U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

# Geology and mineral resources of the Stuyahok area, part of Holy Cross A-4 and A-5 quadrangles, Alaska

by

Marti L. Miller[1], Thomas K. Bundtzen[2], William J. Keith[1], Elizabeth A. Bailey[1], and Damon Bickerstaff[3]

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[1] U.S. Geological Survey, Anchorage, Alaska
[2] Alaska Division of Geological and Geophysical Surveys, Fairbanks, Alaska
[3] Now with Placer Dome U.S., Inc., Anchorage, Alaska

1996

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## INTRODUCTION

This report provides a 1:63,360-scale geologic map and a preliminary resource assessment of the 55-$mi^2$ (142-$km^2$) area surrounding the Stuyahok-Flat Creek placer gold deposits of southwest Alaska. Although production for Stuyahok through 1940 was estimated to be as much as 30,000 oz (933 kg) of placer gold (Cobb, 1973), little information has been published about its geology or resources.

The study area lies in the Ilivit Mountains, north of the Yukon River in the south-central part of the Holy Cross 1:250,000-scale quadrangle (fig. 1). The Stuyahok-Flat Creek area straddles the boundary between the Holy Cross A-4 and A-5 quadrangles (1:63,360 scale) (fig. 2). Wide, sediment-filled and heavily vegetated valleys are separated by accordant rounded ridges. The lowest valley elevation is about 400 ft (122 m); the highest point in the study area is the top of Chase Mountain[1] at 1,890 ft (576 m) (fig. 3). Hillsides are covered by thick brush up to about 900 feet elevation. In the southern half of the study area, the amount of brush cover is far greater than is shown in green on the 1:63,360-scale published topographic maps. Access to the region is primarily by air. When ground is frozen, a 12-mi-long (19-km) cat trail provides surface access from the Yukon River via Tuckers Slough. Much of the study area is either owned or selected by Calista Corporation, Anchorage, Alaska (an Alaska Native regional corporation established under the Alaska Native Claims Settlement Act); the remaining land within the study area is under selection by the State of Alaska (fig. 2).

The Stuyahok resource study was undertaken for several reasons. First, the geology of the Holy Cross quadrangle is known only at a reconnaissance scale and rocks favorable for gold, tungsten, and mercury resources are present (Gray, 1992). Results of this investigation are expected to contribute to the quality of future evaluations of undiscovered resources in the Holy Cross quadrangle. Second, the Stuyahok area includes both Alaska Native and State lands, and also adjoins Federal land, thus offering a wide variety of interested parties. Finally, this focused study offered a unique opportunity to perform cooperative work with a private corporation, thus maximizing available resources.

This investigation was performed under a U.S. Department of Interior, U.S. Geological Survey (USGS) Cooperative Research and Development Agreement (CRADA). (Notice of intention published in Federal Register, vol. 60, no. 29, July 6, 1995.) The agreement was to conduct geologic mapping and geochemical sampling to obtain baseline bedrock, structural, and geochemical data for the Stuyahok area. Costs for the study were shared using in-kind services. Field work was performed from August 7 to 25, 1995 by a crew of four from the USGS and two from Calista. Access to the field localities was primarily by foot and all-terrain vehicle (ATV). However, three days of helicopter support enabled us to expand the coverage beyond the area accessible by foot- and ATV-travel.

This report summarizes the geologic and geochemical data collected during the course of the 1995 field studies. The geologic map was compiled from field data, supplemented by petrographic examination of 308 thin sections. The geochemical program included analysis of 252 rock, 42 stream-sediment, and 111 soil samples. The

[1] Chase Mountain is the unofficial local name for this peak in honor of W.C. Chase, who was one of the original discovers/developers of the placer deposits. We have submitted the name to the Board of Geographic Names for official consideration.

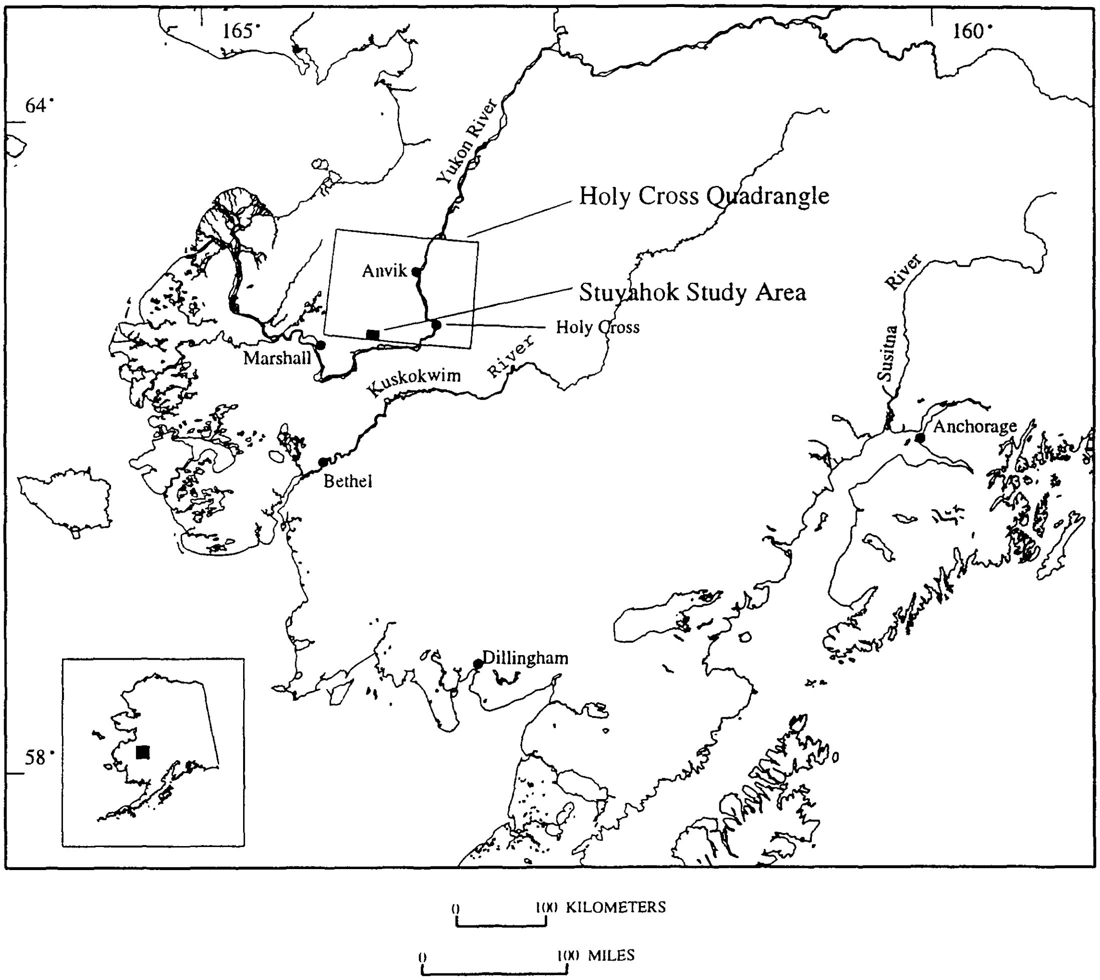



Figure 1. Location of the Stuyahok study area, Holy Cross quadrangle, southwest Alaska.

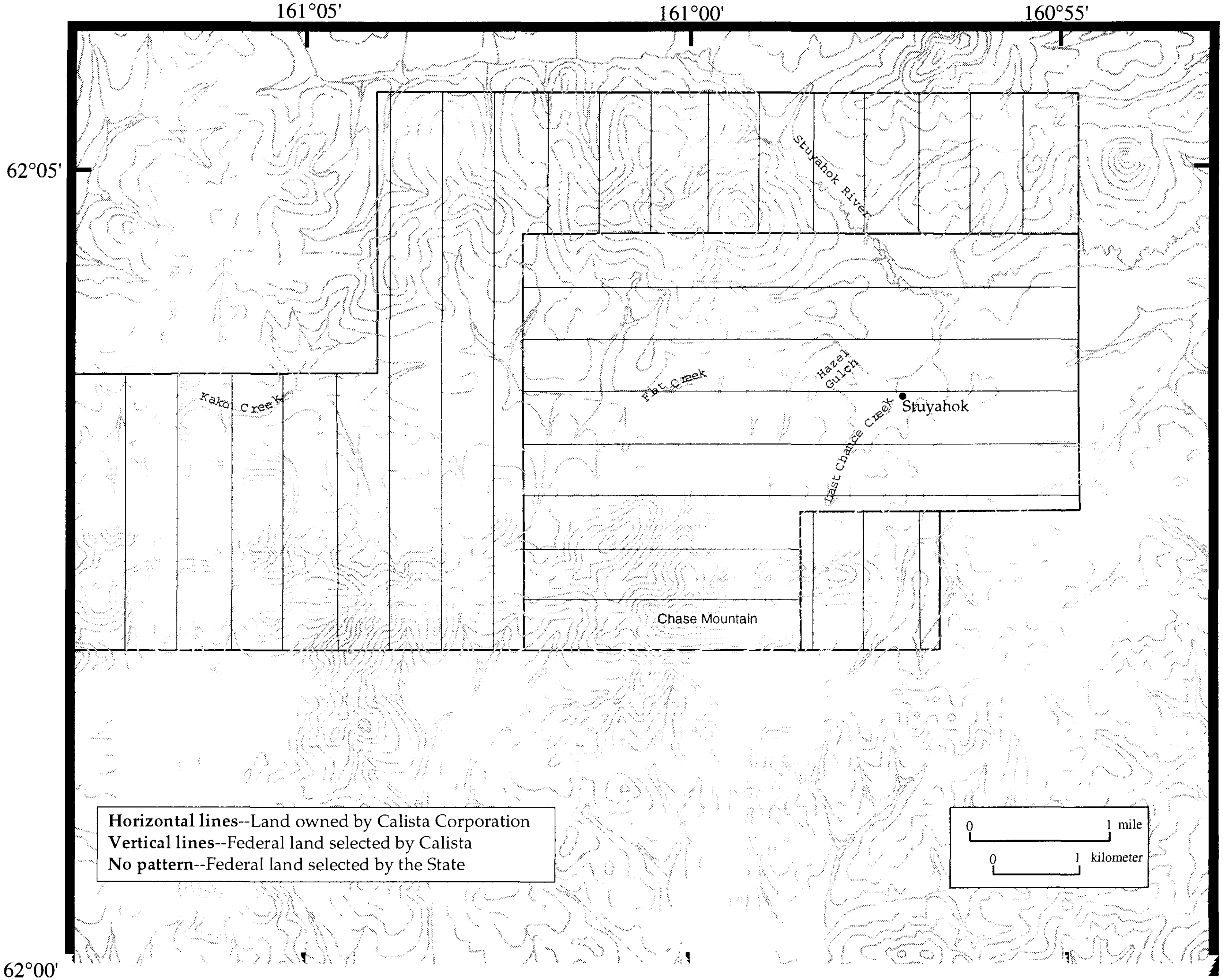



Figure 2. Map of the Stuyahok study area showing land status and topographic features referred to in text. (Topographic base is from the U.S.G.S. 1:63,360-scale series, but only the 100-ft contours are shown here.)

Figure 3. Chase Mountain as viewed from the north. Thermal alteration suggests the mountain is underlain by an unexposed stock.

geochemical anomalies are summarized in the resource assessment section of this report. The actual geochemical data is published in companion open-file reports OF-96-505-B (rock samples) and OF-96-505-C (stream-sediment and soil samples). The resource assessment also incorporates some previously unpublished data collected in 1974 and 1975 by Resource Associates of Alaska (RAA) under contract to Calista Corporation, and some data collected by Calista geologists (all non-USGS data used are included in OF-96-505-B). This report is not intended as a prospect evaluation, but rather it provides a bedrock geologic context for interpreting the resources of the Stuyahok area.

## MINING HISTORY AND PREVIOUS WORK

The Stuyahok-Flat Creek placer deposits, which lie at the southern edge of the Anvik district as defined by Cobb (1973), were formerly included in the Marshall district (e.g. Smith, 1926, 1938, 1942; Joesting, 1942; and Malone, 1965). Lower Flat Creek and limited sections of its gold-bearing tributary creeks were mined during two time periods: first from 1921 to 1940 and then again from 1986 to the present.

The recorded history of the Stuyahok placers dates back to about 1916. During that year, the U.S. Geological Survey performed reconnaissance geologic and mineral resource work along the Yukon River from Anvik to Andreafski (Harrington, 1918). After this expedition, Harrington reported (1918, p. 56) that "Gold colors are said to be obtainable in panning on Stuyahok..." River, but he did not specify where, along the 40-mile course of the river, the gold was found. Subsequently, Martin (1920, p. 50) reported that "...interest was aroused on the lower Yukon in the fall of 1918 by the report that valuable gold placers had been located on Stuyahok River, about 6 miles north of Tucker's fish camp...", which is approximately where the current workings lie.

Placer mining reportedly began at Stuyahok in 1921; during that summer, fifty prospectors were said to be active in the area (Brooks, 1922). Among them were Frederick Kruger (spelling uncertain) and three others, who prospected on Flat Creek (Retherford and McAtee, 1994). From 1922 to 1927, Kruger, joined by W.C. Chase, continued prospecting and mined small amounts of gold (Retherford and McAtee, 1994; Smith, 1926, 1929a, 1929b). One man reportedly continued to prospect in the Stuyahok River valley during 1928 and 1929 (Smith 1930, 1932), but the results of this effort were not recorded.

A larger scale placer operation began to take shape in 1930. Kruger had pipe and other equipment delivered along the Yukon River in preparation for the construction of a hydraulic plant the following year. Over the winter of 1930-31, this equipment was hauled nine miles to the claims by dog team (Smith, 1933a). From 1931 through 1935 Kruger, W.C. Chase, and two partners mined using the hydraulic lift and plant, and pay was considered reasonably good (Retherford and McAtee, 1994; Smith 1933b, 1934a, 1934b, 1936, 1937).

The next step in development came in 1936 when Vance Hitt bought out Kruger and partners and replaced the hydraulic lift with a dragline (Smith, 1938). The new operation employed about a dozen men. Overburden was removed hydraulically and by bulldozer stripping. The dragline scraped pay gravel into sluice boxes mounted on a movable trestle. A second, larger dragline was added to the operation in 1938 (Smith, 1939b). H.R. Joesting (1938) of the Alaska Territorial Department of Mines visited the property in October and reported the placer deposits were yielding fine gold from easily washed gravel at about 30 cents/$yd^3$ (39 cents/$m^3$) at $35/oz gold. Joesting (1938) stated that the source of the fine, flat, and in part rough, gold was not obvious, but he speculated that it might be related to a feldspar porphyry dike noted in old tailings on Hazel Gulch. Hitt's dragline operation continued until 1940, employed 18 to 30 men, and moved an estimated 400,000 $yd^3$ (306,000 $m^3$) of gravel (Retherford and McAtee, 1994; Smith, 1939a, 1939b, 1941b). In 1940 after mining out his claims, Hitt moved all of his equipment for reassembly in the Ruby district (Smith, 1942).

No activity was reported from the property for over thirty years. In 1972, under the Alaska Native Claims Settlement Act, Calista Corporation acquired approximately 7 million acres of land in southwest Alaska, including the Stuyahok-Flat Creek placer mine area. In 1974 and 1975 Calista contracted Resource Associates of Alaska (RAA) to perform a geologic and geochemical reconnaissance investigation of the selected area. The RAA data for the Stuyahok area showed consistent anomalous arsenic values in stream-sediment samples draining north from Chase Mountain. Gold content in the samples was not determined by RAA.

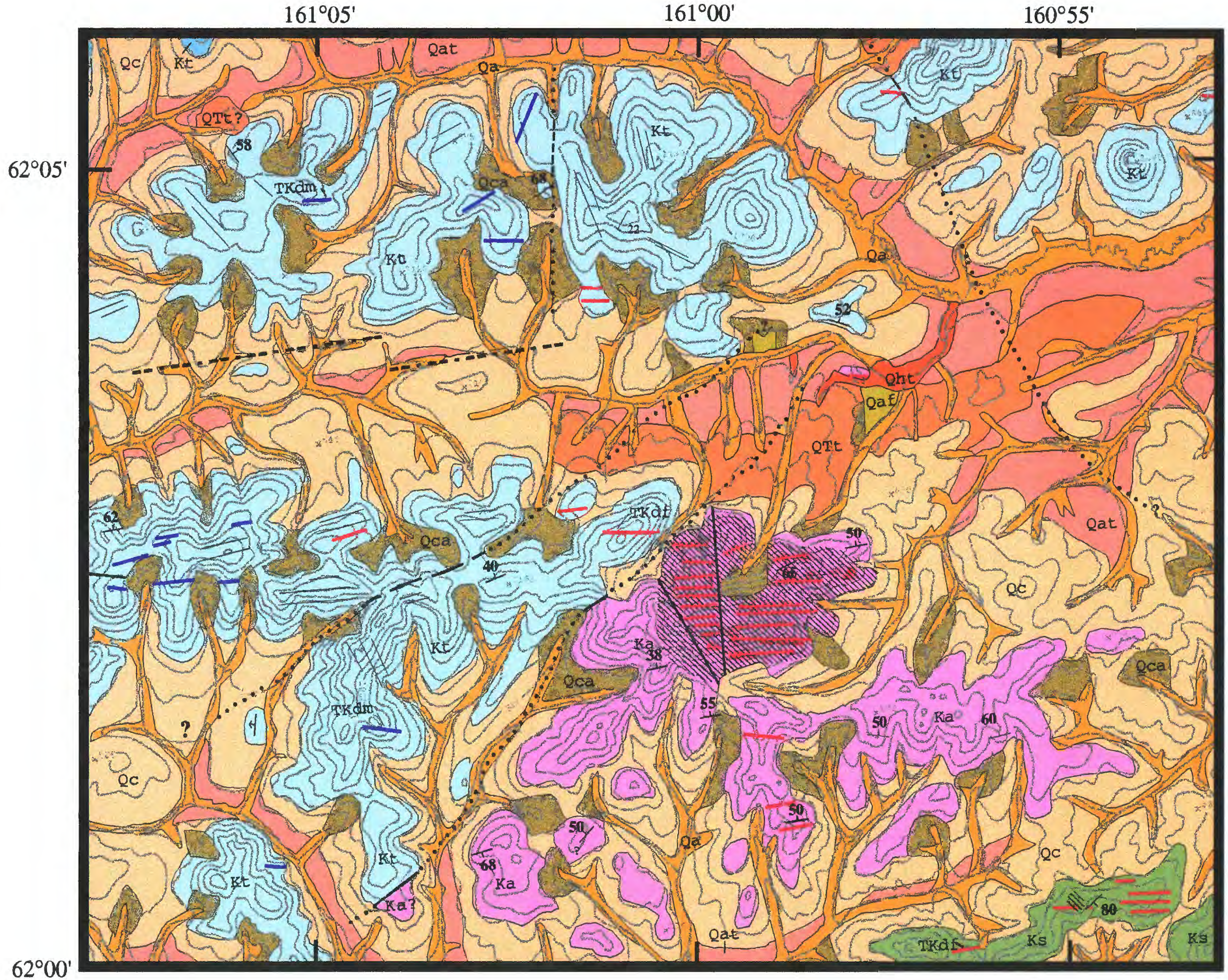
From 1983 to 1992 Calista performed limited geologic mapping and geochemical sampling along Flat Creek and south to Chase Mountain. Some important information was noted over the course of study. (1) All gold-bearing tributaries that saw historic mining were on the south side of Flat Creek. (2) A correlation was noted between the presence of rhyolite porphyry in float and/or bedrock and elevated gold values. (3) Gold-bearing bedrock was identified in Hazel Gulch. (4) Reanalyzed splits of RAA rock, stream-sediment, and soil samples revealed persistent low-level gold values in Last Chance Creek. A soil drilling program was undertaken by Calista in 1994. Additional areas of rhyolite porphyry bedrock were identified under the clay and soil that blankets the area (Retherford and McAtee, 1994).

Placer activity began again in the Stuyahok-Flat Creek area in 1986. Until 1989, Chase Brothers Mining performed small-scale mining on ground leased from Calista. Mining resumed again in 1991 and continues to the present under a lease held by Stuyahok Mining, owned by Ernie Chase (grandson of W.C. Chase, one of the original mine operators) (Retherford and McAtee, 1994).

## OVERVIEW OF THE GEOLOGY

The geologic map (fig. 4) is based on field observations made during the course of this study, supplemented by petrographic examination of 308 thin sections and air photo interpretation. Bedrock exposure is limited to several dozen ridge top outcrops, local frost-riven rubble above about 800 ft (240 m) elevation, a few cut banks along Flat Creek and the Stuyahok River, and several short, caved trenches. There is no evidence of glaciation in the study area, so float was also employed locally as a bed rock indicator. The location of foot traverses and field observation points is shown in figure 5. Detailed map unit descriptions to accompany figure 4 are provided in the following section.

The Stuyahok-Flat Creek study area lies along the southern margin of the Yukon-Koyukuk basin of western Alaska (Patton and Box, 1989). The basin occupies a more than 350-mi-long (560-km) wedge-shaped structural depression that is filled with mid- and Upper Cretaceous terrigenous sedimentary rocks. The flysch is deposited on


161°05'
161°00'
160°55'
62°05'
62°00'
Qc
Kt
Qat
Qa
QTt?
58
TKdm
Qca
68
22
52
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Qaf
QTt
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40
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Qca
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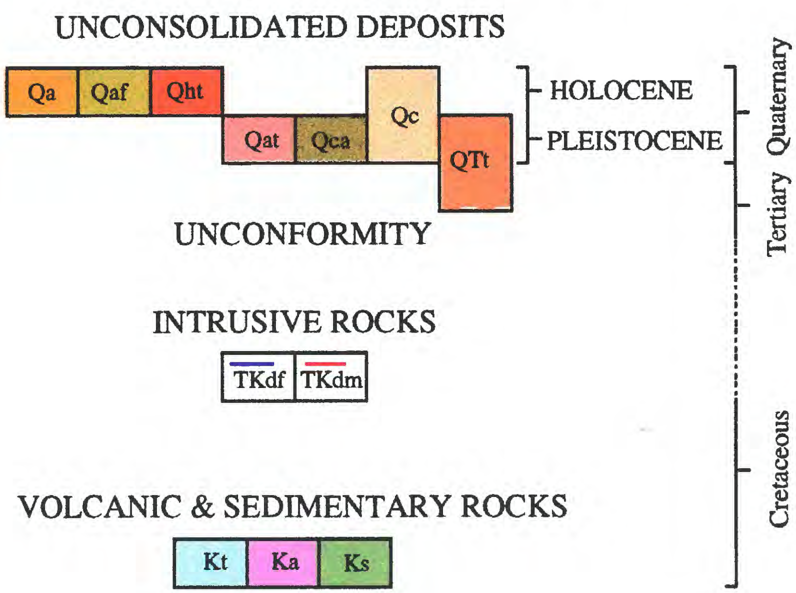
## CORRELATION OF MAP UNITS

(* See description of map units for specific unit age assignments)




## DESCRIPTION OF MAP UNITS

### UNCONSOLIDATED DEPOSITS

| | |
|---|---|
| Qa | Stream alluvium (Holocene) |
| Qaf | Alluvial fan deposits (Holocene) |
| Qht | Placer mine tailings (Holocene) |
| Qat | Terrace alluvium (Pleistocene?) |
| Qca | Colluvial-alluvial deposits (Pleistocene?) |
| Qc | Colluvial deposits, undifferentiated (Holocene and Pleistocene) |
| QTt | Colluvial-fan terrace deposits (late Tertiary? to early Pleistocene) |

### INTRUSIVE ROCKS

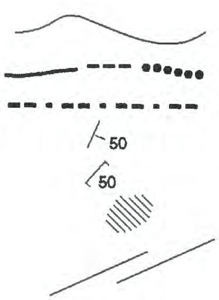
| | |
|---|---|
| TKdf | Felsic and intermediate dikes (Late Cretaceous and early Tertiary?) |
| TKdm | Mafic and intermediate dikes (Late Cretaceous and early Tertiary?) |

### VOLCANIC & SEDIMENTARY ROCKS

Koyukuk Terrane--divided into

| | |
|---|---|
| Kt | Tuffs, sedimentary rock, and flows (Early Cretaceous) |
| Ka | Intermediate to mafic volcanic agglomerate, lapilli tuff, and flows ( Early Cretaceous?) |
| Ks | Sandstone and felsic tuff (Early Cretaceous?) |

## MAP SYMBOLS




CONTACT
FAULT--Dashed where inferred; dotted where concealed
LINEAMENT
STRIKE AND DIP OF BEDDING
STRIKE AND DIP OF CLEAVAGE
HORNFELS
BEDDING TREND--Determined from air photography

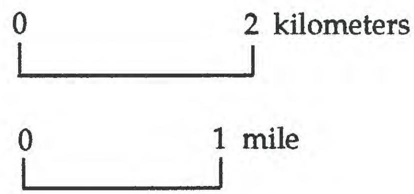



Figure 4. Geologic map and correlation diagram of the Stuyahok study area, south-central Holy Cross quadrangle.


Figure 5. Map of the Stuyahok study area showing location of continuous foot traverses (lines) and field observation points (dots). (Topographic base is from the U.S.G.S. 1:63,360-scale series, but only the 100-ft contours are shown here.)

largely Lower Cretaceous island-arc-type volcanic rocks of the Koyukuk terrane that are exposed on structural highs (Patton and others, 1994). The Koyukuk terrane contains two distinct assemblages: (1) Jurassic tonalite-trondhjemite plutonic rocks and older(?) volcanic and plutonic rocks, that are unconformably overlain by (2) Upper Jurassic(?) and Lower Cretaceous andesitic volcaniclastic rocks and flows; the latter forms the bulk of the terrane (Patton and others, 1994). The Upper Jurassic(?) and Lower Cretaceous volcaniclastic rocks and flows record an episode of andesitic magmatism marked by voluminous pyroclastic and epiclastic volcanic rocks and lesser flows of basaltic to dacitic composition (Patton and others, 1994). Geochemical signatures indicate the magmatism was subduction-related (Patton and others, 1994, Patton and Moll-Stalcup, 1996), and petrographic, structural, and isotopic evidence suggest the Koyukuk terrane developed in an intraoceanic setting (Patton and others, 1994).

The study area is largely underlain by tuff, volcaniclastic rocks, and flows (map units **Kt**, **Ka**, and **Ks**) that we believe correlate with Lower Cretaceous rocks of the Koyukuk terrane. These Lower Cretaceous lithologies are cut by younger mafic to felsic dikes (map units **TKdm** and **TKdf**), which are similar to Late Cretaceous and early Tertiary dikes that are found in many parts of west-central Alaska. Unconsolidated Quaternary deposits (map units **Qa**, **Qaf**, **Qht**, **Qat**, **Qca**, **Qc**, and **QTt**) overlap the older rocks and cover approximately 70 percent of the study area.

In the study area, rocks of the Koyukuk terrane are divided into three map units. **Kt**, a heterogeneous unit, is composed dominantly of andesitic crystal lithic and lapilli tuffs, lesser volcaniclastic sandstones and tuffaceous siltstones, and minor felsic tuffs and andesitic to dacitic flow rocks. Unit **Ka** is characterized by volcanic agglomerate (vent facies) and flows, but also has lapilli tuff, and minor felsic tuff and sedimentary rocks. Unit **Ks** primarily consists of graywacke and siltstone, but also has felsic tuff. Similarities in lithology suggest the three units are related, but structural information is insufficient to determine their relative stratigraphic positions. Some of the volcanic rocks show subaerial features (agglomerate and airfall tuffs); others are subaqueous (pillow lavas, and water-laid tuffs); and the remainder could be either subaerial or subaqueous (crystal lithic tuffs and ash flow tuffs). All three units have local interbedded radiolarian-bearing siltstone or tuffaceous siltstone, indicating deposition in a marine environment. This cumulative data suggest that deposition of the various Koyukuk terrane lithologies was near an emergent/submergent margin of a marine basin. A younger example of this hypothesized environment is well preserved on Adak Island (part of the Aleutian arc), where strata of the late Eocene Andrew Lake Formation include pyroclastic ejecta and radiolarian-bearing tuffaceous mudstones that accumulated on the flanks of an active volcanic complex (Hein and McLean, 1980). The Lower Cretaceous rocks of the study area show low-grade metamorphism to laumontite and locally prehnite-pumpellyite facies.

The Koyukuk terrane rocks are cut by younger dikes, which are divided into two units based on composition, and assigned a Late Cretaceous and early Tertiary age. The dikes in the western half of the map area are dominantly clinopyroxene diabase of unit **TKdm**, while those in the eastern half are porphyritic dacite and rhyolite of unit **TKdf**. The dikes have an east-west preferred orientation and the felsic dikes are particularly numerous on Chase Mountain. In addition, the unit **Ka** rocks of Chase Mountain have been thermally altered to a maximum of hornblende hornfels facies, leading us to believe that a buried stock underlies the mountain.

Ten samples were submitted for major-oxide and trace-element analysis (table 1, fig. 6). Unfortunately all of the samples analyzed were altered (secondary chlorite ± calcite noted in thin section), yielding high loss-on-ignition values (LOI, table 1). However, when recalculated volatile free and plotted on two different classification diagrams, the data plot in groups by unit (fig. 7A and 7B). The total-alkali-silica diagram (fig. 7A) shows that volcanic rocks of the Koyukuk terrane (map units **Kt** and **Ka**) are bimodal (mafic/intermediate and felsic), and that the felsic dikes (unit **TKdf**) are dacitic. In the AFM diagram (fig. 7B), the Koyukuk terrane rocks (again, map units **Kt** and **Ka**) show a calc-alkaline differentiation trend, and the dikes (**TKdf**) mostly plot in the calc-alkaline field.

Surficial deposits of late Tertiary(?) and Quaternary age cover approximately 70 percent of the study area. They were largely mapped from air photos, but field verified locally. Placer mine tailings (**Qht**), stream alluvium (**Qa**), and alluvial fans (**Qaf**) of Holocene age are the youngest deposits. Ancestral stream drainages paralleling modern streams are represented by locally extensive terrace gravels of two ages. The younger terrace deposits (**Qat**) are best documented on Flat Creek and the Stuyahok River. Older terrace alluvium (**QTt**), found mainly on the south side of Flat Creek, may be as old as late Tertiary, based on correlation with similar older terrace gravels found throughout unglaciated interior Alaska (Karl and others, 1988). Extensive colluvial (**Qc**) and local colluvial-alluvial (**Qca**) deposits cover the hill sides. The surficial deposits are commonly mantled by vegetation. Regional tilt to the west or northwest(?) in Holocene time is suggested by stream piracy of several small tributaries on the south side of Flat Creek that may have been shifted to newer westerly channels.

Northwest to north-northwest structural trends dominate throughout most of southwest and west-central Alaska (e.g. Box and others, 1993; Miller and Bundtzen, 1994; Patton and Moll, 1996), but from about the town of Holy Cross down river to Marshall (fig. 1), rocks just north of the Yukon River also show east-west orientation of some contacts, and possibly structures (M.L. Miller, unpub. map compilation). The study area has northeast-, east-west-, and north-trending structural elements. Bedding strikes and dike trends are generally east-west; unit contacts and some faults trend northeast; and other faults trend north. The Lower Cretaceous units are tilted an average of 50 degrees, but structural control in the map area is too sparse for us to define folds. The rocks show no tectonic foliation in either outcrop or thin section. The older units are cut by several high-angle faults. Most significant of these are the two subparallel northeast-trending faults, one of which bounds unit **Ka** on the northwest. These faults are not well exposed and their displacement is not known, but rocks that lie between the two faults have variable bedding strikes, perhaps suggesting structural disruption. The north- and north-west-trending faults exposed on Chase Mountain are clearly defined on air photos, but do not appear to have significant displacement. The northwest-trending fault in the northeast part of the study area was interpreted from air photos; movement is not known. The dikes generally trend east-west and are interpreted to be near-vertical based on their apparent trend across topography. If indeed vertical, they post-date the regional deformation, suggesting the deformation occurred in mid- to Late Cretaceous time. Two east-west linear features in the valley of Flat Creek were also noted in air photos. Given (1) the east-west orientation of the valley, (2) the fact that it is particularly wide for the creek size, and (3) that the dikes are also mostly east-west oriented, we suspect that unmapped high-angle faults cut the Koyukuk terrane in Flat Creek valley.

Table 1. Major oxide and trace element data for rocks collected in the Stuyahok-Flat Creek study area. Map numbers refer to locations in figure 6.

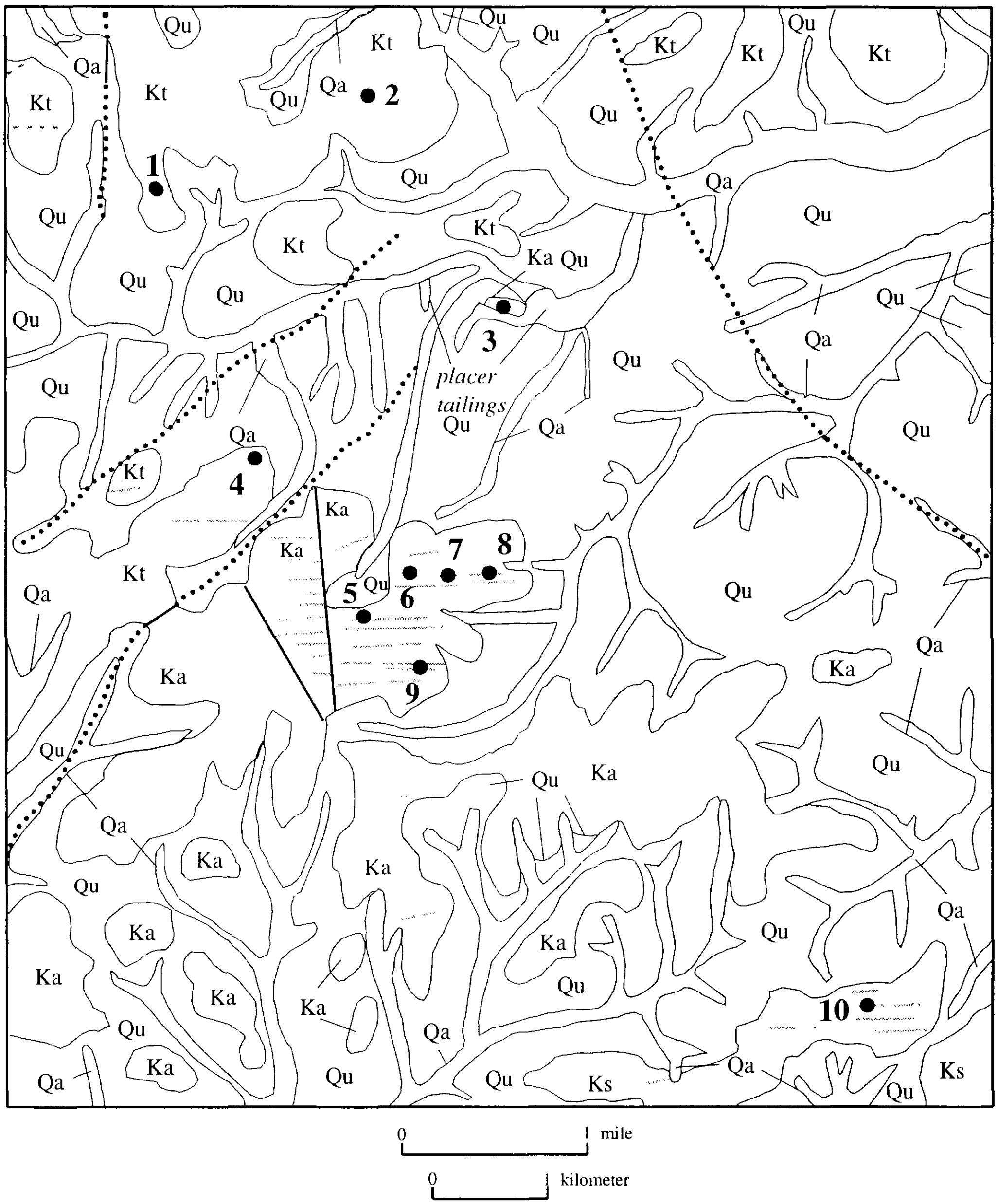
[Major oxides and trace elements determined by X-ray fluorescence. Analyses performed by Inchcape Testing Services, Bondar Clegg]

**MAJOR OXIDES**

| Sample # | UNIT | Rock Type | Map # | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | LOI | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 95AM30A | TKdf | Dike | 1 | 63.73 | 0.56 | 15.10 | 3.91 | 0.07 | 1.91 | 3.88 | 3.46 | 2.58 | 0.22 | 4.22 | 99.87 |
| 95AM65A | Kt | Felsic tuff | 2 | 71.03 | 0.34 | 12.30 | 2.82 | 0.08 | 0.77 | 3.00 | 1.63 | 2.70 | 0.05 | 5.08 | 100.07 |
| 95BT243 | TKdf | Dike + vein | 3 | 80.13 | 0.28 | 12.83 | 0.48 | 0.01 | 0.05 | 0.09 | 0.28 | 0.12 | 0.03 | 5.05 | 99.40 |
| 95BT241 | Kt | Flow | 4 | 51.32 | 0.86 | 16.90 | 9.34 | 0.20 | 4.89 | 5.41 | 3.36 | 2.14 | 0.24 | 4.80 | 99.71 |
| 95BT233A | Ka | Tuff | 5 | 47.89 | 0.80 | 17.05 | 9.52 | 0.14 | 8.31 | 7.75 | 2.30 | 0.30 | 0.07 | 5.84 | 100.07 |
| 95AM04X | Ka | Lapilli tuff | 6 | 49.06 | 0.94 | 18.02 | 8.55 | 0.11 | 5.95 | 6.74 | 4.43 | 0.31 | 0.12 | 4.99 | 99.31 |
| 95AM33A | TKdf | Dike | 7 | 65.63 | 0.60 | 16.10 | 3.53 | 0.06 | 1.01 | 2.56 | 2.81 | 2.43 | 0.22 | 5.09 | 100.22 |
| 95AM35A | TKdf | Dike | 8 | 63.35 | 0.56 | 15.29 | 3.79 | 0.07 | 1.87 | 3.57 | 3.58 | 2.22 | 0.26 | 5.36 | 100.11 |
| 95AM07A | TKdf | Dike | 9 | 61.24 | 0.76 | 15.06 | 3.52 | 0.05 | 1.94 | 5.01 | 2.69 | 2.30 | 0.24 | 6.46 | 99.45 |
| 95AM20B | TKdf | Dike | 10 | 64.24 | 0.58 | 15.74 | 3.52 | 0.06 | 1.75 | 2.19 | 4.51 | 2.45 | 0.18 | 4.05 | 99.54 |

**TRACE ELEMENTS**

| Sample # | UNIT | Rock Type | Map # | Cr | Ba | Sr | Y | Nb | Zr | Rb |
|---|---|---|---|---|---|---|---|---|---|---|
| 95AM30A | TKdf | Dike | 1 | 90 | 1444 | 453 | 23 | 25 | 149 | 104 |
| 95AM65A | Kt | Felsic tuff | 2 | 59 | 2218 | 60 | 46 | 23 | 212 | 124 |
| 95BT243 | TKdf | Dike + vein | 3 | 181 | 113 | 34 | 26 | 41 | 122 | 28 |
| 95BT241 | Kt | Flow | 4 | 63 | 2045 | 225 | 24 | 10 | 78 | 77 |
| 95BT233A | Ka | Tuff | 5 | 285 | 378 | 214 | 17 | 6 | 64 | 19 |
| 95AM04X | Ka | Lapilli tuff | 6 | 159 | 397 | 224 | 22 | 9 | 70 | 19 |
| 95AM33A | TKdf | Dike | 7 | 111 | 1138 | 229 | 22 | 25 | 161 | 85 |
| 95AM35A | TKdf | Dike | 8 | 165 | 1199 | 278 | 22 | 23 | 164 | 81 |
| 95AM07A | TKdf | Dike | 9 | 72 | 1205 | 275 | 15 | 16 | 136 | 78 |
| 95AM20B | TKdf | Dike | 10 | 66 | 1818 | 527 | 21 | 24 | 166 | 96 |




—· · Fault, dotted where concealed
Contact
9● Sample location number, refer to table 1
Qa Quaternary alluvium
Qu Quaternary units, undifferentiated
Felsic dike, unit TKdf
Mafic dike, unit TKdm
Kt Tuffs, sedimentary rock, and flows (Early Cretaceous)
Ka Volcanic agglomerate, lapilli tuff, and flows (Early Cretaceous?)
Ks Sandstone and felsic tuff (Early Cretaceous?)

Figure 6. Simplified geologic map showing location of samples analyzed for major oxide and trace element chemistry. Map numbers are keyed to table 1. (Geology simplified from figure 4; units are the same except for Qaf, Qat, Qca, Qc, and QTt, which are lumped together.)

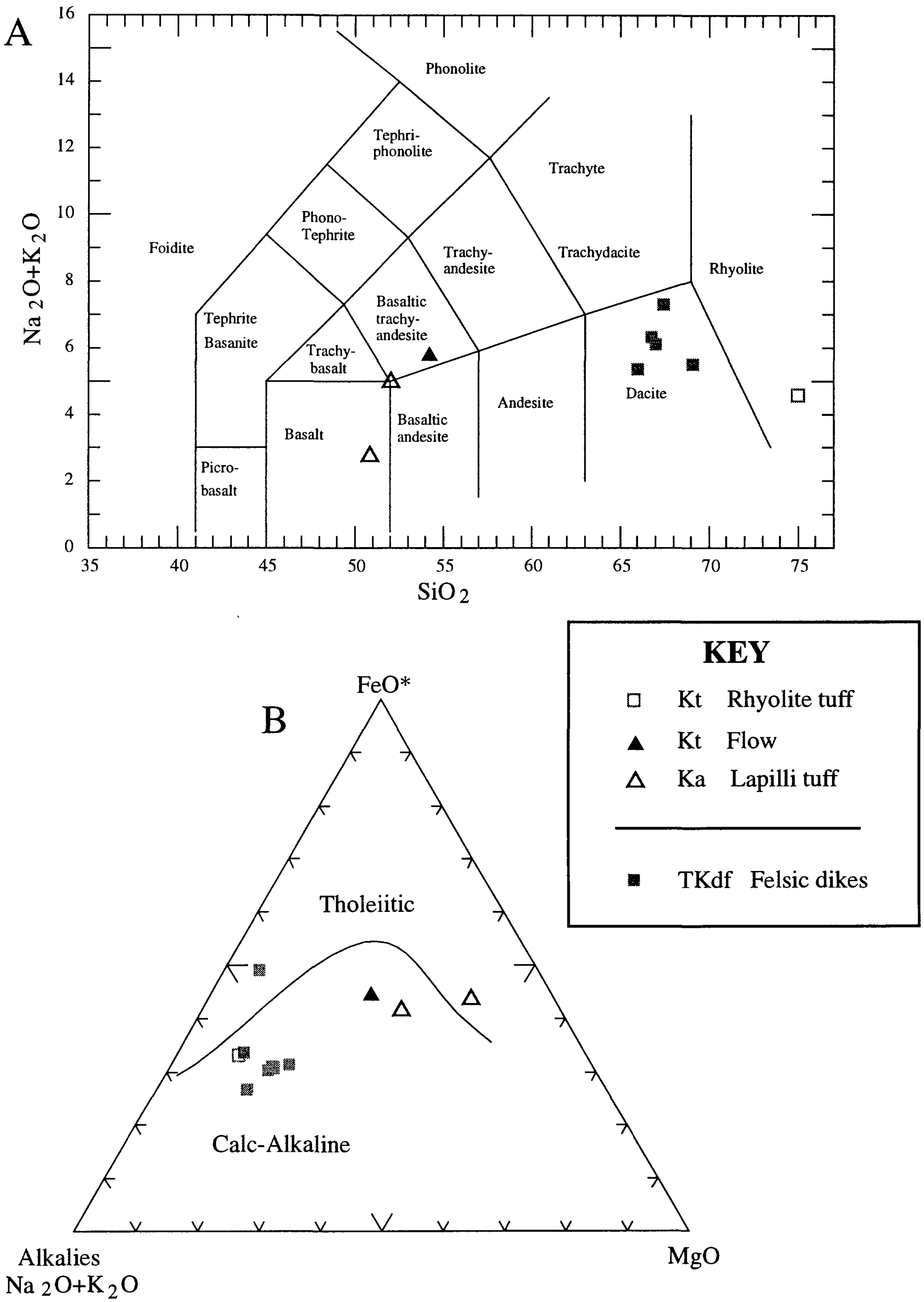



Figure 7. Rock classification diagrams showing geochemical data from the Stuyahok study area. (A) Total-alkali-silica diagram, from LeBas and others, 1986. Oxides are recalculated to 100% volatile-free. (B) AFM diagram, from Irvine and Baragar, 1971.

## DESCRIPTION OF GEOLOGIC MAP UNITS

### SURFICIAL DEPOSITS

**Qa** **Stream alluvium (Holocene)**--Unconsolidated silt, sand, and gravel deposited by modern streams. Unit includes flood plain deposits, which are commonly covered by sphagnum moss, sedges, and pioneer flora such as willow and alder. The mature flood plain areas are extensively covered by white spruce and tussocks. Unit varies from 2 to 12 feet (0.6 to 4 m) in thickness, based on examination in road cuts and mine excavations in the Flat Creek valley. Deposits are Holocene in age.

**Qaf** **Alluvial fan deposits (Holocene)**--Poorly sorted, partially stratified, channelized silt, sand, and gravel found locally on a few streams that drain into Flat Creek. Unit thickness varies, but is estimated to be about 33 feet (10 m) in two fan deposits upstream from the Stuyahok placer mine. Generally considered Holocene in age within study area.

**Qht** **Placer mine tailings (Holocene)**--Symmetrical or irregular stacked piles of water-washed, sorted gravels and in-place slab rock derived from artificially modified stream alluvium during placer gold mining. These tailings result from evenly stacked dragline and bulldozer mining methods. Tailing piles reach a maximum thickness of about 38 feet (12 m) upstream from the Stuyahok placer mine camp. Dragline mining was employed from 1936 to 1940. More recent mining (since 1986) has utilized bulldozers to stack material.

**Qat** **Terrace alluvium (Pleistocene?)**--Moderately to well sorted, well stratified, sand and gravel alluvial terrace deposits; weakly cemented by iron oxides. Unit is 16 to 60 feet thick (5-18 m) and lies above modern flood plain of streams throughout study area, but is best documented on Flat Creek and Stuyahok River. Surfaces are always covered by climax vegetation such as tussock tundra and spruce forests. Terrace alluvium near Stuyahok mine averages 12 feet (4 m) in thickness and is the likely host of the placer gold mined to date. No age data available but unit thought to be Pleistocene in age.

**Qca** **Colluvial-alluvial deposits (Pleistocene?)**--Composite unit of poorly sorted silt, sand, and gravel, and colluvial debris in alluvial-colluvial fans that generally lie near heads of streams. Commonly vegetated with climax vegetation. Thickness of unit is not known. Unit is believed to be Pleistocene in age.

**Qc** **Colluvial deposits, undifferentiated (Holocene and Pleistocene)**--Generally composed of hillslope colluvium and slide rock on moderate to gentle slopes throughout study area. Local downslope movement caused by water action. Unit may include unmapped eolian silt or sand deposits. It is heavily vegetated and of variable thickness. Unit probably includes both Holocene and Pleistocene age deposits.

**QTt** **Colluvial-fan terrace deposits (late Tertiary? to early Pleistocene)**--Complex unit of older terrace alluvium composed of silt, sand, and gravel deposited by ancestral streams that have been overlain by colluvial-alluvial fan deposits. Unit thickness is highly variable, but may reach 105 feet (32 m) in Flat Creek valley. No age data are available, but thought to range from late Tertiary to early Pleistocene, based on analogies to similar deposits dated from the Livengood Bench in interior Alaska (Karl and others, 1988).

## INTRUSIVE ROCKS

**TKdf** **Felsic and intermediate dikes (Late Cretaceous and early Tertiary?)**—Light buff to light grayish green, hypabyssal, porphyritic dacite and lesser rhyolite dikes; may also include intermediate compositions locally. Unit exposed as scattered rubble on ridgetops, as broken pieces in soil auger holes, and as float in tailing piles. Dikes are normally 3 feet (1 m) or less in width (based on maximum width of rubble scatter) and are discontinuous. The dikes are primarily porphyritic and contain from 5 to 25 percent phenocrysts in a finer grained groundmass. Compositions and phenocryst populations vary. The most common types are biotite-quartz-plagioclase ± clinopyroxene ± hornblende dacite, biotite-quartz-plagioclase rhyolite, and hornblende-plagioclase dacite. Clinopyroxene-hornblende-plagioclase dacite (or andesite?) is found locally. Accessory minerals include apatite, zircon, and opaques. Phenocrysts are generally about ½ mm in size, but quartz as coarse as 2 mm and plagioclase as coarse as 4 by 7 mm, are found locally. The phenocrysts are generally euhedral to subhedral, but quartz is commonly embayed, indicating resorption. In one sample from the southeast part of the study area, primary hornblende phenocrysts are partly replaced on the edges by biotite.

Alteration of the dikes is extensive and includes assemblages of chlorite, white mica, calcite, and opaques. Nearly all of the mafic minerals are at least in part altered to chlorite. A large number of the feldspars are white mica and calcite altered, as is much of the groundmass. Secondary opaques occur locally and may be related to hydrothermal alteration. Limited major oxide analytical data from six samples (table 1 and fig. 6) indicate a dacitic composition on a total-alkali-silica diagram (fig. 7A).

The unit is assigned a Late Cretaceous and early Tertiary age because the dikes intrude rocks of Early Cretaceous age, and also because they are similar to Late Cretaceous and early Tertiary granite porphyry dikes mapped 100 miles to the east in the Iditarod quadrangle (Miller and Bundtzen, 1994).

**TKdm** **Mafic and intermediate dikes (Late Cretaceous and early Tertiary?)**—Dark greenish gray to dark green, fine- to medium-grained dikes and sills(?) of mafic to intermediate composition. Unit exposed in rubble only, but appears to intrude rocks belonging to map unit **Kt**. Based on rubble extent, dikes are generally 3 ft (1 m) or less in width, but locally rubble zones are > 100 ft in width (> 30 m). Dike traces are discontinuous; only rarely can they be followed for more than 100 ft (30 m). Many dike trends are parallel or subparallel to bedding strike, leading us to speculate that some may be sills, but in no case was outcrop available to confirm this. Major oxide chemistry is not available, but mafic to intermediate compositions are suspected based on petrographic examination. The dikes are generally diabasic to subophitic in texture and contain magnetite-clinopyroxene-plagioclase + minor quartz. Grain size is generally less than 1 mm, but locally clinopyroxene reaches 4 mm. The primary magnetite shows skeletal form locally.

The dikes all show secondary alteration consisting primarily of chlorite, both interstitially and after clinopyroxene. Secondary prehnite, white mica, sphene, calcite, and opaques are found locally.

No isotopic-age or major-oxide chemical data are available from this unit. The unit is assigned a Late Cretaceous and early Tertiary age because the dikes intrude rocks of Early Cretaceous age, and also because they are broadly similar to Late Cretaceous and early Tertiary dikes mapped 100 miles to the east in the Iditarod quadrangle (Miller and Bundtzen, 1994).

## VOLCANIC AND SEDIMENTARY ROCKS

**Koyukuk Terrane**--divided into three units: **Ka**--volcanic dominant, **Ks**--sandstone dominant, and **Kt**--a heterogeneous unit. The last unit is similar to the Lower Cretaceous andesitic volcaniclastic rock unit described by Patton and Moll-Stalcup (1996) as part of the Koyukuk terrane in Unalakleet quadrangle (directly north of Holy Cross quadrangle). Unit **Kt** however, includes minor felsic tuff, which is not described for the Unalakleet rocks.

Kt **Tuffs, sedimentary rock, and flows (Early Cretaceous)--** Unit underlies most of the study area and is primarily characterized by its heterogeneity. It includes interbedded tuffaceous rocks (crystal lithic tuff, lapilli tuff, ash flow tuff), sedimentary rocks (reworked crystal tuff, volcaniclastic sandstone, tuffaceous siltstone), and volcanic flows. Tuffaceous rocks dominate (comprising about 75 percent of the unit); sedimentary rocks are common (about 20 percent); and flow rocks are minor (about 5 percent). The unit is primarily exposed as frost-riven rubble, but some of the coarser-grained examples form outcrops locally. The interbedded nature is surmised on the basis of parallel rubble trains, not on observed outcrops. The color of the unit varies with rock type--dark greenish gray crystal lithic tuff, green-gray lapilli tuff, gray or red ash flow tuff, gray-green volcaniclastic sandstone, and red or green cherty tuff and tuffaceous siltstone. Although this unit contains many distinct rock types, beds cannot be traced over any distance and mappable marker units are lacking; hence we lump these lithologies into one unit, which is distinct because of its heterogeneity.

Crystal lithic tuff comprises roughly 60 percent of the tuffaceous rocks (or 45 percent of the unit as a whole). The tuffs are generally poorly, but locally moderately well sorted, and contain angular to subrounded clasts up to pebble size. Clasts are composed mainly of volcanic lithics (porphyritic andesite to basalt, and locally, porphyritic dacite, pumice, collapsed pumice, and scoria) and lesser crystals (including clinopyroxene, plagioclase, and locally potassium feldspar). The matrix is largely devitrified glass; relict shards are locally abundant. Andesitic compositions dominate, but felsic crystal lithic tuff also occurs. One unique sample of crystal lithic tuff from the southwest part of the map area has limestone lithic clasts consisting of broken fossil crinoids. Lapilli tuff is the next most abundant of the tuffaceous rocks; it too is largely andesitic, but locally dacitic in composition. It is generally poorly sorted, has very fine to pebbly grains, and is similar to the crystal lithic tuff in clast content (volcanic lithics, including pumice, and crystals of clinopyroxene, plagioclase, and locally potassium feldspar, hornblende, and rarely biotite), but its matrix lacks shards. Minor amounts of felsic tuff are distributed throughout the unit; one river cut exposure lies on the north side of Flat Creek about a half mile up river from the main placer workings at Stuyahok (this tuff yielded 10 ppb Au). The felsic tuff is white, pinkish white, or buff in color and locally displays fine laminations; thickness varies from <1 m to perhaps as much 3 m. Phenocrysts of plagioclase, quartz, and locally biotite or clinopyroxene are found in a largely altered cryptic groundmass of devitrified material that also occasionally includes volcanic lithic clasts. At widely spaced localities, minor amounts of fine-grained rhyolitic and dacitic ash flow tuff occur in rubble. This locally very red weathering rock contains 15 to 40 percent plagioclase, quartz $\pm$ clinopyroxene phenocrysts (<0.2 mm) in a very fine grained matrix of flattened and smeared devitrified glass shards. In addition to devitrification of glass, the tuffaceous rocks of unit **Kt** nearly all show secondary celadonite or chlorite. Other secondary minerals found locally include calcite, white mica, hematite, epidote, laumontite, prehnite, pumpellyite, and chessboard albite.

Sedimentary rocks make up about 20 percent of unit **Kt** and include reworked crystal tuff, volcaniclastic sandstone, and tuffaceous siltstone, which is locally marine microfossil rich. The reworked crystal lithic tuff is poorly sorted and has very fine- to coarse-grained, subangular to subrounded clasts of andesitic volcanic rock, plagioclase, clinopyroxene, and locally hornblende and quartz. It differs from its tuff counterpart in that the grains are slightly more rounded and more closely packed. Volcaniclastic sandstone, volcaniclastic siltstone, tuffaceous siltstone, and silty tuff are widely distributed within the unit. These sedimentary rocks are locally finely layered or graded in 1-to 5-cm-thick beds. The finer grained varieties sometimes show soft-sediment deformation and bioturbation features. Clasts include plagioclase, volcanic lithics, quartz, minor clinopyroxene, and locally hornblende, potassium feldspar, opaques, and albite, in a muddy matrix. The tuffaceous siltstones and silty tuffs commonly contain 100- to 200-micron-diameter round and locally triangular-shaped silica tests from pelagic radiolarians interpreted to have been present in the marine water column at the time of deposition of the rock. Similarly fine (100 micron) unidentified calcite tests are also present locally. Alteration in the sedimentary rocks is similar to that shown in the tuffaceous rocks and commonly includes clay and chlorite, and locally includes calcite, hematite, laumontite, prehnite, and fine epidote.

Volcanic flow rocks comprise about 5 percent of unit **Kt** and include clinopyroxene diabase, clinopyroxene basaltic trachyandesite, clinopyroxene-plagioclase andesite, and plagioclase dacite. The more mafic to intermediate rocks have 15 to 45 percent phenocrysts of plagioclase > clinopyroxene $\pm$ hornblende and are locally trachytic. Fine-grained trachytic dacite containing 2 percent plagioclase phenocrysts caps a distinct round knob that lies north of the Stuyahok River in the northeast part of the study area. The volcanic rocks from unit **Kt** have secondary chlorite and locally calcite, white mica, and clinozoisite.

Major oxide data on one altered sample indicates a basaltic trachyandesite composition (table 1, figs. 6 and 7).

The heterogeneous unit **Kt** is assigned an Early Cretaceous age based on correlation with similar rocks in the adjoining Unalakleet quadrangle to the north. There, andesitic volcaniclastic rocks of the Koyukuk terrane contain a Valanginian Buchia (a bivalve) fossil and radiolarians of possible Early Cretaceous (Valanginian) age (Patton and Moll-Stalcup, 1996).

**Ka** **Intermediate to mafic volcanic agglomerate, lapilli tuff, and flows (Early Cretaceous?)**—Dark green and dark greenish gray volcanic agglomerate, dark green to medium green lapilli tuff, lesser dark green and dark gray, locally pillowed lava flows, and minor interbedded felsic tuff, reworked crystal lithic tuff, volcaniclastic sandstone, and tuffaceous siltstone. Unit is moderately well exposed for this area. The volcanic agglomerate and pillowed lava form distinctive tors on the low ridge south of Chase Mountain.

The majority of the unit is composed of basaltic to andesitic agglomerate and lapilli tuff. The agglomerate consists of angular to subrounded volcanic blocks of a variety of sizes (up to 25 cm) and textures (e.g. porphyritic, pilotaxitic, vesicular, amygdaloidal, pumiceous), as well as crystals of clinopyroxene and plagioclase (locally broken). The matrix is largely chlorite, but probably was originally ashy. The lapilli tuff is essentially a finer grained version of the agglomerate. Here the clasts are poorly sorted, ½ mm to 1 cm (and smaller) and include volcanic lithics, clinopyroxene, plagioclase, and locally hornblende and potassium feldspar crystals. The groundmass locally contains devitrified shard forms, but is largely altered to chlorite. The volcanic agglomerate appears to be primarily a subaerial facies. The lapilli tuff is also probably in part subaerial, but some reworking of juvenile material in a subaqueous environment cannot be ruled out.

Volcanic flow rocks are estimated to compose about 20 to 30 percent of the unit. Pillow forms are found locally and flow units are estimated to range from less than 1 m to perhaps 5 m in thickness. Vesicular and amygdaloidal textures are common; nearly all of the flows are porphyritic with 10 to 45 percent phenocrysts of clinopyroxene, plagioclase $\pm$ magnetite. Hypersthene and fine-grained biotite occur locally. Phenocrysts are generally ½ to 2 mm, but range up to 4 mm and are set in a fine-grained sometimes pilotaxitic groundmass. Compositions range from basalt to andesite.

The remainder of the unit is volumetrically minor, but includes some distinctive interbedded components. A minor amount of fine-grained plagioclase + quartz + volcanic lithic felsic tuff is exposed on the north side of Chase Mountain. Fine-grained tuffaceous siltstone, soft-sediment-deformed silty mudstone, volcaniclastic sandstone, and reworked crystal lithic tuff indicate subaqueous deposition. Further, the presence of radioarian tests in the tuffaceous siltstone and silty mudstone indicate a marine environment.

The unit is extensively altered by secondary celadonite, chlorite, calcite, white mica, sphene, and fine opaques. Locally, prehnite $\pm$ pumpellyite occur in veins, filling vesicles, and interstitially. In addition to these low-grade regional metamorphic products, the Chase Mountain area has been thermally altered, reaching a maximum of hornblende hornfels facies locally (see hornfels pattern on map). On Chase Mountain, disseminated pyrite occurs locally in lapilli tuff, andesitic flow, and felsic tuff; fine, barren quartz veinlets are also found locally. We speculate that Chase Mountain is underlain by a buried stock.

Limited major oxide analytical data indicate basaltic to basaltic trachy-andesite compositions for the agglomerate and flow rocks (table 1, and figs. 6 and 7).

The stratigraphic relationship of this unit with map units **Kt** and **Ka** is uncertain. The unit is assigned an Early Cretaceous? age based on the similarity of its lithologies to parts of unit **Kt**.

**Ks** **Sandstone and felsic tuff (Early Cretaceous?)**—Unit dominantly composed of light to dark gray, fine- to coarse-grained, moderately well to poorly sorted graywacke sandstone, interbedded with lesser white-weathering, water-laid felsic tuff, some light gray reworked felsic tuff-sandstone, and minor green fossiliferous siltstone. Unit is exposed mostly in rubble in the southeast part of the map area. The one outcrop found may have been preserved because it has been thermally altered, perhaps by the local dikes, and shows secondary biotite. The hornfels preserves relict graded bed sets of sandstone, fine sandstone, and siltstone suggesting a turbidity current origin. Clasts in the sandstones are subrounded to angular and include a variety of lithic clasts (volcanic, sedimentary, metamorphic, and plutonic) and detrital minerals (quartz, plagioclase, potassium feldspar, biotite, chlorite, and epidote). Locally the sandstones are volcaniclastic rich and locally they contain limestone clasts. One moderately well sorted coarse- to very coarse-grained sandstone sample has pumice clasts, pieces of broken punctate brachiopod shells, and crinoid-like limestone debris; we interpret the fossil debris to be eroded from older source terrains.

The interbedded felsic tuff beds are fine- to coarse-grained and locally layered. Quartz crystal and felsic volcanic lithic fragments float in an altered matrix containing secondary chlorite and clay. Secondary hematite is locally abundant. Rubble of green siltstone is intermixed with graywacke at one site. The siltstone contains abundant sponge spicules and lesser radiolaria; the green color comes from secondary chlorite. The stratigraphic relationship of this unit with map units **Kt** and **Ka** is uncertain. The unit is assigned an Early Cretaceous? age based on the similarity of its lithologies to parts of unit **Kt**.

## MINERAL RESOURCE ASSESSMENT

### PLACER RESOURCES

Placer gold deposits in the study area were mined during two periods: from 1921 to 1940, and then again from 1986 to the present. They consist of stream gravels of Quaternary age on approximately 2 mi (3.2 km) of Flat Creek and two small south side tributary gulches. Total production has been estimated to be as much as 30,000 oz (1,933 kg) gold from roughly 750,000 $yd^3$ (573,500 $m^3$) of gravel at a recovered grade of about 0.04 $oz/yd^3$ gold. The gravels are shallow stream deposits, averaging about nine feet in thickness, that are covered by about 8 feet of overburden. Based on microscopic examination of one heavy-mineral-concentrate sample from Flat Creek, the deposits contain pyrite, magnetite, ilmenite, minor cinnabar, arsenopyrite, and monazite, as well as placer gold. The gold grains are flat, pitted, and only a small fraction exceed 10-mesh size. Some gold grains appear to be water worn, while other grains are angular, typical of placer gold near lode sources. It is unclear whether the vermicular texture observed in some gold is primary, or was developed during a silver leaching event in the streambed environment. Microprobe analysis of 13 individual grains (T.K. Bundtzen, unpub. data) revealed that the gold is of relatively low purity (ranging from about 660 to 875 fine), similar to placer gold from Kako Creek and Willow Creek, also in the Marshall district (Smith, 1941a). The wide range in fineness among the 13 grains suggests either a single lode source of highly variable fineness, or more likely, more than one lode source contributed to the placer deposits. Microprobe analyses also revealed somewhat unusual associations with other minerals. In several grains, the gold appeared to be intergrown with intricate sunburst-patterned igneous(?) muscovite inclusions, as well as with pyrite and quartz (Bart Cannon, Cannon Microprobe Inc., written commun., 1995). The microprobe data and additional analyses indicate the presence of the usual impurity of silver, but some of the Stuyahok placer gold also contains anomalous amounts of bismuth (1.50 percent), mercury (up to 0.61 percent), copper (up to 0.64 percent) and antimony (up to 0.17 percent) (T.K. Bundtzen, unpub. data). Anomalous copper and bismuth values, and the associated gangue minerals (listed above) are consistent with a relatively high-temperature environment of formation for the lode source. In contrast, the mercury values are consistent with a lower temperature, perhaps additional, lode source.

Stuyahok Mining is working a north limit bench of Flat Creek that was apparently missed by previous operators. Air photo analysis indicates that this bench should continue for some distance upstream from the present workings. The existence of gold, mercury, and arsenic anomalies in stream-sediment samples collected during this study suggests the potential for additional placer gold for about two miles (3.2 km) above the present placer workings. Samples collected by RAA (and confirmed by stream-sediment and heavy-mineral-concentrate data from this study) indicate anomalous gold values in sediments in Last Chance Creek, which has never been mined. Additional placer gold prospects may exist in the tributaries draining Chase Mountain, which contains a significant mineralized hornfels aureole.

## LODE RESOURCES

Two different, but possibly related, lode gold sources may exist in the Stuyahok area. There appears to be an association with quartz porphyry rhyolite and/or dacite dikes and the distribution of the placer gold deposits. In addition, the Chase Mountain dike swarm and associated hornfels lie immediately south of the Flat Creek placer deposits. The style of placer gold, coupled with the association of rhyolite or granite porphyry dikes, suggest similarities to the Donlin Creek, Ganes-Yankee Creek, and other granite- (or rhyolite-dacite-) porphyry-associated gold-polymetallic deposits in southwest Alaska (Bundtzen and Miller, 1996).

Resource areas (figs. 8A and 8B) were defined on the basis of geologic and geochemical information collected during the course of this study, supplemented by older proprietary data from Resource Associates of Alaska (RAA), and by information collected by Calista Corporation. Although primarily intended to identify potential

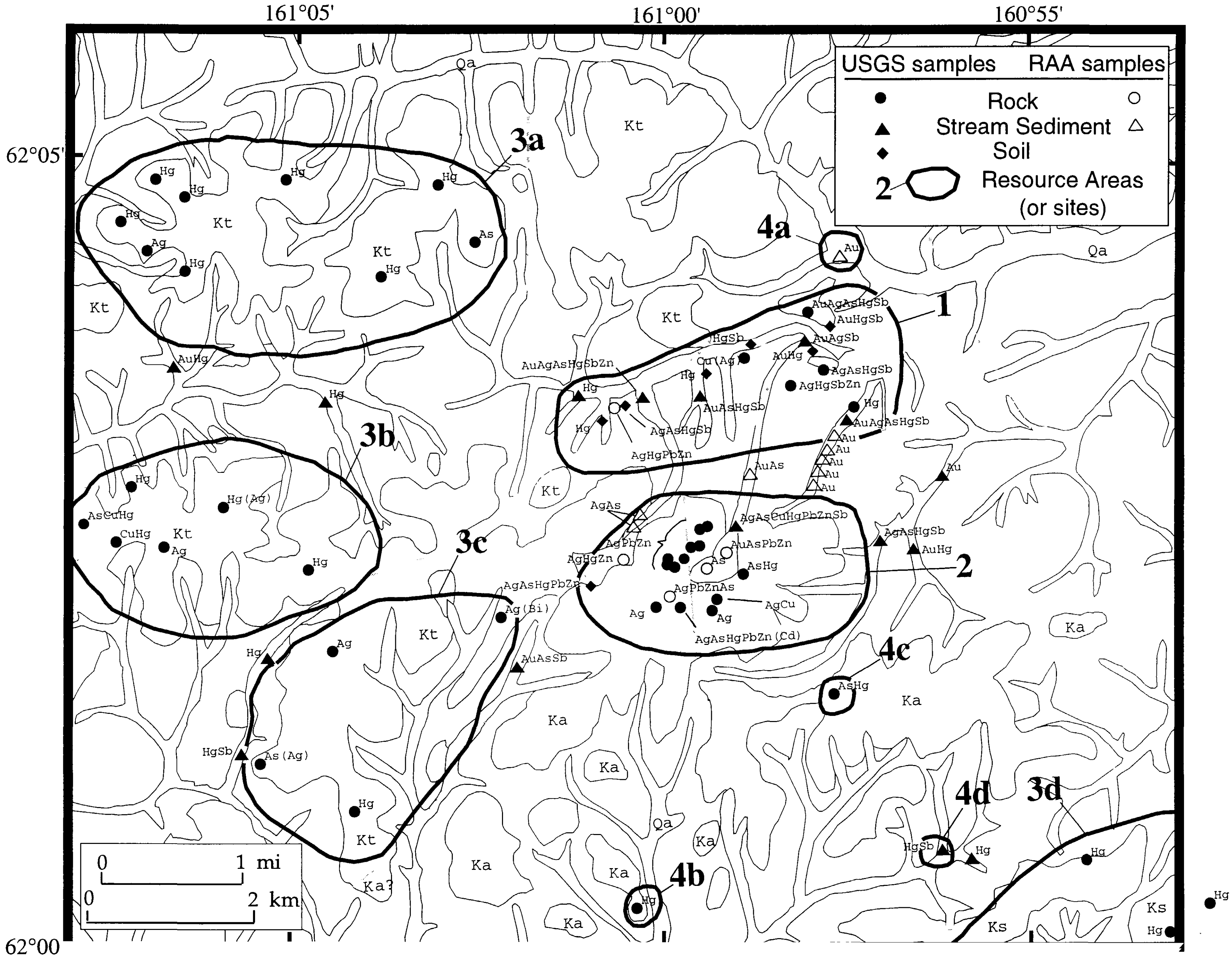



Figure 8A. Map showing resource areas and the geochemical anomalies that define them (plotted on a simplified geologic map). Units are the same as in figure 6.

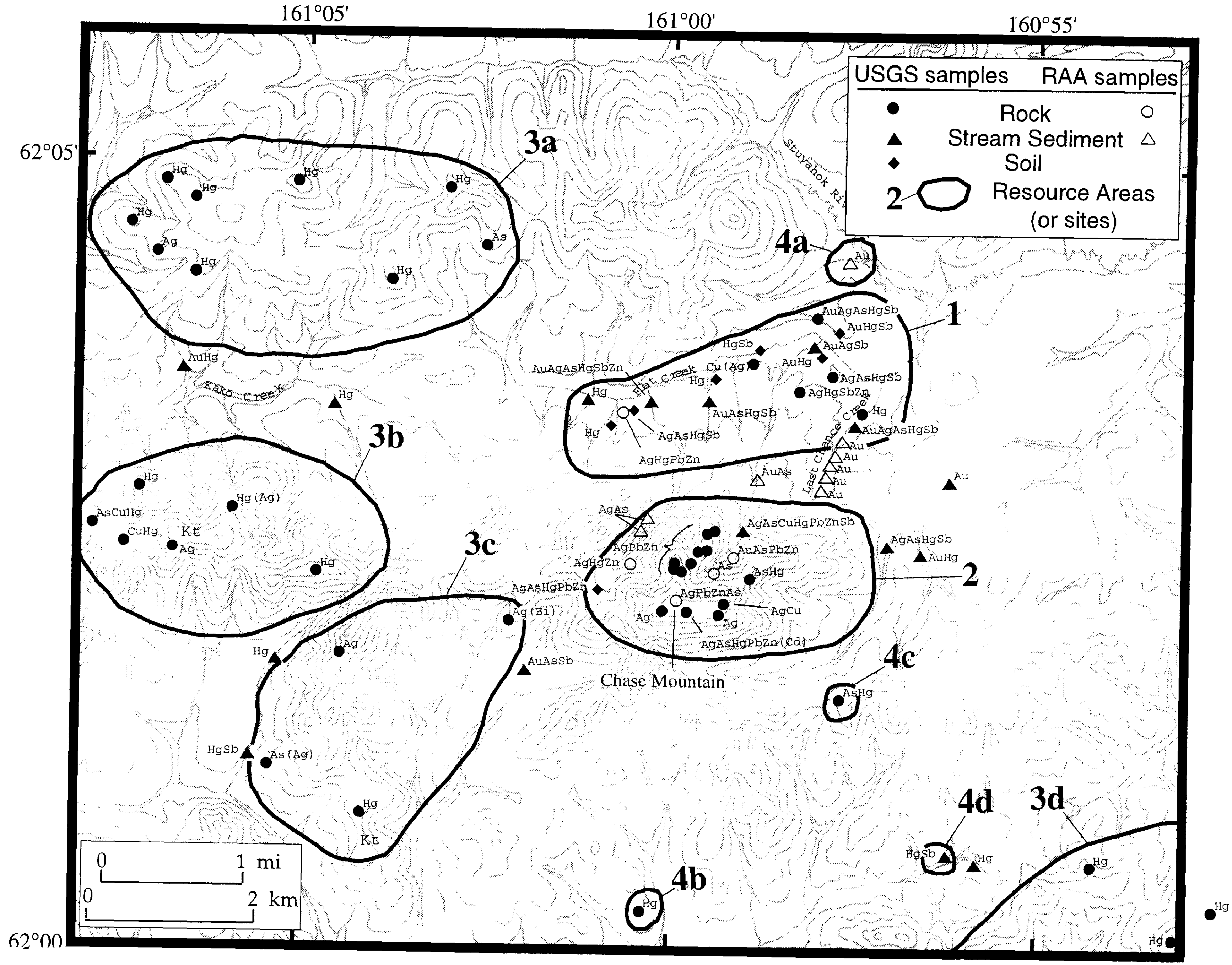



Figure 8B. Map showing resource areas and the geochemical anomalies that define them (plotted on a topographic map).

areas of lode resources, the areas outlined may also locally contain placer resources. New geochemical data from this study include analyses of 252 rock samples (all single grab samples, mineralized where noted), 42 stream-sediment, 33 heavy-mineral-concentrate, and 111 soil samples. The complete data (including the RAA analyses) are published in companion open-file reports OF-96-505-B and OF-96-505-C. The resource area boundaries and the geochemical data that help define them (including sample type and anomalous elements) are shown in figure 8A (plotted on a simplified geologic map) and figure 8B (plotted on a topographic map). In the following section, each resource area is briefly described, and the anomalous metal values are summarized. We note that silver values are consistently higher in the RAA data (perhaps two to three times higher) than in our data.

Description of Resource Areas

*Area 1*

Area 1 (figs. 8A, 8B) includes the main Stuyahok placer workings, several miles of Flat Creek, and a Quaternary bench north of Chase Mountain. Although primarily underlain by unconsolidated Quaternary deposits, Area 1 is defined on the basis of the concealed bedrock, which is assumed to include approximately east-west-trending rhyolite to dacite porphyry dikes. This area is defined by numerous anomalies in rock, stream-sediment, pan-concentrate, and soil-auger samples.

- Nine rock samples (six from this study and three from RAA) contain anomalous metal values. One sample, a hematite-altered felsic tuff from a river cut on the left limit side of Flat Creek, about a half mile up river from the main placer workings, yielded 10 ppb Au, 0.58 ppm Ag, 111 ppm As, 620 ppb Hg, and 20 ppm As. A sample of sulfide-bearing intermediate tuff collected by RAA yielded 2.3 ppm Ag, >5 ppm Hg, 500 ppm Pb, and 410 ppm Zn. The remaining seven samples are rhyolite to dacite dikes, locally brecciated and healed by chalcedonic quartz veins. Collectively these seven samples yielded up to 2.4 ppm Ag, 700 ppm As, 103 ppm Sb, 328 ppm Zn, and ranged 320 ppb to 3.3 ppm Hg; one Cu value of 157 ppm was obtained.
- Eighteen stream-sediment and seven pan-concentrate samples contain anomalous metal values (eight of the stream-sediment and all of the pan-concentrate samples were from this study; the remaining ten stream-sediment samples were from RAA). The stream-sediment samples yielded anomalous Au (up to 1.08 ppm), Ag (up to 1.6 ppm), As (up to 912 ppm), Hg (90-370 ppb), Sb (up to 8 ppm), and Zn (up to 350 ppm, locally). Four of the pan-concentrate samples had visible gold and collectively they yielded Au up to 32.7 ppm (averaged >4 ppm Au), As to 439 ppm, and Sb to 30 ppm.
- Samples from two soil transects yielded anomalous values in Au + Hg ± Sb. Samples from five other soil transects are anomalous in Hg ± Sb ± As.

*Area 2*

Area 2 (figs. 8A, 8B) is centered around Chase Mountain, which is primarily underlain by lapilli tuff, agglomerate, and flow rocks belonging to map unit **Ka**. The older rocks are cut by numerous approximately east-west oriented dacitic to rhyolitic dikes. The area has been thermally altered (to a maximum of hornblende hornfels facies) and may be underlain by a felsic to intermediate stock. This area is defined by numerous anomalies in rock, stream-sediment, pan-concentrate, and soil-auger samples.

- Twenty-four rock samples (eighteen from this study and six from RAA) contain anomalous metal values. A duplicate run of one of our lapilli tuff samples yielded 10 ppb Au and no other anomalies (no Au was detected--limit 5 ppb--in the original run of the sample). One 7 ppb Au value was obtained from a rerun RAA sample of unknown lithology; this sample also yielded 297 ppm As and 450 ppb Hg. The remaining samples include a variety of tuffs and dikes that locally have disseminated pyrite or are hematite altered. Collectively these remaining samples yielded up to 4.5 ppm Ag (and averaged 0.8 ppm Ag), 300 ppm As, 450 ppb Hg, >1,000 ppm Pb, and 620 ppm Zn; locally one Cu value of 581 ppm and one Cd value of 5.9 ppm were obtained.
- Eighteen stream-sediment and five pan-concentrate samples contain anomalous metal values (five of the stream-sediment and all of the pan-concentrate samples were from this study; and thirteen of the stream-sediment samples were from RAA). The stream-sediment samples yielded anomalous Ag (up to 4.4 ppm), As (range 74-305 ppm), and locally Hg (up to 450 ppb) and Au (5 ppb in one sample). One stream-sediment sample also yielded 98 ppm Cu, 146 ppm Pb, and 320 ppm Zn. Two pan-concentrate samples yielded Au values (13 and 81 ppb), As up to 169 ppm, and Sb up to 26 ppm.
- Soil samples from two transects collected during this study were anomalous in Ag + Hg $\pm$ As $\pm$ Pb $\pm$ Zn $\pm$ Sb. One RAA soil sample was anomalous in Au + Ag and three were anomalous in As $\pm$ Pb $\pm$ Zn.

<u>*Areas 3*</u>

The four areas labeled 3a, 3b, 3c, and 3d (figs. 8A, 8B) show low-grade, but relatively consistent Hg $\pm$ Ag $\pm$ As anomalies. Three of the four areas are underlain by volcaniclastic rocks of unit **Kt** and the fourth by sedimentary and felsic tuff rocks of unit **Ks**; in all four areas the older units are cut by mafic and/or felsic dikes. All samples were from this study.

- Area 3a is defined by nine rock samples and one stream-sediment sample. The rocks show relatively consistent Hg anomalies (110-680 ppb), one 0.4 ppm Ag value, and one 34 ppm As value. The stream sediment yielded 35 ppb gold and 280 ppb Hg.
- Area 3b is defined by nine rock samples from six localities, and by one stream-sediment sample. The rocks show consistent Hg values (100 to 830 ppb), one 64 ppm As value, local Ag values to 0.4 ppm, and Cu values to 154 ppm. The stream sediment sample yielded 110 ppb Hg.
- Area 3c is defined by four rock and two stream-sediment samples. The rocks show relatively consistent Ag values of 0.2-0.4 ppm, and local values of 94 ppm As, 200 ppb Hg, and 12 ppm Bi. The stream-sediment samples yielded 90-100 ppb Hg, and 2-4 ppm Sb.
- Area 3d is defined by three rock samples and one stream-sediment sample. The rocks show Hg values of 130-870 ppb; the stream sediment yielded 90 ppb Hg.

We are not certain what the Areas 3 anomalies are due to, but in southwest Alaska, elevated mercury is commonly related to epithermal mineralization localized along dikes or structural features (Sainsbury and MacKevett, 1965). Our data is not detailed enough to further define the anomalies found in areas 3a, 3b, 3c, and 3d.

*Sites 4*

The four points labeled 4a, 4b, 4c, and 4d (figs. 8A, 8B) mark single-site, single-medium, anomalies. They are included because our data is not sufficiently detailed to rule out their significance.

- Site 4a is defined by a 10 ppb Au value in a stream-sediment sample collected by RAA and later reanalyzed for gold. This anomaly lies very near our well-defined Area 1, hence it could be considered to support or extend that area. However, the stream-sediment sample collected near the same site during the course of this study did not show a gold anomaly (detection limit 5 ppb). We normally consider any gold anomaly to be significant, but our uncertainty regarding the validity of this sample has led us to mark this as a site anomaly of uncertain origin.
- Site 4b is defined by a single value of 150 ppb Hg in a volcanic flow rock.
- Site 4c is defined by values of 530 ppb Hg and 32 ppm As from a pyrite-bearing lapilli tuff.
- Site 4d is defined by a stream-sediment sample that yielded 240 ppb Hg (and 3 ppm Sb from the pan-concentrate sample).

## CONCLUDING REMARKS

This report summarizes geologic and geochemical data collected in the Stuyahok-Flat Creek study area under a cooperative agreement with Calista Corporation. The geologic map provides a framework for interpreting rock, stream-sediment, and soil geochemical samples. A preliminary mineral resource assessment outlines anomalous areas. The raw geochemical data are provided in companion Open-file Reports 96-505-B and 96-505-C, but the anomalous geochemical values that define the resource areas are summarized herein.

The Stuyahok-Flat Creek area may host two distinct, but perhaps related, mineralized systems--one centered around the Stuyahok placer workings (Area 1) and the other centered around Chase Mountain (Area 2). The study area also shows scattered mercury and other miscellaneous element anomalies (Areas 3 and Sites 4). From soil auger samples and trench exposures we know that felsic dikes occur locally in the Hazel Gulch area of Flat Creek valley. From bedrock exposures we also know that most of the felsic dikes trend approximately east-west. We speculate that east-west structures (faults) control the dike and valley orientation, and that east-west-oriented, perhaps gold-bearing felsic dikes cut bedrock under at least part of the Flat Creek valley floor yielding the mineralized zone outlined as Area 1[2]. The hornfels cap of Chase Mountain implies the presence of a buried stock. Perhaps a mineralized cupola area is responsible for the mineralized zone outlined as Area 2. The miscellaneous mercury and other anomalies of Areas 3 (a, b, c, and d) and Sites 4 (a, b, c, and d) may indicate the presence of other small epithermal systems.

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[2] As mentioned previously in the geology overview section, from about the town of Holy Cross down river to Marshall (fig. 1), rocks north of the Yukon River show an east-west orientation of some contacts and structures, distinctly different from the regional northeast-orientation found throughout most of southwest Alaska. It is interesting to note that gold placer deposits of Stuyahok, Kako Creek, and Marshall (~ 20 mi southwest, and ~35 mi west-southwest from Stuyahok, respectively) all occur within this area of more east-west-dominant trends.

A better understanding of the geology and resources of the Stuyahok-Flat Creek area would of course be obtained with additional work. Isotopic age determinations would help us better understand the igneous history. Determination of the radiolarian ages could help confirm the correlation between the volcanic and volcaniclastic rocks of the Stuyahok area and those of the Lower Cretaceous Koyukuk terrane. A geophysical survey across Chase Mountain might determine the presence and depth of a buried stock. Drilling on Chase Mountain could establish both the presence of a stock and mineralized cupola. A more detailed sampling program in the Flat Creek valley (auger/soil) would better indicate the extent of the mineralization and could also contribute to our understanding of the system.

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