It is also apparent that a glacial advance of major proportions differentially eroded the lava flow that overlies the debris flow. Two K-Ar age determinations on plagioclase in the andesite that apparently overlies the debris flow near the mouth of Loraine Creek indicate an age of no older than about 200,000 years at the 95-percent confidence level (J. D. Obradovich, written commun., 1979, U.S. Geological Survey samples DKA 3763 and 3810). Therefore the age of the underlying debris flow is probably only slightly older.

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[1] Geographic name submitted to the U.S. Board of Geographic Names for approval in 1979.

Table 1.--Mineral constituents of matrix of selected Chetaslina volcanic debris-flow deposits. Matrix apparently was hydrothermally altered before being transported and deposited (see map for sample localities)

[Identifications by X-ray diffraction; sample 8, identification also by petrographic methods. Values (in estimated parts in ten) give a very general indication of relative amounts of the mineral present. tr, trace; ----, not present or no analysis; <, less than; +, slightly more than]

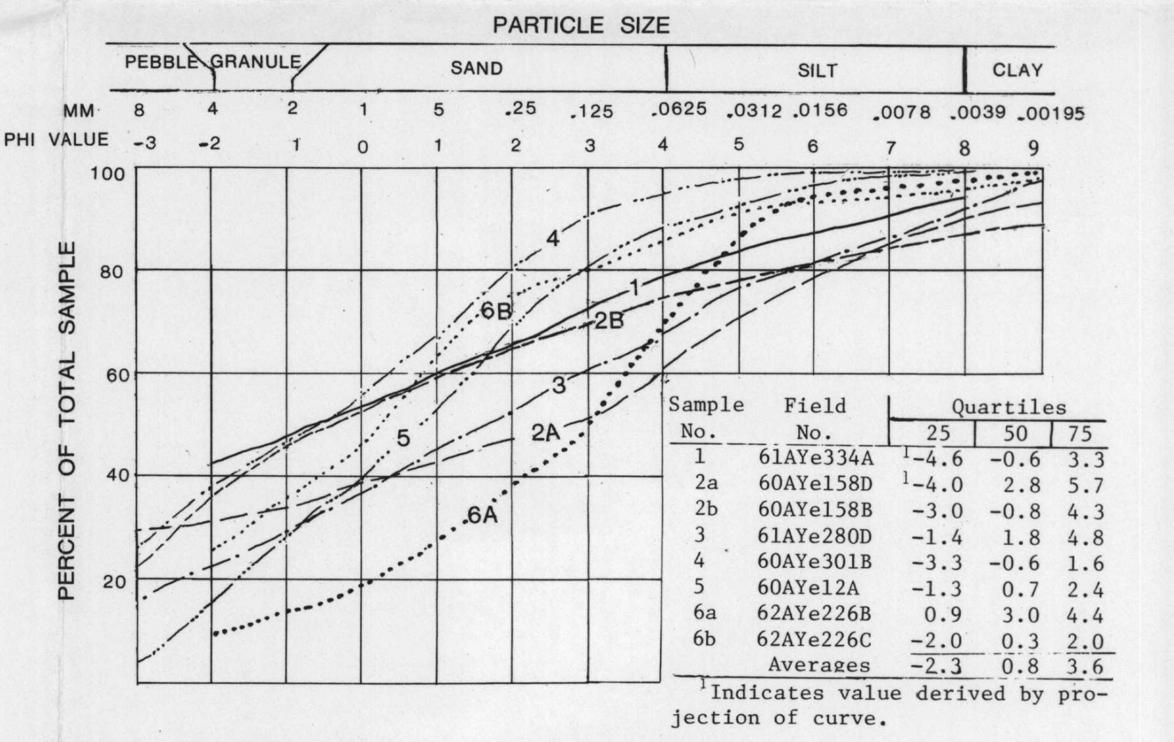
	Size fraction and percent of total sample[1]						
	Sample 7[2]			Sample 2c[3]			Sample 8[4]
Constituent minerals	sand 43.6	silt 40.2	clay 16.3	sand 44.2	silt 38.1	clay 15.8	clay(?) and silt(?) 100
Plagioclase feldspar	----	----	----	6	4+	tr	----
Quartz	8	5	tr	<1	tr	----	----
Mica	1	tr	tr	----	----	----	----
Mixed-layer chlorite-montmorillonite	----	----	----	----	----	tr?	----
Montmorillonite	1	4	5	1+	3+	9	Present.
Kaolinite	tr	tr	tr	----	----	----	A kaolinitic clay present, possibly dickite.
Vermiculite	----	----	tr	----	----	----	----
Clinoptilolite	----	----	----	<1	<1	----	----
Alunite	----	----	----	----	----	----	Present.
Jarosite	----	1	4	tr	<1	<1	----
Gypsum	tr	----	----	<1	----	----	Present.

[1] Particle-size range of fractions: sand, about 0.062-2 mm, -1.0-4.0 phi; silt, 0.002-0.062 mm, 4.0-9.0 phi; and clay, <0.002 mm, >9.0 phi.

[2] Sample 7, field no. 60AYe-304A; analyst H. C. Starkey, U.S. Geological Survey Lab. No. DEG-17.

[3] Sample 2c, field no. 60AYe-158C; analyst H. C. Starkey, U.S. Geological Survey Lab. No. DEG-279.

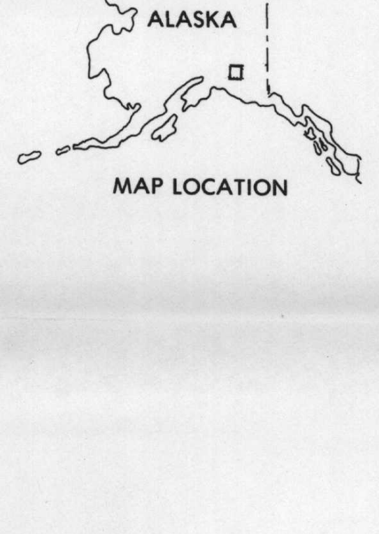
[4] Sample 8, field no. 54ANi-125; petrographic inspection by R. L. Smith, X-ray analyst Fred Hildebrand, U.S. Geological Survey Lab. No. IWM-764, Job. No. 2236.



Sample No.	Field No.	Quartiles 25	50	75
1	61AYe334A	[1]-4.6	-0.6	3.3
2a	60AYe158D	[1]-4.0	2.8	5.7
2b	60AYe158B	-3.0	-0.8	4.3
3	61AYe280D	-1.4	1.8	4.8
4	60AYe301B	-3.3	-0.6	1.6
5	60AYe12A	-1.3	0.7	2.4
6a	62AYe226B	0.9	3.0	4.4
6b	62AYe226C	-2.0	0.3	2.0
	Averages	-2.3	0.8	3.6

[1] Indicates value derived by projection of curve.

Figure 1.--Cumulative size-gradation curves of samples of matrix of selected Chetaslina volcanic debris-flow deposits. No samples were from materials that were obviously altered hydrothermally. Analyses by R. H. Bennett and Eric Smirnow.



MAP LOCATION

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