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GEOLOGIC MAP OF THE HEALY A-2 QUADRANGLE, ALASKA

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DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Fluvial deposits

The distribution of surficial deposits in the Healy A-2 Quadrangle was determined mainly by photogeologic interpretation, supplemented by field checks in selected areas during bedrock mapping efforts in 1972.

Qal FLOOD-PLAIN ALLUVIUM---Unconsolidated deposits in modern stream drainages. Material ranges from coarse, unsorted gravel in highland valleys to finely bedded silt in large river drainages.

Qat TERRACE ALLUVIUM---Deposits of locally vegetated terraces adjacent to modern flood plains. Mostly sand, silt, and gravel with some wood and peaty material.

Qaf ALLUVIAL-FAN DEPOSITS---Poorly consolidated gravels and sands with coarser proximal material and finer distal material.

Frost-rived debris and mass-movement deposits

Qct COLLUVIUM AND TALUS---Unconsolidated, angular bedrock rubble and soil debris. Forms cones or aprons that flank ridges on highland areas and broad solifluction sheets on gentle slopes.

Qrg ROCK-GLACIER DEPOSITS---Lobate, tongue-shaped, and spatulate accumulations of angular bedrock rubble with varying amounts of interstitial ice. Restricted to cirques and mountain valleys. A few may be active.

Glacial deposits

Drift sheets are preserved at different elevations and relative positions in major valleys. Various till units (Qdt) are mostly composed of nonstratified sand and gravel with a silt or clay matrix. The units mapped represent undifferentiated drift, including terminal, medial, and ground moraines. Five ages of drift are recognized in the map area, based on position, morphologic characteristics, and 11 radiocarbon age dates of correlative drift sheets near the study area (Woodward-Clyde Consultants, 1982; Smith, 1981). Older deposits generally occur at higher elevations and are less well preserved, more subdued, and more heavily vegetated.

Qdic ICE-CONTACT DEPOSITS---Material comprising kames, kame terraces, eskers, and ice-disintegration features; well sorted and stratified to unsorted and nonstratified. Includes deposits formed in narrow, glacier-confined channels and ice-disintegration deposits with characteristic hummocky knob-and-kettle topography. Eskers consist of low, steep-sided, sinuous ridges formed of poorly sorted, irregularly stratified alluvium deposited in subglacial tunnels. Some deposits may be usable as road base and construction material.

Qdt — TILL OF UNKNOWN AGE---In Susitna River valley may correlate with pre-Wisconsin till (Qdt_4).

Qdt_5 — EARLY HOLOCENE(?) TILL---Confined to north-draining, high alpine valleys south of Butte Creek.

Qdt_4 — LATE WISCONSIN TILL---11,000 to 9,000 yr B.P. Correlative with younger Butte Lake glaciation of Welsch and others (1982).

Qdt_3 — LATE WISCONSIN TILL---25,000 to 11,000 yr B.P. Correlative with Butte Lake glaciation of Welsch and others (1982).

Qdt_2 — EARLY WISCONSIN TILL---75,000 to 40,000 yr B.P. Correlative with Clear Valley glaciation of Welsch and others (1982).

Qdt_1 — PRE-WISCONSIN TILL---Older than 100,000 yr B.P. Correlative with thick piedmont glaciation of Welsch and others (1982).

Glaciofluvial deposits

Qdo — OUTWASH DEPOSITS---Sorted and stratified sand and gravel deposited by streams that drain glacial termini and margins.

METAMORPHIC ROCKS

Metamorphic rocks described below represent a gradational sequence along the south flank of the Maclaren metamorphic belt (Turner and Smith, 1974; Smith, 1981). The textural gradation from slaty argillite through gneiss represents a transition from greenschist facies to upper amphibolite facies. Most metamorphic rocks were recrystallized from pelitic protoliths whose conglomerate zone (Jsc) south of Butte Creek contains Late Jurassic megafossils (Smith, 1981; table 1).

Kgn — GNEISS AND HIGH-GRADE SCHIST---Grayish-brown to rust-weathering pelitic gneiss and silvery-brown schist. Dominantly biotite-quartz plagioclase b garnet with local sillimanite-bearing variants. Gneissic texture mainly layered with local folds. Forms large tors up to 20 ft (6 m) high on some ridges. Graphite, apatite, tourmaline, and zircon are common accessory minerals. Includes local mafic and calc-magnesian horizons. Unit is equivalent to pelitic gneiss in adjacent Healy A-1 Quadrangle, where a K-Ar age of 66.2 m.y. was obtained from hornblende in the gneiss (Smith, 1981).

Ks — SCHIST---Medium- to coarse-grained biotite-plagioclase-quartz schist with local garnet and feldspar porphyroblasts up to 0.5 mm. Dominantly gray or brown weathering. Includes local amphibole-bearing horizons with hornblende occurring as randomly oriented prisms on foliation surfaces. Stippled pattern near intrusive contacts indicates hornfelsed zone in schist. K-Ar ages of 53.0 m.y. (loc. 3, table 2) and 57.2 m.y. (Healy A-1 Quadrangle, Smith, 1981) were obtained from biotite in this unit.

Khp AMPHIBOLE-BEARING PHYLLITE---Medium-dark-gray spotted phyllite with planar compositional laminations. Spotted with porphyroblastic biotite. Includes interlayered beds with randomly oriented amphibole on foliation surfaces. Amphibole prisms commonly 0.5 to 3 mm long. K-Ar age of actinolitic hornblende from this unit in Healy A-1 Quadrangle is 64.1 m.y. (Smith, 1981).

Kp PHYLLITE---Silvery-gray, biotite-bearing phyllite; locally calcareous, with local biotite porphyroblasts as long as 2 mm. Minor compositional banding with more quartzose layers parallel to foliation. Grades into amphibole-bearing phyllite (Khp) unit.

SEDIMENTARY AND VOLCANIC ROCKS

KJa SLATY ARGILLITE, SILTSTONE, AND GRAYWACKE---Black to olive-gray argillite, siltstone, and graywacke with incipient to well-developed slaty cleavage. Commonly thin bedded with cyclic graded intervals up to a few inches thick. Festooned cross-bedding and load casts common. Slaty cleavage mainly parallel to, but locally oblique to bedding. Graywacke sandstone is fine to medium grained, gray or olive gray with varying amounts of chlorite, calcite, or epidote. Hornfelsed and hydrothermally altered zones are indicated by stippled pattern. Hornfels is typically light gray or tan weathering with white siliceous laminations. Limonitic (altered), metalliferous hornfels occurs near intrusive rocks south of Gold Creek.

Jsc CONGLOMERATIC SEDIMENTARY ROCKS---Interbedded polymictic conglomerate, sandstone, siltstone, and shale south of Butte Creek. Numerous repeated fining-upward graded sequences. Conglomerates contain subrounded cobbles up to about 4 in. (10 cm); most clasts are basalt, diabase, argillite, and graywacke in a dark, calcareous graywacke matrix. Exposed section upright and over 1,000 ft (300 m) thick.

Amphitheatre Group

Weakly metamorphosed tholeiitic lavas, agglomerates, and associated sedimentary rocks of the Amphitheatre Group are exposed in a broad belt across the southern part of the Mt. Hayes and Healy Quadrangles. These rocks are similar to the Nikolai Greenstone of the McCarthy area to the southeast; however available faunal evidence from central Alaska suggests the Amphitheatre Group is slightly younger---late Karnian or Norian versus pre-late Karnian for the Nikolai Greenstone (Csejtey and others, 1978).

TRab BASALTIC METAVOLCANIC ROCKS---Grayish-olive to gray-green metabasalt and basaltic andesite. Aphanitic to porphyro-aphanitic with plagioclase clusters as large as several millimeters. F low units vary in thickness from several inches to about 100 ft (30 m). Local flows and flow tops are amygdaloidal; typically, amygdules are filled with quartz, epidote, and calcite. Volcanic rocks consist mainly of plagioclase, clinopyroxene, and iron-titanium oxides in a

subophitic or intergranular texture. Propylitic alteration common, especially along shear zones or fractures. Stippled pattern indicates thickly bedded massive flows with columnar jointing.

TRas INTERBEDDED SEDIMENTARY AND VOLCANIC ROCKS---Dark-gray argillite and siltstone; tan, gray, white, pink, and light-green chert; gray recrystallized limestone and calcarenite; and thin units of metamorphosed volcanic flow rock.

TRal RECRYSTALLIZED LIMESTONE---Gray-weathering beds of fine-grained marble and calcarenite that form thicker members within the interbedded sedimentary and volcanic rocks (TRas). Locally dark gray to black; contains numerous calcite veins. Similar limestones from the Amphitheatre Group in adjacent Healy A-1 (Smith, 1981) and Talkeetna Mountains D-2 (Csejtey and others, 1978) Quadrangles yield late Karnian and Norian (Late Triassic) megafossils.

INTRUSIVE ROCKS

Butte Lake intrusive complex

The Butte Lake complex is a composite intrusive suite exposed over approximately 20 mi^2 (52 km^2) on an upland plateau in the central Healy A-2 Quadrangle. The complex is compositionally zoned with a quartz monzonite core surrounded by a grandiorite-diorite border phase. Satellite stocks of hornblende gabbro occur on the east and west ends of the complex.

TKbqm BIOTITE-HORNBLENDE QUARTZ MONZONITE AND GRANODIORITE---Light-gray, fine- to medium-grained, equigranular to seriate biotite-hornblende quartz monzonite and granodiorite. Locally porphyritic with pinkish poikilitic potassium feldspar phenocrysts as long as 1 cm. Contains biotite and hornblende in varying proportions, but generally mafics total 5 to 15 percent. Mafics and feldspars crudely foliated. Disseminated pyrite and limonitic alteration present locally. K-Ar age of hornblende from locality 2 in the center of the complex is 55.9 ± 1.7 m.y. (table 2).

TKbgd BIOTITE-HORNBLENDE GRANODIORITE---Gray, fine- to medium-grained, hypidiomorphic granular biotite-hornblende granodiorite. Textures are equigranular to seriate. Moderately foliated along southern margin of body. Rounded xenoliths common locally. Contains up to 15 percent hornblende with minor biotite. Hornblende prisms as large as several millimeters parallel foliation. A leucocratic phase that contains less than 10 percent mafics occurs in the northern part of the unit (indicated by less dense pattern). Contains accessory sphene, augite, and apatite with local chloritic alteration. K-Ar age dates on hornblende from locality 1 are 63.5 ± 1.9 m.y. and 64.3 ± 1.9 m.y. (table 2).

TKba EPIDOTE-HORNBLENDE GRANODIORITE---Medium-grained, equigranular to seriate, epidote-bearing hornblende granodiorite with minor biotite and accessory sphene; pinkish potassium feldspar phenocrysts

present locally. Epidote occurs in abundant epidote-quartz veins and as fine, disseminated subhedral grains that replace plagioclase, hornblende, and olive-brown biotite. Greenish gray on fresh surfaces.

TKbgb HORNBLENDE GABBRO AND DIORITE---Medium- to very coarse grained hornblende gabbro and diorite; exposed mainly as rubble crop. Includes local pegmatitic phases with greenish, altered plagioclase and hornblende prisms as large as 1.5 in. (4 cm). Irregular clots of dark hornblende gabbro in foliated diorite common in some areas. Biotite to 5 percent present in some samples. Rounded xenoliths locally abundant.

Gold Creek intrusives

The Gold Creek intrusives are exposed along the low ridge south of Gold Creek. They are predominantly of intermediate composition, and those on the east end of the ridge are hydothermally altered and mineralized with local stockwork fractures, quartz veinlets, and minor fine-grained, disseminated pyrite, chalcopyrite, and molybdenite(?). These mineralized intrusives are surrounded by rust-weathering, greenish, pyritic hornfelsed siltstone (stippled zone) with minor limonitic breccia and quartz veins. This mineralized system is a probable source of placer gold in Wickersham Creek and Gold Creek.

TKcqm QUARTZ MONZONITE---Group of small intrusive bodies exposed south of Gold Creek. Predominantly medium-grained equigranular or seriate, nonfoliated, biotite-hornblende quartz monzonite, with local pods of granodiorite and granite. Propylitic alteration common locally with chlorite replacing biotite and secondary calcite in feldspar sites.

TKcd INTERMEDIATE DIKES---Small, dark-gray, aphanitic to porphyritic, nonfoliated dikes of intermediate composition in the Gold Creek vicinity. Locally pyritic.

Other intrusive bodies

TKgd BIOTITE-HORNBLENDE GRANODIORITE TO DIORITE---Nonfoliated, medium-grained, equigranular biotite-hornblende granodiorite with local dioritic phases. Xenoliths of foliated to nonfoliated, fine-grained country rock as large as several inches are common. Biotite and hornblende generally compose 10 to 20 percent total volume. K-Ar age dates of 48.8 ± 1.5 m.y. (biotite) and 44.8 ± 1.3 m.y. (hornblende) were obtained from this intrusive body about 3 mi (4.8 km) west of the study area (Turner and Smith, 1974).

TKi SMALL INTRUSIVES OF INTERMEDIATE COMPOSITION---Medium- to coarse-grained, slightly foliated biotite-hornblende diorite to porphyritic quartz monzonite with local potassium feldspar and quartz phenocrysts. Occur mainly within high-grade metamorphic terrane in northwest part of quadrangle.

Mzi SMALL STOCKS, DIKES, AND SILLS---Mafic and intermediate intrusive bodies often associated with the Amphitheatre Group of Triassic age. Includes diabase sills and plugs, basaltic dikes, hornblende porphyry, and diorite bodies. Often weakly metamorphosed.

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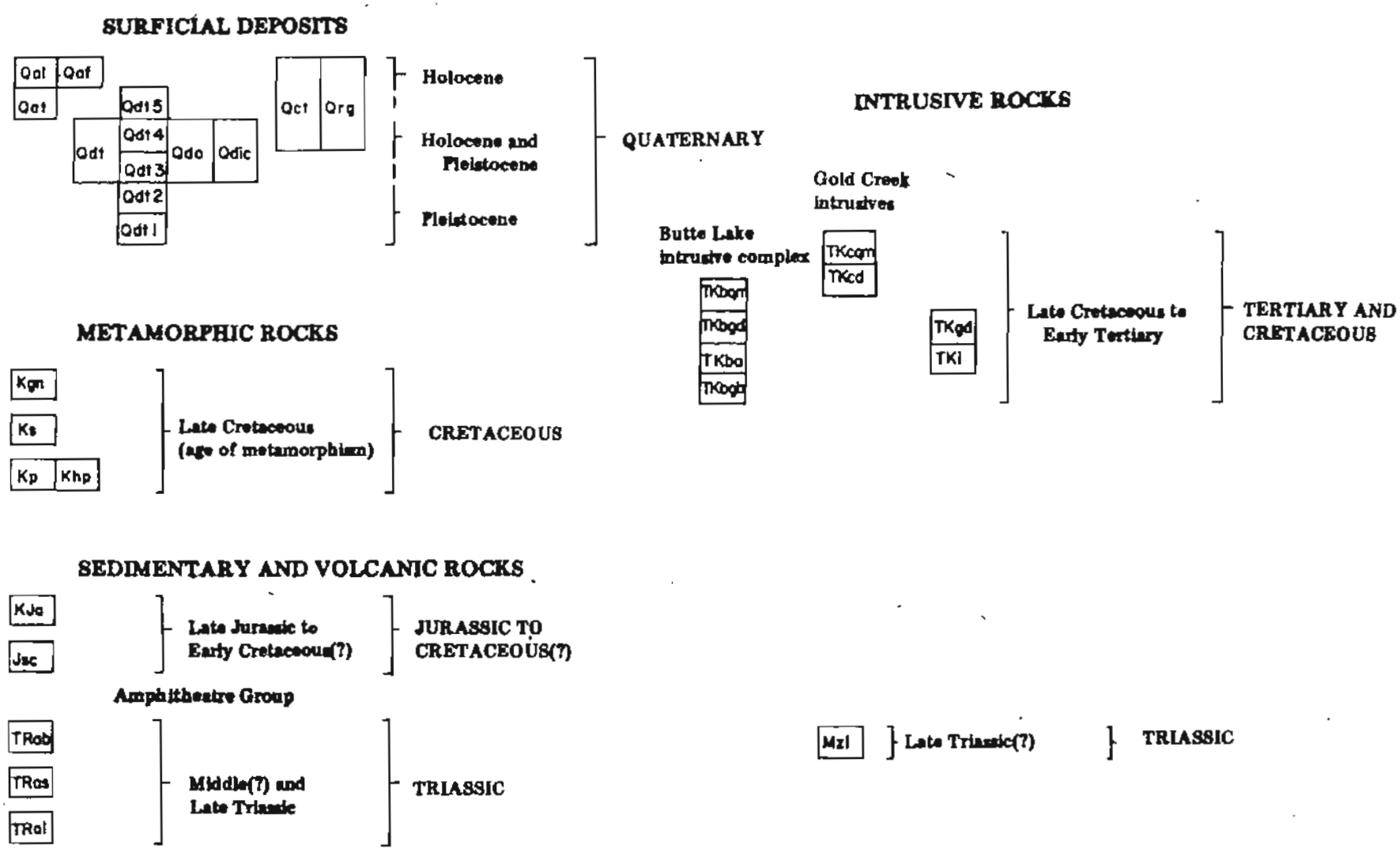
CORRELATION OF MAP UNITS



GEOLOGIC MAP SYMBOLS

Contact, dashed where approximately located, dotted where concealed

High-angle fault, dashed where approximately located, dotted where concealed

Inferred thrust fault, extended to map area from adjacent Healy A-1 Quadrangle (Smith, 1981)

Lineament, inferred from airphotos, may represent faults

Morainal ridges, resulting from stillstands or readvances of ice terminus

Solifluction lobes, especially prevalent on gentle slopes covered with veneer of older glacial drift

Mzi
Igneous dike, with appropriate rock type from map legend

Strike and dip of beds

20
Inclined, beds upright

30
Inclined, tops of beds unknown

45
Overturned

Vertical bedding

Strike and dip of foliation and cleavage

63
Inclined foliation

Vertical foliation

30
Foliation surface wavy or wrinkled

50
Prominent cleavage, in most cases probably axial-plane cleavage

Strike and dip of joints and minor folds

15
Inclined joint

Vertical joint

10
Plunge of minor fold axes

5
Shear zone showing dip

F1
Fossil locality (table 1)

2
H 63
K-Ar age date locality, H = hornblende, B = biotite (table 2)

(2)
Location of rock sample analyzed for major elements (table 3)

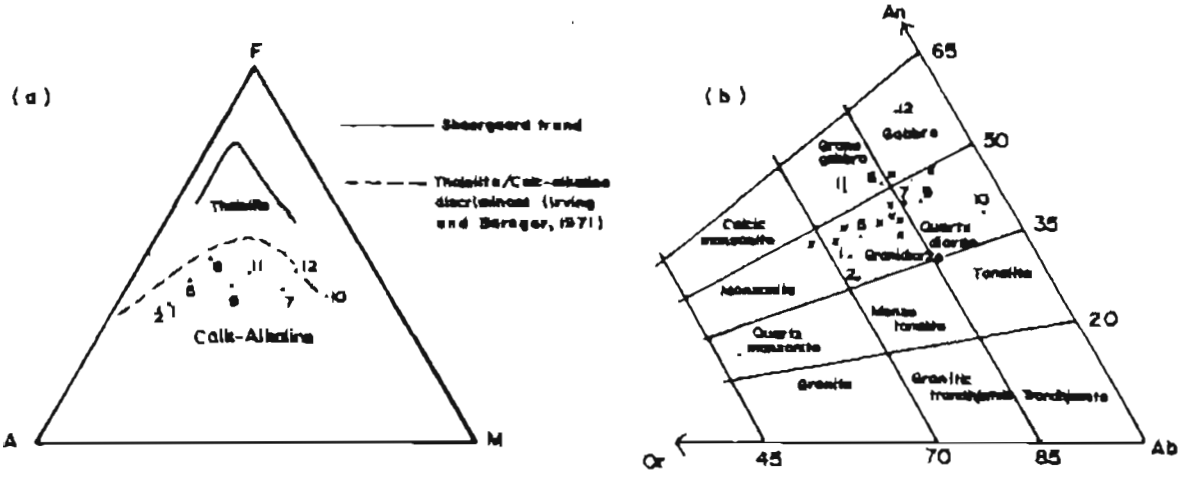


Figure 1. (a) AFM plot showing calc-alkaline nature of granitoid rocks (table 3). (b) Normative Or-Ab-An plot of plutonic rocks (table 3) showing similarities to Tertiary and Cretaceous rocks (x) from adjacent Healy A-1 Quadrangle (Smith, 1981). Rock classification fields from Hietanen (1963).

Table 1. *Megafossil data.*

Locality	Geologic unit	Assemblage	Age of assemblage	Reference	Comments
F1	Jsc	*Buchia rugosa* *Oxytoma* sp. *Pleuromya*(?) sp. Pectinid clam *Ditripa*(?) sp. (worm tube)	Late Jurassic (Kimmeridgian)	D.L. Jones (written commun., 1973); cited in Csejtey and others, 1978.	Fossils and lithology remarkably similar to rocks of the Gravina-Nutzotin terrane of eastern Alaska Range (Berg and others, 1972).

Table 2. *Potassium-argon age dates of intrusive and metamorphic rocks, Healy A-2 Quadrangle, Alaska from Turner and Smith (1974).*

Map no.	Unit	Mineral dated	Age ± 1δ (m.y.)
1a	TKbgd	Hornblende	64.3 ± 1.9
1b	TKbgd	Hornblende	63.5 ± 1.9
2	TKbqm	Hornblende	55.9 ± 1.7
3	Kp	Biotite	53.0 ± 1.6

Table 3. *Major-element chemistry*[1] *and normative mineralogy of selected igneous and metamorphic rocks.*

Map no.	1	2	3	4	5	6	7	8	9	10	11	12
Unit	TKbgd	TKbqm	Kp	Kgn	TKbgd	TKbgd	TKod	Kda	TKgd	TRas	TRab	Mzi
SiO_2	61.4	63.8	55.7	64.9	59.3	55.6	52.4	63.2	55.3	50.3	53.9	52.2
Al_2O_3	17.5	16.4	13.4	15.5	17.0	18.4	14.6	15.6	18.0	10.3	16.5	15.4
Fe_2O_3	2.8	2.3	0.8	0.9	2.3	2.8	1.7	1.5	0.8	1.0	1.4	1.5
FeO	2.2	2.4	5.8	3.4	4.0	4.7	6.3	4.5	5.5	7.6	6.6	7.0
MgO	1.6	1.5	3.5	2.9	2.1	2.3	7.2	3.1	3.3	10.7	4.7	6.3
CaO	5.6	4.6	9.4	0.9	6.5	8.0	6.9	3.4	6.9	12.3	7.6	10.9
Na_2O	3.6	3.7	1.9	1.3	3.4	3.4	3.1	3.2	3.9	2.3	2.7	2.4
K_2O	3.4	3.3	1.5	1.9	2.3	1.9	1.5	1.1	1.5	0.32	2.4	0.8
H_2O+	0.61	0.78	1.4	1.7	0.95	0.83	2.5	3.0	1.1	1.5	1.5	2.3
H_2O-	0.03	0.10	0.15	0.19	0.05	0.01	0.35	0.07	0.05	0.05	0.10	0.06
TiO_2	0.62	0.63	0.93	0.79	0.77	0.92	1.30	0.73	1.2	1.2	0.93	0.92
P_2O_5	0.30	0.24	0.16	0.27	0.35	0.44	0.33	0.15	0.35	0.12	0.35	0.09
MnO	0.11	0.10	0.10	0.39	0.14	0.15	0.13	0.09	0.09	0.15	0.13	0.14
CO_2	0.06	0.02	4.1	0.02	0.02	0.06	0.62	0.10	0.03	0.33	0.03	0.04
TOTAL	99.8	99.9	98.9	99.1	99.7	99.5	98.9	99.7	98.7	99.2	99.1	100.1
					CIPW Norms							
quartz	14.5	18.3	15.9	37.6	12.4	8.6	2.7	27.1	5.1	--	4.2	2.6
orthoclase	20.3	19.7	9.5	11.6	16.7	11.4	9.3	3.4	9.1	1.9	14.5	4.8
albite	30.7	31.6	17.2	15.7	29.1	29.2	27.5	6.7	23.8	24.5	23.4	20.7
anorthite	21.7	18.5	25.3	2.8	23.1	29.7	22.5	28.0	27.9	15.0	26.5	29.4
diopside	3.4	2.3	19.5	--	5.9	6.3	8.9	16.5	3.9	38.0	8.9	20.4
hypersthene	3.3	4.3	9.0	19.1	6.9	7.9	23.1	14.2	15.8	4.2	17.5	17.9
magnetite	4.1	3.4	1.2	1.3	3.4	4.1	2.6	2.3	1.2	1.5	2.1	2.2
ilmenite	1.2	1.2	1.9	1.5	1.5	1.8	2.6	1.4	2.3	2.4	1.8	1.8
apatite	0.7	0.6	0.4	0.6	0.8	1.0	0.8	0.4	0.9	0.3	0.8	0.2
olivine	--	--	--	--	--	--	--	--	--	12.2	--	--
corundum	--	--	--	9.7	--	--	--	--	--	--	--	--

[1]Analyses by U.S. Geological Survey using methods described by Shapiro and Brannock (1962).

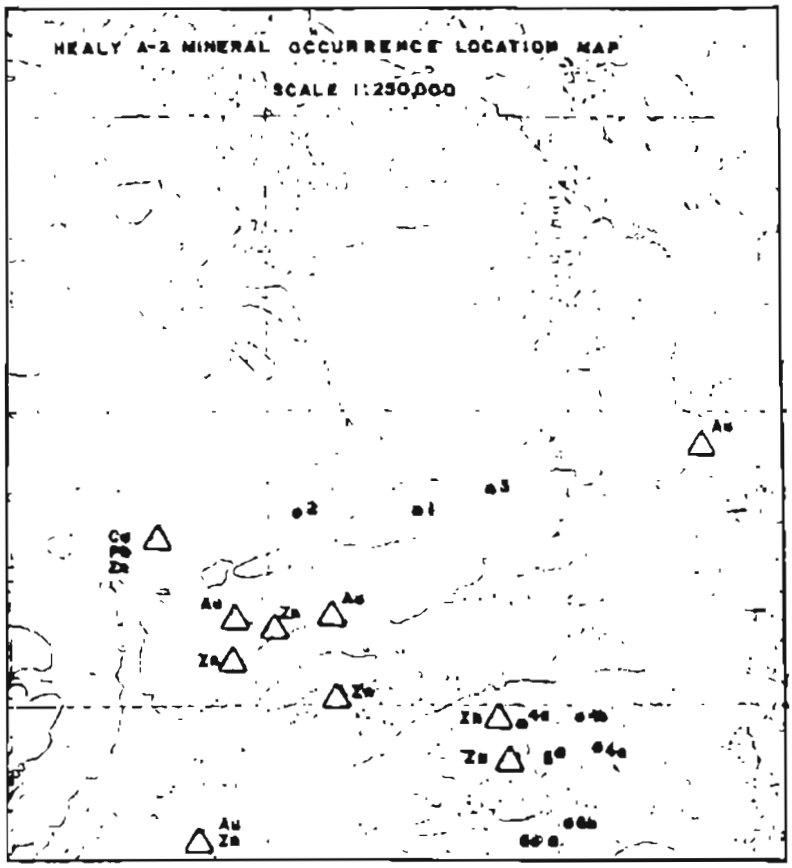


Table 4. *Mineral occurrences.*

Locality	Summary	References
1	Gold Hill: Mineralized quartz monzonite stock and adjacent hornfelsed siltstone. Selected rock samples contain visible pyrite, chalcopyrite, and molybdenite(?) and are anomalous in copper and gold.	Smith and others, 1975. D.L. Stevens, oral commun., 1983.
2	Gold Creek: Small amount of placer gold discovered in 1903; no record of mining.	Cobb, 1978, p. 35.
3	Wickersham Creek: A little placer gold found in 1903; not successfully mined.	Cobb, 1978, p. 87.
4a,b,c,	Butte Creek: Copper minerals, mainly chalcopyrite, with minor malachite, azurite, and bornite in volcanic rocks south of creek. One copper occurrence is in fault zone in limestone and argillite. Magnetite in talus probably derived from amphibolite and limestone. Placer gold in amounts too small for profitable mining reported from unknown location along Butte Creek.	Cobb, 1978, p. 13.
5	Unnamed: Northeast-striking zone with abundant magnetite and associated rusty-colored iron staining at 4,300-ft elevation in talus along faulted contact zone between interbedded argillite/limestone and amphibolites that contain basic dikes. Another vertical rust-colored zone of carbonate veining with secondary copper that trends N. 20° E. cuts the amphibolite (assayed at 0.1% Cu).	Kaufman, 1964, p. 10,12.
6a,b	Unnamed: Talus contains minor malachite and azurite associated with quartz and epidote within volcanic rocks.	Kaufman, 1964, p. 10.
Zn	Indicates location of anomalous stream-sediment sample (element indicated).	Smith and others, 1975.