MAP SHOWING MINERAL RESOURCE POTENTIAL OF THE PAIUTE INSTANT (PRIMITIVE) STUDY AREA, MOHAVE COUNTY, ARIZONA

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SUMMARY

A geologic and geochemical investigation and a survey of the existing mines and prospects have been conducted to determine the mineral resource potential of the Paiute Instant (Primitive) Study Area, Mohave County, Ariz. The study area encompasses part of the Virgin Mountains and the Sullivans Canyon area. Precambrian metamorphic and igneous rocks are exposed in the core and are overlain by folded and faulted Paleozoic and Mesozoic quartzose and carbonate rocks. Mesozoic sedimentary rocks are overlain by Cenozoic volcanic and sedimentary units. The geochemical and mines and prospects survey indicates that the study area contains some mineral deposits that presently are not economically significant. Oil and gas has not been discovered in the area, and the resource potential is apparently nil or at best very low; any future oil and gas exploration would most likely be conducted outside the study area where favorable exploration localities exist. Other combustibles such as coal and oil shale are not known to occur in the study area. There is no evidence of geothermal activity or surficial radioactive mineralization.

Several areas in the Paiute Instant Study Area are judged to have at best a low mineral potential. These include areas of copper, lead, manganese, molybdenum, nickel, silver, tungsten, and zinc mineralization, as well as occurrences of dumortierite, beryllium, arsenic, barium, gypsum, gem minerals, sand, gravel, and limestone. The metallic deposits and dumortierite, beryllium, and arsenic occur over small surface areas. Significant production has not resulted from mining activity in mineralized areas. Sand, gravel, limestone, gem minerals, gypsum, and barium occurrences are far from major markets. Currently, there are no active mining operations in the study area.

INTRODUCTION

During summer and winter of 1978, the U.S. Geological Survey and the U.S. Bureau of Mines conducted a mineral resource appraisal of the Paiute Instant (Primitive) Study Area. This report summarizes the findings and includes a mineral resource potential map of the study area.

Location, size, geographic setting, and access

The study area is located in the northwest corner of Mohave County, Ariz., a few miles south of U.S. Interstate 15 and the Virgin River (see location map insert on map). The Utah state boundary is about 6 mi (10 km) north of the study area, and Nevada is within 7 mi (11 km) to the west. The nearest population center is Mesquite, Nev., about 10 mi (19 km) to the west. St. George, Utah, is approximately 30 mi (48 km) northeast, and Las Vegas, Nev., is about 80 mi (129 km) to the southwest.

The study area, which is outlined on the mineral potential map, comprises about 55 mi^2 (142 km^2). Most of the area encompasses part of the rugged northeast-trending Virgin Mountains and extends to the east surrounding the steep and cliff-walled Sullivans Canyon area. A number of steep-walled canyons and gorges entrenched on the west side of the Virgin Mountains are also included in the study area. Mount Bangs, the highest point in the area, is 8,012 ft (2,420 m) above sea level; the lowest point, about 2,400 ft (732 m) above sea level, is between Hedricks and Figure 4 Canyons. Topographic relief ranges from about 3,400 ft (1,040 m) per one mile on the west side of the Virgin Mountains crest to about 2,400 ft (730 m) per half mile from Sullivans Canyon to the crest. Access to the periphery of the study area is provided by dirt roads and jeep trails that extend into several canyons including Elbow, Hancock, and Hedricks Canyons. Foot trails provide access into the interior of the area; one foot trail, starting at the head of Cottonwood Wash, traverses most of the Virgin Mountains crest. A helicopter was used to gain entry to the more remote parts of the study area.

Present and previous studies

Data that contributed to the evaluation of mineral resources were collected by the U.S. Geological Survey and the U.S. Bureau of Mines. The U.S. Geological Survey (USGS) was responsible for gathering geologic (see Villalobos, 1980a) and geochemical data (see Villalobos, 1980b). USGS fieldwork consisted of field checking geologic maps and aerial photographs, mapping, and collecting 195 sediment and rock samples for geochemical analyses. Samples collected by the USGS were analyzed for 31 elements by the six-step semiquantitative spectrographic method. All major ephemeral streams and many minor tributaries were traversed and sampled. When possible, dry stream-sediment samples for geochemical analyses were collected just upstream from confluences. Representative bedrock samples were collected from several major ridges. During all traverses, evidence of rock alteration or mineralization were searched for and samples from such areas were obtained. Geochemical data from sediment samples were evaluated statistically to determine anomalous and high values that are referred to in this report and resource map. Anomalous values are defined as equal to or above the threshold; high values are below the threshold but above one geometric deviation above the geometric mean (see Villalobos, 1980b). The U.S. Bureau of Mines (USBM) conducted fieldwork to assess the mining activity and associated mineralization of the study area. Forty-three samples taken from mines and prospects were analyzed by spectrographic, chemical, and fire assay analyses (see Hamm, 1980). USBM spectrographic analysis results are on file at the USBM Intermountain Field Operations Center, Denver, Colo.

This report also relies on a review of previous studies by other workers. A geologic map of the Virgin and Beaver Dam Mountains, Arizona, by Moore (1972) was field checked and modified for the geologic map of the Paiute Instant (Primitive) Study Area. Metallic mineral occurrences reported by the Arizona Bureau of Mines (Keith, 1969a, b) were field checked. Earlier stratigraphic studies (McKee, 1938, 1945, 1960, 1963; McNair, 1951; Stewart and others, 1972; and Wheeler, 1943) and field observations were used for description of rock units.

GEOLOGIC SETTING

Units in the study area range from Precambrian crystalline rocks to Quaternary basalt flows and alluvial deposits. Precambrian rocks are exposed in the core of the Virgin Mountains and are unconformably overlain by Paleozoic and Mesozoic sedimentary rocks.

The oldest rocks in the study area consist of Precambrian metamorphic and igneous rocks. The metamorphic rocks are composed of alternating bands of gneiss, schist, amphibolite, and localized occurrences of calc-silicate and marble. The igneous rocks consist of pegmatite, which occurs as masses of veins, dikes, and sills, and granite, which occurs as dikes and sills. The igneous rocks are commonly intruded parallel to gneissic bands. Most of the metamorphic rocks are exposed on the west flanks and crest of the Virgin Mountains; in these areas igneous rocks are sparse, but east of the crest, they are more abundant.

Paleozoic units consist of carbonate and quartzose clastic sedimentary rocks that were once deposited in an ancient shallow marine environment (McNair, 1951). The oldest Paleozoic rock unit is a sandstone and shale unit, which is overlain by a thick sequence of carbonate and quartzose detrital rock. Carbonate units include dolomite and limestone which are sometimes interbedded with sandstone and siltstone. The younger Paleozoic units consist primarily of limestone interbedded with sandstone and siltstone red beds and gypsum. The Paleozoic rocks are unconformably overlain by Mesozoic sedimentary rocks that include clastic and evaporite deposits. The Mesozoic units include red beds that consist chiefly of sandstone and siltstone; these are interbedded with conglomerate beds and gypsum. Most Paleozoic and Mesozoic rocks occur on the east side of the study area, exposed in Sullivans Canyon. In the northern part, Paleozoic units form an anticline whose limbs are exposed on both the west and east flanks of the Virgin Mountains.

Cenozoic units are made up of Tertiary and Quaternary(?) conglomerate that is overlain by Tertiary or Quaternary(?) basalt flows or Quaternary alluvial deposits. The Quaternary alluvial deposits consist of unconsolidated, poorly sorted boulders, cobbles, gravel, sand, and finer clastic material deposited in ephemeral stream channels and in fans.

The Paiute Instant (Primitive) Study Area is situated in a structural transition zone. The complexly folded and faulted Virgin Mountains are the easternmost extension of the Basin and Range physiographic province at this latitude, and the gently tilted strata exposed in the Sullivans Canyon area are part of the west edge of the Colorado Plateau province. In western Arizona, Moulton and Owings (1978) have postulated that some mountain ranges consisting of Precambrian, Paleozoic, and Mesozoic rocks are overthrusts with large displacements. This concept contrasts with the widely held view that tectonism of the Basin and Range type in western Arizona is caused by extensional forces that produce normal faults. There is no evidence in the study area of a widespread thrust fault system. The tectonic forces that have acted to create the Virgin Mountains have produced numerous structural complexities. Attitudes and distribution of Paleozoic, Mesozoic, and Cenozoic rocks show that the sedimentary rocks have been folded and faulted. An anticlinal structure in the Virgin Mountains is defined by rocks dipping northwest and northeast along a northerly trending axis. The anticline is obscured by many high-angle reverse and normal faults described by Moore (1972). The latest episode of tectonism is evidenced by normal faulting that displaces Tertiary and Quaternary deposits in the west side of the study area. Faulting in this area has produced west-facing scarps on Quaternary alluvial fans.

MINING ACTIVITY

Six shafts, four adits, and ten prospects constitute the visible evidence of mining activity in the area, and there are no patented mining claims. Research at the Mohave County Courthouse in Kingman, Ariz., revealed a few unpatented claim locations associated with the mine workings shown on the mineral resource potential map. Several gemstone claims are scattered throughout an area of approximately 6 mi^2 (16 km^2) in the southeast part of the study area.

Although oil and gas leases overlap part of the south end of the study area, no wells have been drilled (see Hamm, 1980).

GEOLOGY AND GEOCHEMISTRY

The Paiute Instant Study Area has limited resources. Only a few low-potential mineralized areas were recognized from geologic and geochemical evidence. The low-potential mineralized areas delineated on the accompanying mineral potential map occur in Precambrian, Paleozoic, and Mesozoic rocks. Most of the occurrences have been prospected or mined.

Mineralization in Precambrian rocks

In the Paiute Instant Study Area, Precambrian gneiss consists of foliated bands of granitic gneiss, biotite-hornblende-garnet gneiss, biotite-hornblende gneiss, amphibolite, mica schist, and small isolated occurrences of calc-silicate and marble. These rocks are intruded by irregularly shaped pegmatite sills, dikes, and veins that roughly trend parallel to foliation. Mineralization in Precambrian gneiss occurs at several locations in the study area, including mines and prospects in Hedricks and Hancock Canyons and the Mount Bangs area.

The Hedricks Canyon area has been prospected (loc. 1) in an area of fractured and faulted Precambrian granitic gneiss, amphibolite, and pegmatite. Visible mineralization occurs mostly as malachite along fractured surfaces on amphibolite. Samples collected and analyzed by USBM show concentrations of copper ranging from 84 to 720 ppm. Other than the copper-carbonate stain, there is little evidence of mineralization in the immediate or surrounding area.

In the Hancock Canyon area, Precambrian rocks have been hydrothermally altered (loc. 2) across an area of approximately 1 acre (0.4 hectare). Disseminated pyrite and chalcopyrite (2 to 5 mm in diameter) occur throughout sheared and faulted bands of granitic gneiss. The mineralized zone is about 150 ft (45 m) wide and about 250 ft (75 m) long. Geochemical analyses show high and anomalous amounts of copper and zinc. Rock samples have copper contents ranging from 150 to 500 ppm. A sediment sample collected downstream within half a mile from the caved adit has 300 ppm copper and 700 ppm zinc. Amounts of silver up to 0.2 per ton were detected in samples from a shear zone at the caved adit portal.

Tungsten was detected in quartz and feldspar pegmatites that intrude Precambrian gneiss. Pegmatite samples were collected from a 6-in. (15-cm)-thick vein in granitic gneiss and amphibolite near the mouth of Hancock Canyon (loc. 3). Samples had scheelite inclusions ranging in size from approximately 1 to 5 mm; an analysis of a sample showed 150 ppm tungsten. Other minerals associated with these pegmatites include crystals, as large as 2 in. (5 cm) in diameter, of hornblende, pyroxene, and tourmaline. Sheelite was also detected in pegmatite samples collected from a prospect dump located south of Mount Bangs (loc. 6); a sample contained 50 ppm tungsten. Samples collected by USBM contained less than 0.03 percent (300 ppm) WO_3. A black-light visual inspection of rock samples from both locations revealed that scheelite content was meager and verified the low tungsten content in the analyses.

In the Mount Bangs area, beryllium was detected in a pegmatite sample and in a sediment sample derived from Precambrian pegmatite and gneiss terrane (area 1). A dumortierite prospect (loc. 4) also occurs in pegmatite rocks south of Mount Bangs. These occurrences are in what appear to be pegmatite sills that range from about 50 to 150 ft (15 to 45 m) in thickness, some of which can be traced for about a mile (1.6 km). The sills are steeply dipping and roughly parallel the foliation of gneissic host rock. The pegmatite sills form bands alternating within the predominant garnet-bearing granitic gneiss. The beryllium and dumortierite-bearing pegmatite is composed of quartz, feldspar, and muscovite, with minor accessory biotite and tourmaline. Beryllium content, probably from scattered occurrences of beryl or chrysoberyl, was 15 to 30 ppm in rock samples and 20 ppm in the sediment sample. The dumortierite occurs as a vein 2.5 ft (0.8 m) wide.

Localized occurrences of calc-silicate rocks and impure marble are associated with other Precambrian metamorphic and pegmatite rocks in the Mount Bangs area (area 2). The calc-silicate rocks and impure marble occur as elongate bodies about 20 to 80 ft (6 to 24 m) wide and approximately 300 ft (90 m) long, roughly paralled to the foliation of gneiss and schist bands. The metamorphic rocks in this area consist primarily of granitic gneiss, garnet-biotite schist, and amphibolite. Pegmatite veins and dikes intrude all the metamorphic rocks including the calc-silicate, marble, gneiss, and schist. Manganese prospects (locs. 5 and 7) occur in this area of alternating calc-silicate rocks, impure marble, and garnet-biotite schist and amphibolite. Manganese oxide (pyrolusite) occurs as coatings on these rocks. An impure black marble sample with pyrolusite intergrowths and coatings contained 5,000 ppm manganese.

Mineralization in Paleozoic and Mesozoic rocks

Paleozoic units include limestone, dolomite, sandstone, siltstone, shale, and evaporites. These rocks are overlain by Mesozoic units composed of sandstone and siltstone red beds interbedded with gypsiferous strata. Known mineralization in Paleozoic and Mesozoic rocks occurs at several localities. In Sullivans Canyon, a copper mineralized area has been prospected. About a mile (1.6 km) southeast of Mount Bangs, a lead and zinc prospect occurs in limestone. Geochemical analyses indicate possible minor mineralization in Figure 4 and Sullivans Canyon. Gypsum deposits are exposed in the Sullivans Canyon area.

The most significant area of mineralization occurs in Sullivans Canyon (area 3). Copper mineralization occurs as fracture-filling and intergranular growths of malachite and azurite in Permian red beds. The red beds consist of medium- to coarse-grained crossbedded sandstone. Locally these beds are intensely fractured, and minor faults were observed to offset beds by a few feet. Mineralization is concentrated in fracture and fault surfaces. This type of mineralization, in fractured rocks stained with hematite, is similar to a breccia-pipe copper and uranium deposit found in Hack Canyon, 60 mi (100 km) east-southeast of the study area (Lloyd Swapp, Bureau of Land Management, Arizona Strip District, oral commun., 1978). Geochemical analysis of mineralized rock samples show anomalous concentrations of copper (about 1 to 2 percent, equivalent to 10,000 to 20,000 ppm), high values for arsenic (7,000 ppm), and anomalous silver (7 ppm). Surface mineralization is restricted to very small areas that are estimated to measure roughly 50 ft (15 m) x 50 ft (15 m).

Minor mineralization occurs in the south part of the study area (locs. 8 and 9 and area 4). Silver, copper, lead, molybdenum, and zinc were detected in rock and sediment samples. Bedrock in the general area of location 8 consists of thick-bedded Permian Kaibab Limestone in fault contact with older Paleozoic carbonate rocks. At location 9, bedrock consists of finely laminated, white to buff dolomitic limestone that is mapped within undifferentiated Cambrian, Ordovician, and Devonian carbonate rocks. Mineralization at these locations occurs near a fault that has produced a zone of fractured and brecciated rocks cemented with some recrystallized calcite and quartz. Mineralization occurs as fracture-filling and disseminated growth of malachite and azurite at location 8, galena at location 9, and pyrite and magnetite in an altered area within area 4. Area 4 includes highly oxidized zones with copper- and iron-bearing minerals that are altered to cuprite and limonite. Chemical analyses of rock samples show high copper (150 ppm) and lead (100 ppm); sediment samples contain high lead (300 ppm), molybdenum (150 ppm), zinc (2.7 and 7.2 percent), and anomalous silver (0.7 ppm).

In area 5, which includes Figure 4 Canyon and part of Sullivans Canyon, analyzed sediment samples had shows of silver (3 ppm), arsenic (values ranged from 500 to 1,500 ppm), copper (values ranged from 200 to 700 ppm), lead (values ranged from 200 to 700 ppm), molybdenum (values ranged from 100 to 150 ppm), nickel (700 ppm), and zinc (values ranged from 150 to 300 ppm). Bedrock that underlies the drainage basins of sediment samples consist chiefly of Cambrian, Ordovician, and Devonian carbonate rocks, Mississippian limestone, and Pennsylvanian and Permian limestone and sandstone; these units are extensively folded and faulted. Many faults have produced narrow zones of brecciation with angular clasts of country rock cemented with recrystallized calcite. Mineralization was not noted in breccia zones. However, the detection of anomolous and high concentrations of several associated elements indicates that undiscovered mineral occurrences may exist in this area (area 5). The high concentrations of lead, molybdenum, zinc, and other previously mentioned elements in dry stream sediments is unusual, and area 5 may merit further exploration.

Silver (1.5 ppm), arsenic (500 ppm), copper (700 ppm), lead (700 ppm), zinc (500 ppm), and barium (10,000 ppm) were detected in a magnetic separate from a sediment sample collected from a tributary to Sullivans Canyon in the northeast part of the study area (area 5). The drainage area is underlain by faulted limestone, siltstone, and gypsiferous beds of the Permian Toroweap Formation and Kaibab Limestone and Permian red beds of sandstone, siltstone, and gypsiferous beds. Mineralization was not observed in exposures within this area, but the detection of certain elements in amounts that deviate substantially from other magnetic separate values suggests that some minor mineralization may exist here.

Anomalous and high values of barium (ranging from 1,500 to greater than 10,000 ppm) were detected in contiguous drainages of Sullivans Canyon (areas 7 and 8). Sediment samples are derived from Tertiary and Quaternary(?) basalt, and limestone, sandstone and siltstone red beds, and gypsiferous beds from the Permian Toroweap Formation and Kaibab Limestone. The Permian units are overlain by the Triassic Moenkopi Formation, which consists of red beds and evaporite deposits. Gypsum beds about 1 ft (30 cm) thick occur in these units. Barium is probably concentrated in the red beds with interbedded gypsiferous strata. There is no evidence that these deposits have been worked, probably owing to the rugged terrain and inaccessibility.

MINES AND PROSPECTS

Mining in or near the study area is limited. The mines and prospects are small-scale operations, and all are currently inactive. Known market production has not occurred from the mining activity mentioned in this report. Small ore shipments for assay have been made from locations 6 and 9.

Hedricks Canyon shaft and prospects

At Hedricks Canyon, in the northwestern part of the study area (loc. 1), three prospects and one vertical shaft were sampled. The shaft is driven into granitic gneiss and pegmatite. Surface debris surrounding the shaft indicates that amphibolite was intersected. Subsurface inspection of the shaft was not possible owing to its present unstable condition, but it is estimated to extend to a depth of more than 100 ft (30 m).

Chemical analysis of six samples taken from the shaft dump and prospects show copper in quantities ranging from 84 to 720 ppm. Intensely fractured garnets are common in the granitic gneiss at the shaft; they range in size from microscopic to about 1 in. (2.5 cm) in diameter.

Three additional shafts found in the vicinity of the sampled workings range in depth from 8 ft (2.5 m) to approximately 60 ft (20 m). These shafts are in extremely weathered and unstable rock; no mineralization is visible.

Hancock Canyon adit and prospects

One adit (caved) with an adjoining excavated area, and two prospect pits were found in Hancock Canyon (loc. 2). Local structural control is provided by several small faults in the area of the caved adit. The adit was driven southward along a vertical shear zone in pyrite-bearing, hydrothermally altered granitic gneiss. Pyrite is exposed at the adit and along the exposed face west of the adit. Analysis of three samples taken from the dump and the shear zone above the portal contain silver in quantities ranging from a trace to 0.2 oz per ton. Gold content ranges from none detected to trace amounts.

Scheelite was found in a vein of quartz and feldspar, averaging about 6 in. (15 cm) in width, at a prospect near the mouth of Hancock Canyon (loc. 3). The prospect consisted of a dozer cut about 200 ft (60 m) long, exposing granitic gneiss, amphibolite, and pegmatite dikes and veins. Scheelite occurrences in the vein were small and spotty.

Mount Bangs workings

Several manganese prospects and the Temple View tungsten prospect (locs. 5, 6, and 7) are in Precambrian metamorphic rocks on the slopes of Mount Bangs (Hancock Peak). Pits and trenches expose manganese-oxide that occurs as coatings on fracture surfaces of metamorphic rocks and appears to be discontinuous. The pits are small and shallow, ranging from about 3 to 6 ft (1 to 2 m) in depth and measuring from approximately 6 to 12 ft (2 to 4 m) in diameter.

The Temple View tungsten prospect (loc. 6) was worked intermittently in 1977 and 1978. The workings consist of a narrow, shallow trench 20 ft (6 m) long. Two samples taken from the trench and dump material contained less than 0.03 percent WO_3.

South-end workings

Just outside the south boundary of the Paiute Instant (Primitive) Study Area is a shaft with a cave connecting adit (loc. 8). The country rock is Permian limestone containing traces of malachite and azurite. Brecciated limestone and granite xenoliths(?), together with localized hematite stain, indicate that the shaft is possibly in a breccia pipe. Two samples were taken from apparent overburden and wallrock material of the shaft and caved connecting adit; assay results showed negligible amounts of economic minerals. One sample taken from an area where the mineralized rock was apparently stockpiled contained 5.4 percent copper and 1.15 percent arsenic.

The Goddess workings (loc. 9) are about 2 mi (3 km) southeast of Mount Bangs. Lead- and zinc-bearing minerals occur as open-space fracture filling in the calcite and limestone. Two of nine samples from the Goddess workings had high silver, lead, and zinc content. Both samples were taken from the upper part of a caved shaft. Silver values were 0.5 and 2.9 oz per ton; lead, 1.5 and 2.2 percent; and zinc, 2.7 and 7.2 percent.

Sullivans Canyon adits

Two adits were found on the east side of Sullivans Canyon about 7 mi (11 km) south of the Virgin River. Both adits are situated in Permian red bed sandstone with malachite and azurite mineralization. The upper adit (loc. 10), the larger of the two, follows disseminated copper mineralization for 100 ft (30 m). The lower adit (loc. 11) extends 14 ft (4 m) into a pocket of hematite-stained sandstone that contains copper mineralization. Both mineral occurrences appear to be related to a localized breccia-pipe formation.

The condition of mining equipment at the upper adit indicates that the working has been inactive for several years. However, a claim notice for the Blue Baby No. 1 mine at the lower adit is dated 1976.

Samples from the upper adit show traces of silver and 0.61 percent copper. Assays from the lower adit indicate 0.1 to 0.2 oz per ton silver, and 1.0 to 2.3 percent copper and 0.51 to 0.43 percent arsenic.

Examination with a geiger counter shows radioactivity levels are not above background.

Dumortierite prospect

A prospect near the junction of Cottonwood Wash and the Elbow Canyon Road (loc. 4), in a northeast-southwest trending pegmetite, was found to contain the blue aluminum silicate mineral dumortierite. The pegmatite is traceable for more than 1 mi (1.6 km) and is 100 ft (30 m) wide at the prospect. The prospect has been covered, but the dumortierite reportedly occurs as a vein about 2.5 ft (0.75 m) wide within the pegmatite (M. Woodbury, Bureau of Land Management, Arizona Strip District Office, oral commun., 1978). There are no other reported occurrences of dumortierite in the region.

Reserve estimates

Mineral deposits in the study area include arsenic, barium, beryllium, copper, lead, manganese, molybdenum, nickel, silver, tungsten, and zinc mineralization. Other occurrences include dumortierite, gem minerals, gypsum, sand, gravel, and limestone. None of the mineral deposits was deemed economic for present or foreseeable future markets. Breccia pipes within the study area boundaries may be genetically related to deposits of uranium at depth that only core dilling or shaft sinking would reveal.

Base metals, precious metals, and other types of potentially economic mineralization are so erratically distributed that reserves cannot be calculated.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The examination of geology, mines and prospects, claims, and a geochemical survey did not reveal widespread indications of substantial, near-surface mineral resources in the Paiute Instant (Primitive) Study Area; thus most of the area has no mineral potential. Some minor mineralized areas of low potential are recognized. With the possible exception of the Goddess silver, lead, and zinc deposit (loc. 9) just outside the south end of the study area, the southeast areas at best might host small and economically insignificant deposits.

Exploration activity by major mining companies is not known for the study area. A small number of mines and prospects (6 shafts, 4 adits, and 10 prospects) are located at or near known mineralized areas. The scattered small-scale workings are abandoned, caved, or covered up, and all are inactive. From all indications, production from these worked areas has been insignificant or nil.

Rock and sediment samples collected from or near the workings contain anomalous but noneconomic amounts of arsenic, beryllium, copper, lead, manganese, tungsten, and silver. At Hedricks Canyon (loc. 1), trace amounts of copper were detected. Hancock Canyon had sulfide minerals with copper and silver at location 2 and tungsten at location 3. A number of prospects occur in the Mount Bangs area; elements present in notable amounts include manganese (at locs. 5 and 7), tungsten (loc. 6), and beryllium (area 1). A dumortierite prospect (loc. 4) is south of Mount Bangs. Deposits in the south part of the study area, east of Cottonwood Wash contain arsenic- and copper-bearing minerals at location 8, and lead, silver, and zinc at location 9. Samples from Sullivans Canyon (locs. 10 and 11) show concentrations of arsenic, copper, and traces of silver. The geochemical analyses of rock and sediment samples from the known mineralized areas suggest that the potential deposits would be low grade and not in concentrations that could be mined profitably. The metallic mineral resource potential is low for these areas (areas 1, 2, 3, and 4).

The geochemical survey also revealed traces of various elements concentrated in areas that may include undiscovered mineral deposits. Anomalous and high values for arsenic, copper, lead, molybdenum, nickel, and zinc were detected in sediment samples from contiguous drainages in the Figure 4 Canyon and Sullivans Canyon areas (areas 5 and 6). Areas of alteration were searched for on foot and by helicopter. Zones of faulting and brecciation were examined and sampled. Surficial mineralization in these areas was searched for but not found. At best, the Figure 4 Canyon and Sullivans Canyon areas are probable low-potential areas for metallic mineral resources. The anomalous and high values for copper and other metals suggest that undiscovered mineralization may occur in areas 5 and 6.

Limestone, gypsum, and sand and gravel deposits are plentiful in the study area. Thin gypsiferous beds are discontinously exposed along the cliffed east walls of Sullivans Canyon (areas 7 and 8). Numerous sediment samples collected from tributary drainages to Sullivans Canyon have high values for barium, which is probably concentrated in the gypsiferous beds. Because all of these deposits are far from major markets and are in highly inaccessible areas, they are economically unattractive at present. The gem minerals, garnet and yellow quartz, occur in the area. The garnets observed are fractured and of poor quality, and the yellow quartz is scarce. Neither mineral is economically valuable.

The oil and gas potential in the study area is apparently nil or very low. The area has no potential for coal, oil shale, geothermal resources, phosphate, or sodium and potassium compounds.

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