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MINERAL RESOURCE POTENTIAL OF THE ARNOLD MESA ROADLESS AREA, YAVAPAI COUNTY, ARIZONA

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Arnold Mesa Roadless Area (U.S. Forest Service number 03092), Prescott and Tonto National Forests, Yavapai County, Ariz. The Arnold Mesa Roadless Area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

Proterozoic volcanic rocks of Gap Creek underlie the southern part of the Arnold Mesa Roadless Area. They strongly resemble the host rocks for the large massive sulfide deposit at Jerome, Ariz., and may thus have the potential for the occurrence of similar ores of copper, silver, and gold. Although the unit is largely covered by younger rocks with an aggregate thickness of up to 2,500 ft, the similarity of rock types between this area and Jerome gives the area containing volcanic rocks of Gap Creek a moderate potential for the occurrence of copper, silver, and gold resources in massive sulfide deposits.

The northern half of the roadless area is underlain by a Proterozoic tonalite pluton that is exposed in erosional windows in younger, overlying rocks. The tonalite is the host for a local porphyry copper deposit at Squaw Creek, gold-quartz veins at the Chicken Wire gold mine, and altered shear zones at the Rustler claims; all are outside of the roadless area. Evidence for similar deposits or for ore deposits of any type was not observed in exposures of the tonalite within the roadless area. The tonalite is, however, a known host for small ore deposits in the vicinity of the roadless area, and unexposed areas of the pluton may contain porphyry or vein deposits similar to those at nearby mining areas. The potential of the Squaw Peak mine is very high for resources of copper and molybdenum in a porphyry-type setting.

Evidence gathered by Ross and Farrar (1980) suggests that a geothermal anomaly exists near the eastern margin of the roadless area. However, waters of suitable temperature for geothermal energy production have not been discovered. Therefore, the potential of this area for geothermal energy resources seems low.

INTRODUCTION

During 1980 the U.S. Geological Survey and the U.S. Bureau of Mines (USBM) conducted field investigations to evaluate the mineral resource potential of the Arnold Mesa Roadless Area, Yavapai County, Ariz. (fig. 1). Field studies included geologic mapping (Wolfe, 1983a), aeromagnetic mapping (Davis and Wolfe, 1983), geochemical sampling (Wolfe, 1983b), and a survey of known mines and prospects (McColly and Korzeb, 1981).

Location, size, and geographic setting

The Arnold Mesa Roadless Area comprises about 28,000 acres in and along the flanks of the Black Hills south of Camp Verde, in central Arizona (fig. 1). The Black Hills form a northwest-trending divide between the Agua Fria drainage on the west and the Verde River on the east. The crest and southwest flank of the divide within the study area are moderately dissected gently rolling uplands. The northeast flank is steep terrain that forms the western wall of the Verde

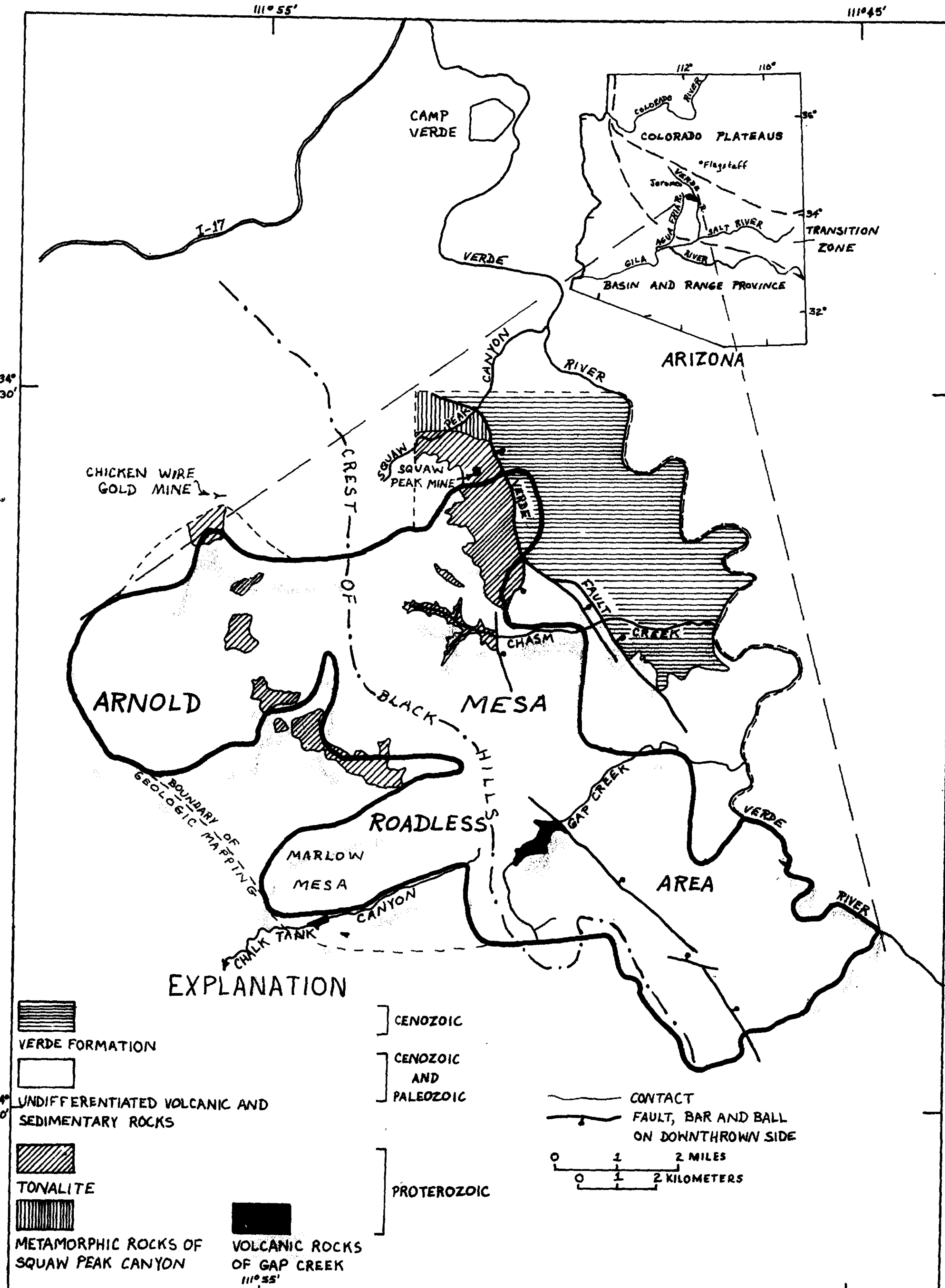

Figure 1.--Map showing location of Arnold Mesa Roadless Area (U.S. Forest Service area 03092) and geologic and geographic features.

Valley. The northeast flank has a total relief within the study area of almost 4,000 ft and is deeply incised by the canyons of Gap and Chasm Creeks. Unpaved roads provide access to much of the perimeter of the Arnold Mesa Roadless Area, but the interior is accessible only by foot, horse, or helicopter.

Geologic setting

The Arnold Mesa Roadless Area is within the transition zone between the Colorado Plateaus to the northeast and the Basin and Range province to the southwest (fig. 1). The transition zone is a belt about 70 mi wide that extends diagonally from northwest to southeast across central Arizona and parallels the topographic margin of the plateaus. The zone is underlain by Precambrian rocks and gently dipping Paleozoic strata that are similar to Precambrian and Paleozoic rocks in the southern part of the Colorado Plateaus in the Grand Canyon.

Proterozoic rocks in the northern part of the study area, in the vicinity of Squaw Peak Canyon, include foliated mafic and, locally, intermediate metavolcanic rocks of greenschist facies that are intruded by a Proterozoic pluton composed mainly of tonalite. The tonalite is widely exposed in the northern and central parts of the area. In the southern part of the study area, Proterozoic rocks exposed along Gap Creek, in Chalk Tank Canyon, and locally along the Verde River are predominantly relatively unmetamorphosed dacite and rhyolite and subordinate mafic volcanic or volcaniclastic rocks.

Gently dipping Paleozoic dolomite and limestone and subordinate sandstone and siltstone rest unconformably on the Proterozoic rocks. These strata, Cambrian to Pennsylvanian or Permian in age, have an aggregate maximum thickness of 730-910 ft. However, they pinch out locally between the Proterozoic tonalite and the late Tertiary Hickey Formation in the western part of the map area and in the headwaters of Chasm Creek.

The transition zone in central Arizona between the Colorado Plateaus and Basin and Range province was the locus of voluminous eruptions of basaltic lava and pyroclastic deposits that now rest on the eroded surface of the Paleozoic and Precambrian rocks. In the Black Hills, the basalts, included in the Hickey Formation, are late Miocene in age (McKee and Anderson, 1971); later volcanism continued to the north, culminating in numerous Quaternary eruptions on the southern Colorado Plateaus in the vicinity of Flagstaff.

A northwest-trending line of erosional windows exposes tonalite and Paleozoic strata beneath the Hickey Formation basalt in the northwestern part of the study area (fig. 1). Tonalite-basalt contacts that dip steeply to the southwest define a pre-Hickey slope that was overrun by southwestward-flowing lavas.

Silicic eruptions occurred at local volcanic centers. A prominent center, of late Miocene age, was immediately east of the Verde River at the approximate latitude of Gap Creek. Dacite breccias and ash-flow tuffs from this center are interbedded with basalts like those of the Hickey Formation. A smaller, somewhat younger center erupted dacite lava included within the Verde Formation at the north end of the map area near Squaw Peak Canyon.

Numerous high-angle faults, dominantly of northwest trend, are present from the general vicinity of the Black Hills north to the southern edge of the Colorado Plateaus. Much of the faulting is late Miocene to early Pleistocene in age; hence faulting and volcanism in this part of the transition zone were partly contemporaneous.

Northwest-trending linear basins of late Cenozoic age characterize the transition zone and suggest that extension and basin subsidence occurred here as well as in the Basin and Range province. The map area includes the southernmost part of one of these basins, the 30-mi-long Verde basin, which contains more than 3,100 ft (Nations, 1974) of late Cenozoic basin fill deposits of the Verde Formation.

The Verde basin and its sedimentary fill are bounded on the southwest by the Verde fault, which, in the northern part of the map area, is a conspicuous, single, steep, normal fault. Near Chasm Creek, however, the single fault splays southward into several high-angle faults that can be traced only a short distance southeast of Chasm Creek. Another fault system, similar to the Verde fault in trend and sense of movement but offset en echelon from it, extends from the upper part of Gap Creek to the southern boundary of the roadless area.

Mining activity

Prospecting and claim-staking, the principal mining activities, have occurred intermittently from about the mid-1800's to the present. No mineral production is known from within the roadless area and, at the time of field examination, there was no mining or exploration work within the roadless area boundary.

GEOLOGY, GEOPHYSICS, GEOCHEMISTRY, AND GEOTHERMAL CONSIDERATIONS PERTAINING TO MINERAL RESOURCES ASSESSMENT

Geology

The Proterozoic volcanic rocks of Gap Creek are lithologically similar to and probably correlative with rocks of the Ash Creek Group which host the large massive sulfide deposits at Jerome (Anderson and Creasey, 1958), about 30 mi to the northwest. Direct evidence of significant amounts of sulfides in the volcanic rocks of Gap Creek was not found during geologic mapping, although exposures of the rocks were limited. However, the volcanic units have intermediate to silicic compositions, and banded iron-formations are intercalated with the volcanic rocks; both lithologies are characteristic of other Proterozoic massive sulfide deposits in Arizona (Donnelly and Hahn, 1981). This suggests that the volcanic rocks of Gap Creek were deposited in an environment similar to that which produced massive sulfide deposits in the region.

The contact between the volcanic rocks of Gap Creek and the tonalite pluton is buried by younger rocks and was not seen. It must trend northeast or east from the vicinity of Marlow Mesa in the southwestern part of the roadless area. Regardless of the intrusive or fault origin of the contact, the zone may be the locus of fractures that could have provided pathways for mineralizing fluids. Although the cover of younger rocks is 1,000 ft or more over much of the contact zone, it is relatively thin, locally less than 100 ft, in the vicinity of Marlow Mesa.

The Proterozoic tonalite pluton underlies the Phanerozoic rocks in the northern half of the roadless area and is exposed in several large erosional windows in the overlying units. Sulfides or weathered products of sulfides were not seen in the tonalite. Quartz veins, fractures, and sheared zones cut the pluton, and sericite, epidote, and chlorite alteration locally envelopes these veins and fractured zones. However, quartz veins and alteration zones do not extend into the Paleozoic rocks, nor are they known elsewhere in the Paleozoic or Cenozoic rocks. They may represent Precambrian fractures or shear zones that subsequently provided access for hydrothermal fluids.

The tonalite pluton is the host for copper and molybdenum sulfides and related alteration in the Squaw Peak mine area just north of the roadless area boundary. A detailed study by Roe (1976) led to the conclusion that the deposit was part of a porphyry copper-molybdenum system related to a quartz monzonite stock of Laramide age. Concentric alteration, trace element, and ore-mineral patterns focus on what Roe (1976) mapped on the surface as a quartz monzonite porphyry. Wolfe (1983a) did not recognize such a pluton where Roe had mapped it and concluded that exposures in that area were of altered tonalite. However, examinations by Roe of more than 24,000 ft of drill core and drill cuttings revealed that a porphyritic pluton is present in the subsurface and that it dips southwest. Alteration zones grade outward from a central potassic core through successive haloes of phyllic and propylitic alteration; the areal extent of the latter zone is 2,400 ft wide and 4,600 ft long (Roe, 1976). The major mineralized zone contains 0.3 percent copper and more than 0.01 percent molybdenum, and it forms a north-trending zone, coincident with the potassic alteration, that is approximately 800 ft wide and 1,200 ft long on the surface. The mineralized zone is bowl-shaped, concave upward, and extends to a maximum depth of about 800 ft (Roe, 1976).

Additional mineralized areas containing copper, and some gold and silver, occur where quartz fills breccia zones in the tonalite at the Chicken Wire gold mine just north of the far western part of the roadless area. Sulfides and secondary copper minerals indicative of mineral deposits similar to those of the Chicken Wire gold mine or of the Squaw Peak mine were not seen in tonalite in the roadless area even where quartz veins, fractures, or sheared zones with sericitization, epidotization, or chloritization were found.

The rocks that bury most of the Proterozoic rocks in the Black Hills within the study area are Paleozoic sedimentary rocks and Cenozoic volcanic rocks that have an aggregate thickness as much as 1,000 ft but locally are as thick as 2,500 ft. Evidence of mineral deposits was not recognized in these rocks nor in the Verde Formation east of the Verde fault within the roadless area (fig. 1).

Geophysics

Magnetic anomalies in the Arnold Mesa area are closely related to the distribution and magnetic properties of basaltic lava flows (Davis and Wolfe, 1983). Alteration of tonalite in the area of the Squaw Peak mine to the north may contribute to a local magnetic low. However, the low is part of a reentrant that continues south to southeast beyond the area of alteration and mineralization and is instead interpreted to be a manifestation of the Verde fault. The aeromagnetic map does not show any other features that indicate rocks containing metallic mineral deposits.

Geochemistry

A total of 128 samples was collected during the course of geologic mapping. Most are grab samples selected to represent the mapped geologic units as well as outcrops where mineralization was suspected. Twenty-seven are samples of unconsolidated sediment. Because geologic field evidence shows that mineralization is confined to the Precambrian rocks, the sediment samples were located so as to sample drainages in which Precambrian rocks are exposed.

All sediment samples were sieved, and the minus 80-mesh fraction was analyzed for 30 elements by semiquantitative spectrographic analysis and for uranium and thorium by neutron activation analysis. Results are given with the geochemical map (Wolfe, 1983b).

Table 1 shows geochemical values that are considered anomalous (see Wolfe, 1983b). Anomalous values are those that significantly exceed values for the same elements in relatively unaltered samples of the same rock unit or, in the case of sediment samples, values significantly greater than those of unaltered source rocks exposed upstream in the same drainage net. Local mineralized zones and attendant chemical anomalies in the tonalite are associated with quartz veins that cut the tonalite and the metamorphic rocks of Squaw Peak Canyon. Some of the quartz veins, which are most abundant north of the roadless area, also contain chemical anomalies. Enriched elements include manganese, silver, arsenic, boron, copper, molybdenum, lead, and zinc, but not all are concentrated in anomalous amounts in any single sample.

The greatest anomalies are outside of the roadless area in a mineralized quartz vein (sample 101, fig. 2) that cuts the metamorphic rocks of Squaw Peak Canyon near the intrusive contact with the tonalite and in brecciated and mineralized tonalite adjacent to a quartz vein at the Chicken Wire gold mine (samples 103B-F). Samples collected in this study showed lower levels of enrichment in the area of the Squaw Peak mine (samples 97A, 97B, 106), which is also outside of the roadless area. However, Roe (1976), in a survey of soil geochemistry in the vicinity of Squaw Peak mine, reported maximum concentrations of approximately 0.8 percent for copper, 140 ppm for molybdenum and 700 ppm for zinc. Roe noted that the primary metallic minerals are chalcopyrite and molybdenite, which are associated with quartz veins and, in the host tonalite, are disseminated grains or masses related to mineralized fractures and veins. Secondary products derived from weathering of sulfides include malachite, chrysocolla, and azurite (Roe, 1976).

Low levels of enrichment in silver, lead, boron, and zinc were found in a quarry in the Rustler mine area (samples 26A-D). The tonalite at the quarry is sheared and altered, but no quartz veins were seen.

Table 1.--Anomalous geochemical values (ppm) in the Arnold Mesa area

[Leaders (---) indicate concentrations below anomalous values; sample localities identified in figure 2. From Wolfe (1983)]

Element	Mn	Ag	As	B	Cu	Mo	Pb	Sb	Zn	
Limit of detection	10	0.5	200	10	5	5	10	100	200	
Threshold of anomalous values	2,000	1	200	100	200	100	200	100	200	
Sample No.	**Mn**	**Ag**	**As**	**B**	**Cu**	**Mo**	**Pb**	**Sb**	**Zn**	**Notes**
Quarry approximately 0.7 mi (1.1 km) north of Chasm Creek near east boundary of roadless area										
26A	---	2	---	---	---	---	---	---	---	Oxidized tonalite.
26B	---	3	---	---	---	---	---	---	---	Sheared tonalite.
26C	---	2	---	100	---	---	300	---	200	Do.
26D	---	1	---	100	---	---	---	---	300	Do.
Prospect in NE1/4SW1/4 sec. 3, T. 12 N., R. 4 E.										
64B	---	---	---	200	---	---	---	---	---	Altered tonalite adjacent to quartz vein.
64C	---	---	---	---	300	---	---	---	---	One in.-wide epidote-quartz vein.
Dump at Mine Spring (Squaw Peak mine)										
97A	---	3	---	---	3,000	100	---	---	---	Altered, mineralized tonalite.
97B	---	5	---	---	5,000	150	---	---	---	Mineralized tonalite.
Granitic dike intruding metamorphic rocks of Squaw Peak Canyon										
100	---	5	---	---	---	---	---	---	---	
Prospect: mineralized quartz vein intruding metamorphic rocks of Squaw Peak Canyon										
101	---	10	---	---	>20,000	>2,000	1,000	---	500	
Chicken Wire gold mine, NW1/4SE1/4 sec. 33, T. 13 N., R. 4 E.										
103B	>5,000	7	---	200	20,000	---	---	100	700	Altered, mineralized tonalite.
103C	---	7	300	100	7,000	---	1,500	---	1,000	Brecciated and mineralized tonalite.
103D	---	1	---	---	1,000	---	---	---	---	Quartz vein.
103E	5,000	3	200	200	1,000	---	300	---	1,000	Altered tonalite.
103F	---	1.5	300	300	1,000	---	---	---	---	Altered, mineralized tonalite.
Dump at abandoned shaft, NW1/4SE1/4 sec. 33, T. 13 N., R. 4 E.										
104A	---	2	---	---	---	---	---	---	---	Quartz vein fragment.
104B	---	2	200	100	200	---	---	---	---	Altered tonalite fragment.
Dump at Squaw Peak mine										
106	---	5	---	---	500	---	---	---	---	Altered mineralized tonalite.
Sediment samples from washes draining tonalite										
57A	---	---	---	---	---	---	---	---	200	Panned in field.
71	---	3	---	---	---	---	200	---	500	
72	---	1.5	---	---	---	---	---	---	---	
76	---	---	---	---	---	---	---	---	200	

Fractures, faults, or shears apparently provided conduits for fluids that produced minor alteration and mineralization of the tonalite. Low levels of enrichment in silver, lead, and zinc were also found in sediment samples (samples 71, 72, 76) from gullies that drain the tonalite where it is within the roadless area between the quarry and Squaw Peak mine. This suggests that low-level mineralization is present locally in the tonalite within the roadless area.

Additional sample values from the U.S. Bureau of Mines study of the Chicken Wire gold, Squaw Peak, and Rustler mines are included in the section of this report entitled "Mining districts and mineralized areas."

Geothermal energy

Silica geothermometry of spring waters shows a zone immediately east of the Arnold Mesa Roadless Area and partly overlapping its southeast corner in which reservoir temperatures slightly above 100°C are indicated (Ross and Farrar, 1980). Slightly lower silica geotemperatures (82°C-96°C) were determined for springs distributed near the northeast boundary of the roadless area. Water temperature of Verde Hot Springs, located along the Verde River approximately 2.5 mi southeast of the southeast corner of the roadless area, is 39°C. Elsewhere in and near the study area spring and well temperatures measured by Ross and Farrar are from 8°C to 25°C.

The sampled springs and wells all lie within and east of the Verde fault zone and its projection to the southeast. Their modestly elevated geochemical reservoir temperatures may be a manifestation of deep circulation in the Verde fault zone or along related faults. Measured temperatures are insufficient for the spring waters to comprise a geothermal resource of themselves. However, because of dilution the measured water temperatures and calculated reservoir temperatures are probably minimum source temperatures.

No calculated reservoir temperatures are available west of the Verde fault zone or within the boundaries of the roadless area, and there are no warm springs.

MINING DISTRICTS AND MINERALIZED AREAS

Although most of the Arnold Mesa Roadless Area falls within the Squaw Peak mining district, the known mineral occurrences of the district lie outside of the roadless area boundary. Three mineralized areas, at the Squaw Peak, Rustler, and Chicken Wire gold mines, account for most of the local mining activity and for nearly all of the 98 claims identified from Yavapai County records. On the basis of descriptions, the remaining claims are randomly distributed inside the area, but vagueness and the general lack of development work or adequate monumentation prevented their identification on the ground.

Two adits in the Rustler claim area were the only prospects found inside the roadless area. No mineral production is known from either site. Some mineral production is known from the Squaw Peak and Chicken Wire gold mines, which are outside but near the roadless area boundary. Fringe claims from these properties extend into the roadless area, but mineral deposits have not been discovered or developed within them.

Squaw Peak mine

Roughly one-fourth of the Squaw Peak claims, centered in secs. 29 and 30, T. 13 N., R. 5 E., extend into the roadless area, but none of the mine workings or known mineral deposits do (Roe, 1976).

Because safe entry into the Squaw Peak mine was not possible at the time of examination, literature sources, primarily Hill (1949) and Roe (1976), are the basis for the mine description and production history.

By 1916, the property was active, though no production was recorded until 1944-46 (Hill, 1949, p. 2). In 1946, there were more than 4,000 ft (1,200 m) of underground workings, and the total production from treating 1,000 tons of ore was 5.40 dry tons of 98.82 percent molybdenite (MoS_2) and 36.034 tons of copper concentrate averaging 22.85 percent copper, 1.92 oz/ton of silver, and 0.016 oz/ton of gold (Hill, 1949).

Exploration work conducted by Phillips Petroleum Co. and Essex International, Inc., during the early 1970's resulted in estimated reserves at Squaw Peak of 20 million tons averaging 0.36 percent copper with substantial molybdenum (Roe, 1976).

Roe (1976) does not give an average grade for molybdenum, but on the basis of the reported production (Hill, 1949), it must have been 0.5-0.6 percent MoS_2 in the ore zone. The reserve estimate was based on more than 16,000 ft of diamond drilling, detailed geologic mapping, geochemical studies, and 43,000 line-ft of induced polarization work. Roe (1976) further states that the chief minerals are chalcopyrite and molybdenite representing a Laramide porphyry copper deposit that is mainly in a moderately to highly fractured, north-trending, subelliptical, 1,200- by 800-ft mineralized and altered zone within the Proterozoic tonalite.

During the USBM study, 13 samples were taken from dumps, mineralized outcrops, and underground workings on the Squaw Peak claims. Five samples from the accessible parts of two adits, and eight samples from numerous cuts and pits were taken; approximately 300 ft of mine workings were mapped. Copper values ranging from 0.15 to 1.19 percent and molybdenite values ranging from 0.01 to 1.47 percent confirmed the presence of significant copper and molybdenum (sites A, B, C, G, table 2).

Rustler claim area

The Rustler claim area contains three patented lode-mining claims and many adjoining unpatented claims, extending end-to-end along the roadless area boundary in an unsurveyed area north of Chasm Creek. Approximately 20 of these claims lie within the roadless area. Mine workings consist of a pit, or quarry, on the patented Rustler claim, roughly 100 ft wide, 200 ft long, and 50 ft deep, and two adits about 600 ft apart, which lie 1,000 ft southwest of the patented claims. No evidence of mineralized deposits was observed in the sheared tonalite exposed in the pit, but traces of boron, lead, and zinc were found (samples 26B-D, table 1). Material from the pit was used for flood-control construction on the Verde River.

One adit is caved about 10 ft from the portal, and the other extends about 80 ft into the hillside. Two samples were taken at each site. The highest values found were 0.04 percent copper, 0.3 percent lead, 0.008 percent molybdenite, 0.003 percent silver,

Table 2.--Mines and prospects sampled and analyzed by USBM (McColly and Korzeb, 1981) in and near Arnold Mesa Roadless Area, Yavapai County, Arizona

[Areas identified in figure 2]

Site	Name	Location	Commodity	Geologic unit	Workings	Remarks
A	Hillside claim.	NW1/4 sec. 30, T. 13 N., R. 5 E.	Copper-------	Metamorphic rocks of Squaw Peak Canyon.	115-ft adit.	No reported production; samples show 0.03-0.09% copper and 0.01% molybdenite.
B	Annex #4 claim.	NE1/4 sec. 30, T. 13 N., R. 5 E.	Copper, molybdenum.	---do------	170-ft adit.	No reported production; samples show 0.2-0.6 oz silver per ton, 0.14-1.12% copper and 0.01-0.09% molybdenite.
C	Gulch claim.	SW1/4 sec. 29, T. 13 N., R. 5 E.	---do--------	Tonalite---	Flooded adit.	No reported production; dump samples show 0.11-0.25% copper and 0.08% molybdenite.
D	Apache Maid #1.	Unsurveyed area north of Chasm Creek.	Copper-------	---do------	Caved adit.	No reported production; dump samples show traces of copper.
E	Apache Maid #2.	---do---------	---do--------	---do------	80-ft adit.	No reported production; samples show 0.01-0.04% of copper and 0.04-0.3% lead.
F	Chicken Wire gold mine.	SE1/4 sec. 33, T. 13 N., R. 4 E.	Gold, silver.	Tonalite with quartz veins.	440-ft adit.	Minor production reported by owner; samples show 0.057-1.31 oz gold per ton, and 0.2-1.4 oz silver per ton.
G	Squaw Peak mine.	SE1/4 sec. 30, T. 13 N., R. 5 E.	Copper, molybdenum.	Tonalite---	Open shaft and caved adit.	Production from 1944-46 was 5.40 tons of molybdenite concentrate and 36.034 tons of copper concentrate (Hill, 1949). Samples from accessible workings and from nearby dumps and outcrops show 0.15-1.19% copper, 0.01-1.47% molybdenite and 0.2-0.8 oz silver per ton. Estimated reserves--20 million tons averaging 0.36% copper with substantial molybdenum (Roe, 1976).

and 0.5 percent zinc (sites D and E, table 2). No gold was found in the four samples.

Chicken Wire gold mine

Two lode mining claims, one patented and one unpatented, constitute the property of the Chicken Wire gold mine in sec. 33, T. 13 N., R. 4 E., located a half mile north of the roadless area. Two other unpatented lode claims have been identified adjacent to the patented claim, but these are inactive.

Narrow, generally flat-lying quartz veins and stringers in Precambrian tonalite have been exposed and mined by means of several small, underground workings. Approximately 500 ft of workings were accessible at the time of the USBM evaluation; additional workings were either caved or back-filled.

Gold and silver values in three samples taken from the most prominent quartz vein ranged from 0.06 to 1.31 oz of gold per ton and 0.2 to 1.4 oz of silver per ton (site F, table 2). Antimony, arsenic, bismuth, lead, and zinc were detected in the samples but were only slightly anomalous. Copper-oxide minerals were visible in portions of the workings, but were considered too sparse to justify sampling.

Production from the property is not recorded, but was probably small. The current owners stated that high-grade native gold worth a few hundred to a few thousand dollars was produced from pockets in the mine (W. F. Colcord, oral commun., 1980). The current, part-time mining at the property is essentially exploration work.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The Proterozoic volcanic rocks of Gap Creek, which are exposed only locally within the roadless area, are inferred to underlie all of the southern part of the area (fig. 2). The limited exposures of the rock units reveal dominantly porphyritic dacite and rhyolite with minor amounts of tuff, welded tuff, basaltic or andesitic volcanic or metavolcanic rocks, and a small amount of banded jasperoid rock (iron-formation). These lithologies are strikingly similar to those that host large massive sulfide deposits at Jerome (Anderson and Creasey, 1958) and suggest a similar environment of deposition. Although evidence of a significant occurrence of metals in the volcanic rocks was not found, the similarity between the rocks in the roadless area and those at Jerome suggests that massive sulfide deposits containing copper, silver, and gold could occur within the roadless area. Jerome-type massive sulfide deposits do not have extensive surface expressions of ore or alteration (Anderson and Creasey, 1958), so the absence of sulfides or alteration in the limited exposures certainly does not preclude the presence of mineralized areas beneath the cover of younger rocks. However, the thick and nearly continuous cover of younger rocks is a severe impediment for exploration and mine development in the underlying rocks. Despite that problem, the potential of the area for copper, silver, and gold resources in massive sulfide deposits in the volcanic rocks of Gap Creek is considered to be moderate; the feasibility of exploration does not mitigate that potential.

The Proterozoic tonalite pluton underlies the northern half of the roadless area, although it is largely obscured by younger rocks. The pluton is the host for a local porphyry copper deposit at the Squaw Peak mine, gold-quartz veins at the Chicken Wire gold mine, and altered shear zones at the Rustler claim area. All three areas are outside the limits of the roadless area; the latter two are of very limited extent, and Roe's (1976) detailed maps and cross sections show that the Squaw Peak deposit is also of local extent and does not extend into the roadless area. Neither mineralized zones nor ore deposits were observed during geologic mapping in the exposed areas. Indeed, quartz veins, which are characteristic of the nearby deposits, are scarce in the exposed tonalite in the roadless area, although such veins can be of very local extent and therefore easily overlooked. Evaluation of the covered portions of the pluton is difficult. Similarly, Laramide porphyry copper deposits similar to that at the Squaw Peak mine may be concealed by the cover of younger rocks; using the latter deposit as a guide, the horizontal extent of such a deposit would be less than 1 mi^2. Therefore, the potential of exposed areas of the tonalite for mineral resources is low; that for the unexposed areas may be low to moderate because the pluton is a known host for small ore deposits (fig. 2). The identified resources at the Squaw Peak mine, which is just outside of the roadless area, indicate a high potential of the Squaw Peak mine for copper and molybdenum resources in a Laramide porphyry-type deposit (fig. 2).

The southern boundary of the tonalite is not exposed, but it must be within a zone that extends northeast or east through the roadless area from the vicinity of Marlow Mesa. If the contact zone is one along which the tonalite has been significantly sheared or fractured, it may represent a particularly favorable setting for hydrothermal deposits.

Rock suitable for crushing into aggregate occurs throughout the roadless area. However, deposits outside the area are more accessible and closer to markets. No other significant potential is known for the Paleozoic and Cenozoic rocks that cover most of the roadless area.

Ross and Farrar (1980) evaluated geochemical evidence that ground water near the eastern boundary of the roadless area had been in contact with reservoir rocks of elevated temperature. Their results suggest that a geothermal anomaly exists near the eastern margin of the roadless area (fig. 2). However, waters of temperature suitable for geothermal energy production have not been discovered, and the potential of the area for geothermal energy resources seems low. No potential is known within the area for other sources of energy.

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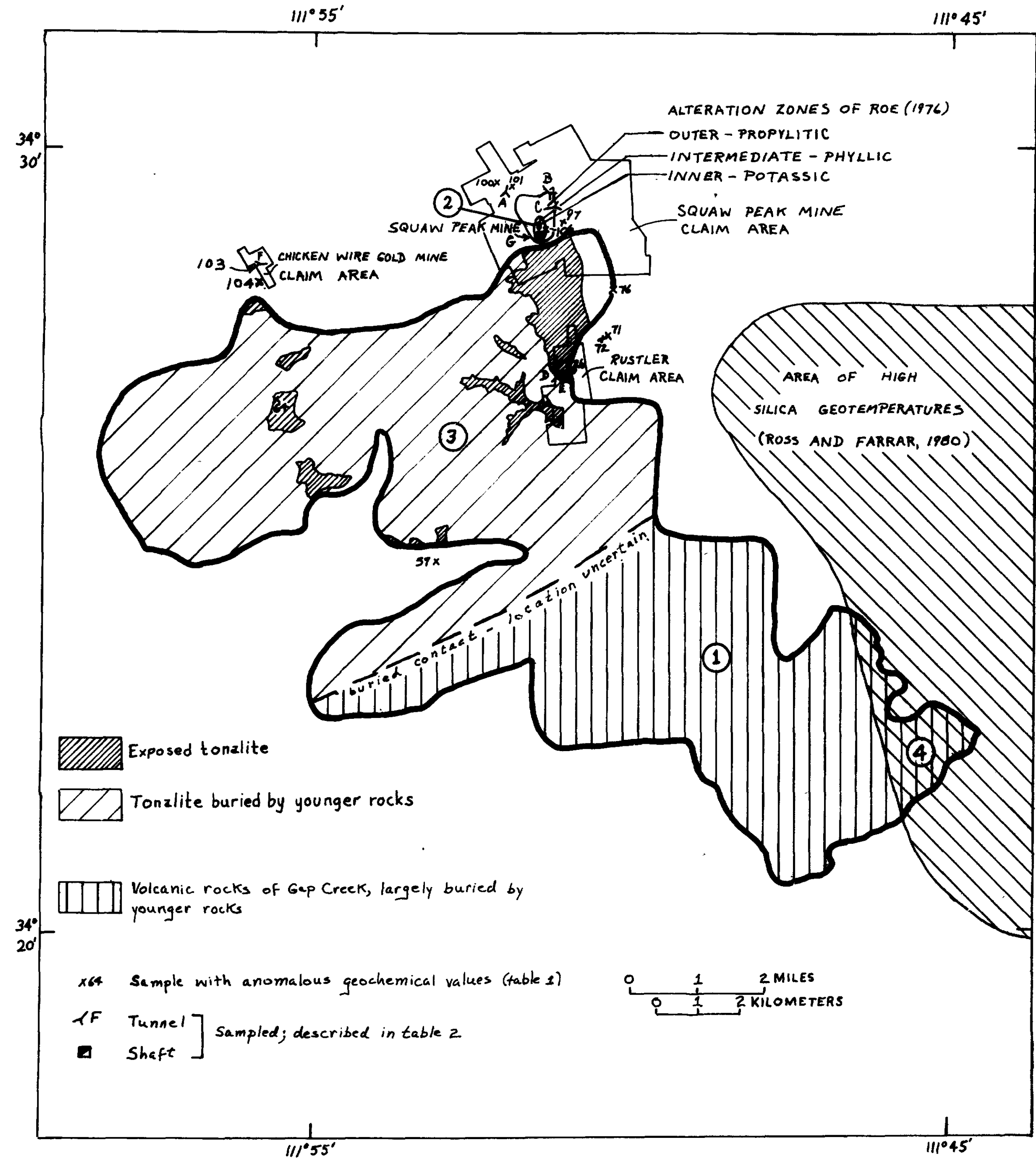

Figure 2.--Map of Arnold Mesa Roadless Area showing assessment of mineral resource potential and locations of mines and prospects sampled by U.S. Bureau of Mines (McColly and Korzeb, 1981), mining claims, anomalous geochemical samples, and geothermal anomaly indicated by chemistry of ground water. Shows areas of (1) moderate potential for copper, gold, and silver resources; (2) high potential for copper and molybdenum resources; (3) low potential for resources in porphyry copper-molybdenum or gold-quartz veins; and (4) low potential for geothermal resources.

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