

Chapter J. Mineral Resource Potential of the River Mountains Area of Critical Environmental Concern, Clark County, Nevada

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Summary and Conclusions

The River Mountains Area of Critical Environmental Concern (ACEC) contains occurrences of altered and mineralized volcanic rocks that are similar to epithermal precious-metal deposits. An area in the southern part of the ACEC, near Railroad Pass and Boulder City, Nevada, has moderate potential for the occurrence of undiscovered epithermal precious-metal deposits. The results of historical exploration and geochemical studies made for this report indicate that the exposed occurrences do not have high enough precious-metal concentrations to encourage development.

Until the 1960s, there was extensive mining of manganese at the north end of the ACEC. These deposits are not now viable, and there is only low potential for the occurrence of undiscovered sedimentary manganese deposits.

Potentially commercial perlite occurs in the northeast part of the ACEC. There are current mining claims staked for perlite, and a small area has high potential for the occurrence of perlite deposits.

There is no potential for the occurrence of other deposits of locatable or leasable minerals.

The River Mountains ACEC has areas of high, moderate, and low potential for the occurrence of crushed-stone aggregate deposits, and areas of high and low potential for the occurrence of sand and gravel aggregate deposits.

Introduction

This report was prepared for the U.S. Bureau of Land Management (BLM) to provide information for land planning and management, and, specifically, to determine mineral resource potential in accordance with regulations at 43 CFR 2310, which governs the withdrawal of public lands. The Clark County Conservation of Public Land and Natural Resources Act of 2002 temporarily withdraws the lands described herein from mineral entry, pending final approval of an application for permanent withdrawal by the BLM. This report provides information about mineral resource potential of these lands.

The River Mountains ACEC was studied in the field to confirm descriptions of the geology that were gleaned from the scientific literature. Numerous samples were collected and analyzed.

Definitions of mineral resource potential and certainty levels are given in appendix 1, and are similar to those outlined by Goudarzi (1984).

Lands Involved

The River Mountains ACEC is southeast of Las Vegas, directly east of the city of Henderson and northwest of Boulder City. It is reached from city streets and paved roads that surround it, as well as by hiking and bicycle trails that enter the area from the Bootleg Canyon road, at the southeast corner of the ACEC. A loop trail, under development, will skirt the south and west sides of the ACEC (<http://www.rivermountainstrail.com>). A legal description of these lands is included in appendix 2.

Physiographic Description

The River Mountains consist of a series of low mountains whose ridgelines trend north-northwest, parallel to normal faults in the area. Elevations range from about 750 m at the foot of the mountains to a little more than 1,100 m on the highest peaks.

Geologic Setting

The River Mountains are in the central Basin and Range Physiographic Province, generally characterized by north-trending mountain ranges and intervening valleys, and lie between the Sevier orogenic belt and the Colorado Plateaus. The area underwent large-magnitude extension in the middle to late Miocene, and it lies directly north of the Colorado River extensional corridor (Deubendorfer and others, 1998). The rocks exposed in the River Mountains form part of an

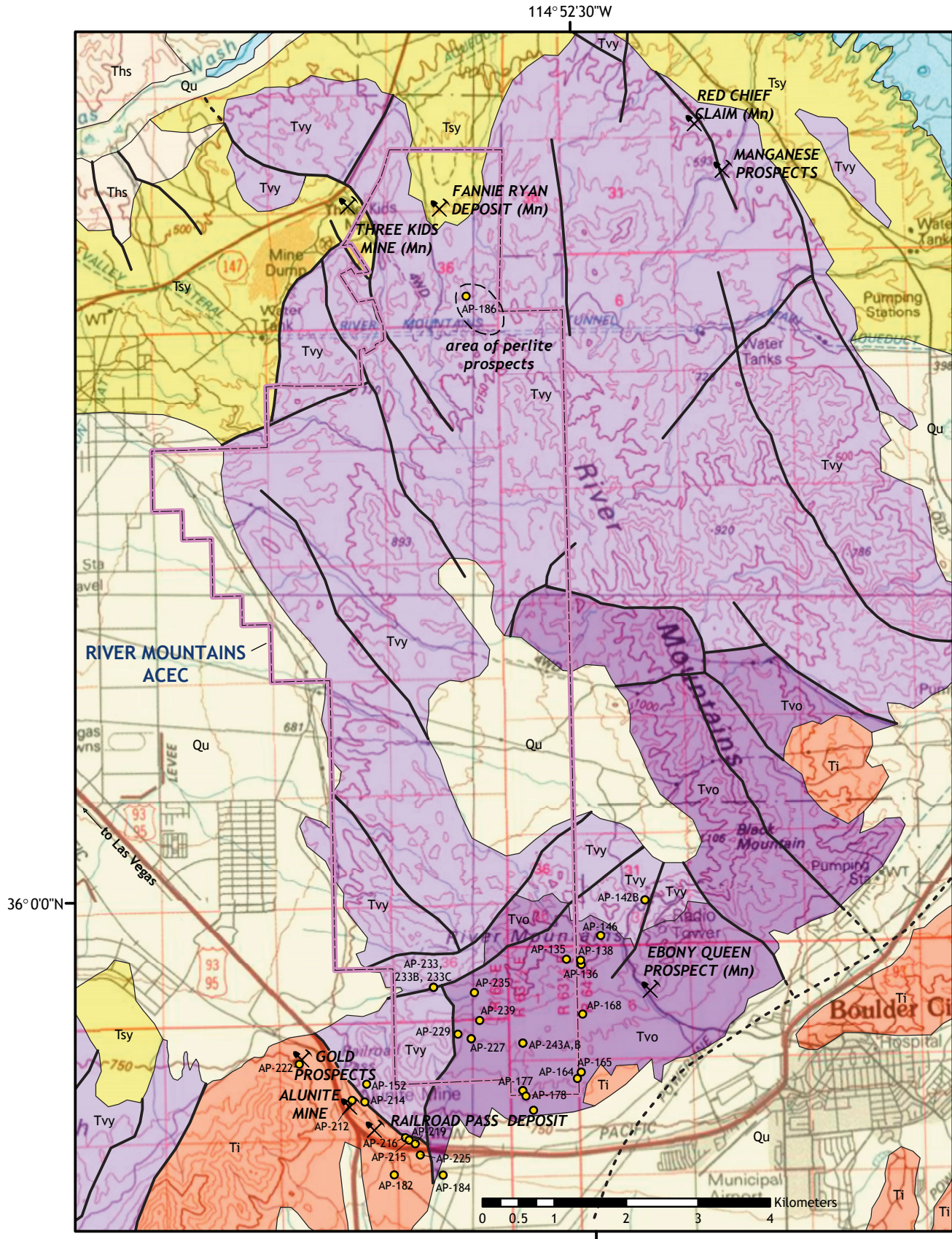


Figure 1. Generalized geology of the River Mountains Area of Critical Environmental Concern (ACEC), showing mines, prospects, and locations of analyzed samples. Geology modified from Stewart and Carlson (1978), Anderson (1977), Bell and Smith, (1980), and Smith (1984). See explanation on page 3.

extensive group of middle Tertiary volcanic rocks that extend west into the Mojave Desert of California and south into western Arizona (Smith, 1982, 1986a, b).

Geology

The rocks in the River Mountains consist of a series of primarily intermediate-composition volcanic and intrusive rocks. These rocks are portrayed on a series of three geologic maps (Anderson, 1977; Bell and Smith, 1980; Smith, 1984)

that were used to help compile the simplified geologic map presented in figure 1.

The oldest group of rocks has been termed the volcanic rocks of River Mountains by Smith (1986a). This group consists of a central intrusion and a sequence of andesites that form the flanks of the volcano. The age of the central pluton is between 13.4 and 12.8 Ma. West of the main outcrop area of this River Mountains volcano is an area underlain by strongly altered and oxidized rocks. The original composition of many of these rocks is uncertain, but they were probably primarily dacites. These rocks, termed the volcanic rocks of Red Mountain by Bell and Smith (1980) and Smith (1984), may be the strongly altered distal equivalents of the rocks of the River Mountains volcano.

A second episode of volcanism produced the volcanic rocks of Bootleg Wash (undated), which are found only in a small outcrop area in the southern part of the River Mountains and consist primarily of andesite and dacite. Succeeding these rocks is a widespread sequence of dacite and andesite domes and flows termed the volcanic rocks of Powerline Road (also undated). Capping the sequence are rhyolites and alkali basalts dated at 12.1 Ma. Each of these four groups of rocks appears to be fault bounded (Smith, 1986a).

Smith and others (1990) and Metcalf and others (1993) studied the petrology of these volcanic rocks and found the andesites and dacites to contain between about 54 and 67 percent silica. They proposed that the rocks formed by mixing of mantle- and crustal-derived magmas, aided by crystal fractionation. They are fundamentally calc-alkaline, although some show elevated potassium contents that are believed to be the result of potassium metasomatism. Several of the rock units commonly contain abundant basaltic inclusions.

All these volcanic rocks are cut by an extensive series of north-northwest-trending normal faults that dip primarily to the east. In detail, the dips of the volcanic rocks are variable, and many of the rocks show no clear bedding features. This structure is thought to be the result of transport and extension related to the west-dipping Saddle Island detachment fault that underlies the River Mountains and McCullough Range (Weber and Smith, 1987). This fault is part of the Lake Mead Fault Zone, and the original position of the River Mountains was apparently tens of kilometers to the east-northeast (Deubendorfer and others, 1998).

The volcanic rocks of Red Mountain are very distinctive on satellite images. This is a result of hydrothermal alteration that has added silica, potassium, and sulfate to the rocks. X-ray diffraction studies of samples from this region show that many of the rocks have been altered to mixtures of quartz, sericite/illite, and alunite.

At the northern end of the ACEC, in the vicinity of the Three Kids Mine, a limited amount of tuffaceous sedimentary rock belonging to the Horse Spring Formation is found above and interlayered with the Miocene volcanic rocks.

All these rocks are overlain by younger sedimentary rocks of the Muddy Creek Formation, and by Quaternary deposits.

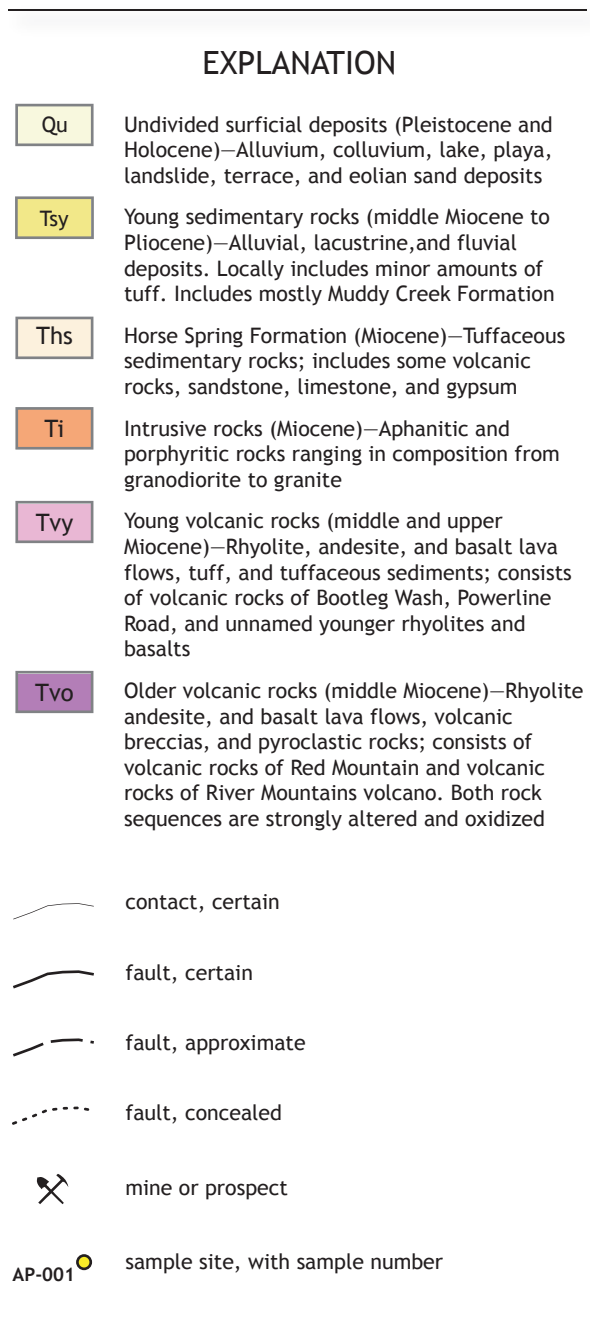


Figure 1. Continued.

Mining History

Gold and alunite were discovered by R.T. Hill at the southern end of the River Mountains in 1908. The hydrothermal alteration was recognized to be similar to that in the Goldfield district, and initial expectations were high for the discovery of important gold deposits. However, exploration failed to discover high-grade gold ore. Sporadic attempts to mine deposits here, in what became known as the Alunite (or Railroad Pass) district occurred into the 1930s, but the total production of gold was probably not much more than 1,000 ounces, and attempts to recover alunite also proved unsuccessful. The principal mine, known as the Quo Vadis, is about 9 km southwest of the ACEC. However, other deposits, including the Alunite Mine and the Railroad Pass deposit, are located within 2 km of the ACEC, just north of U.S. highways 93 and 95, at Railroad Pass (fig. 1). Information about the history of the Alunite district is from Vanderburg (1937) and Longwell and others (1965).

Several manganese deposits were discovered in Clark County during World War I, when there was a rush of prospecting caused by wartime needs for manganese. The Three Kids Mine, which is located at the north end of the River Mountains ACEC (fig. 1), was active intermittently from 1917 until 1952. Low-grade manganese ore was also produced from unnamed deposits immediately west of the Three Kids Mine, and total production until the end of mining in 1961 exceeded 2,000,000 short tons of ore that yielded about 300,000 short tons of manganese. Most of the ore was mined and sold under contract to the U.S. General Services Administration at a price substantially above the world market price. The Ebony Queen prospect is about 1 km east of the ACEC, about 3 km west of Boulder City. This deposit is a vein, a few hundred meters long, and about 1 to 3 m in width. It was initially explored about 1925, but no manganese was produced. Other manganese occurrences in and near the River Mountains and south of Boulder City have been explored, but ore was not found. Information about the history of the manganese deposits is from Vanderburg (1937) and Longwell and others (1965).

Advanced Mining LLC submitted a plan of operations to the BLM for the Dawson perlite claims located east of Henderson in the northern part of the River Mountains ACEC (fig. 1) in September 2000. The plan called for taking bulk samples for testing, and mining at 50,000 short tons per year was planned if test results were positive (Castor, 2001). More recent information on the project has not been received, and no sign of mining or prospecting activity was noted when the area was visited in early 2005. The claims were active as of November 2005.

Mineral Deposits

Two important types of metallic mineral deposit occur in and near the River Mountains ACEC. They are the gold deposits related to quartz-alunite alteration in the Alunite (Rail-

road Pass) district, and the manganese deposits that occur in sedimentary rocks of the Horse Spring Formation and volcanic rocks of the River Mountains. Perlite of possible commercial value also occurs in the volcanic rocks of the River Mountains.

Epithermal Gold Deposits

The old workings at Railroad Pass are on the southwestern margin of a large area of altered volcanic rock that extends east and north from Railroad Pass. These rocks crop out prominently in the southeastern corner of the River Mountains ACEC (fig. 2). The combination of scattered high precious-metal values, locally anomalous amounts of Bi, Te, and Sn, and widespread altered quartz-alunite rock suggests that this area can be best classified as a high-sulfidation epithermal precious-metal deposit.

The color patterns in figure 2 were generated using Advanced Spaceborne Thermal Emission and Reflection (ASTER), which is a 14-band multispectral satellite imaging system (Rowan and others, 2003). The composite color image uses the ratio of ASTER bands 7 (2.235–2.285 μm) and 6 (2.185–2.225 μm). Ground-truth comparisons of the areas colored intense pink in the image, both here in the southern River Mountains and farther south, in the Searchlight district, suggest that this color commonly indicates pervasive quartz-alunite alteration.

The altered rocks, which appear in visible light as various shades of red, yellow, and orange because of fine-grained iron-oxide minerals (fig. 3), correspond closely with rocks mapped by Anderson (1977), Bell and Smith (1980) and Smith (1984) as intensely altered and oxidized volcanic rocks. The altered rocks may be part of a hydrothermal system related to the River Mountains volcano of Smith (1982) or to the Boulder City pluton, dated by Anderson and others (1972) at 13.8 Ma. Of 34 samples analyzed using X-ray diffraction (XRD), 12 were found to contain sericite/illite, 10 alunite (fig. 4), two kaolinite/dickite, and one pyrophyllite. In places, the altered rock contains barite±gypsum veins (sample AP-182, fig. 3; fig. 5) and breccia cemented by gypsum+pyrite. Green copper oxide minerals occur locally. The strongest alteration generally occurs along faults (fig. 6) or resistant silica ledges (fig. 7).

Figures 1 and 2 show the location of rock samples collected during this study that were geochemically analyzed for a variety of elements related to hydrothermal mineralization (Ludington and others, 2005). Of 33 samples analyzed, all but 2 show evidence of sulfur enrichment. Twenty of the 33 samples are at least moderately anomalous in Ag, As, Bi, Cd, Cu, Mo, Pb, Sb, Sn, Te, Tl, W, or Zn. Five samples are highly anomalous: AP-184 (Ag, Bi, Cu, Mo, Zn), AP-233B (Cu, Zn), AP-182 (Mo, Pb), AP-275 (Ag, Pb), and AP-282 (Cu). Only three samples have been analyzed for gold, and they yielded background values (1–7 parts per billion, ppb). One sample reported by Smith and Tingley (1983) from dumps at the Alunite Mine (fig. 1) contains 0.1 parts per million (ppm) Au and <0.5 ppm Ag, and their sample 1327 (fig. 1) contains 0.5 ppm Au and 1 ppm Ag. None of these anomalous samples contain

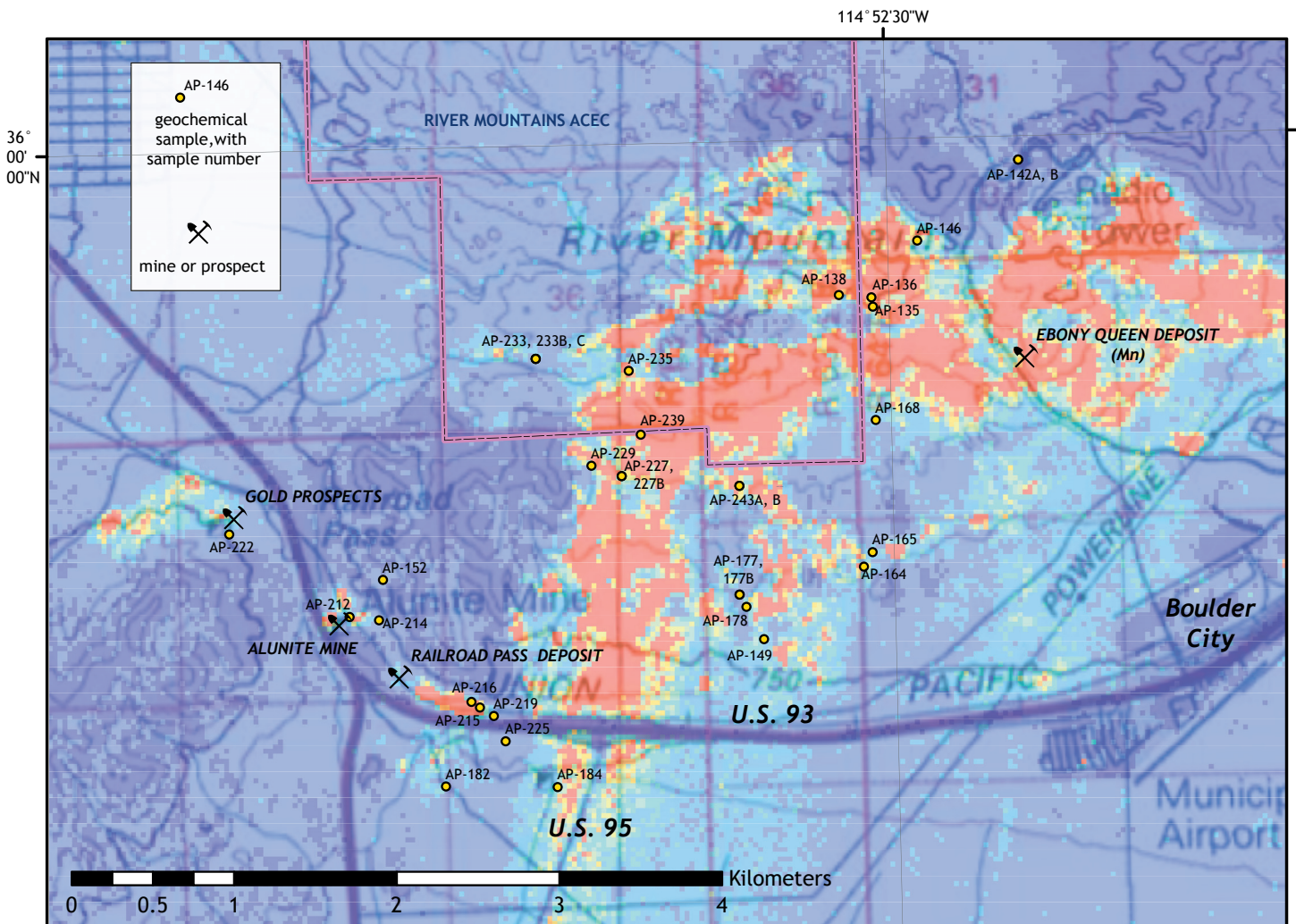


Figure 2. ASTER image (ratio of bands 7/6) of southern part of the River Mountains Area of Critical Environmental Concern (ACEC; outlined in pink). Red color indicates quartz-alunite alteration. See text for details.



Figure 3. Altered and mineralized rocks within the River Mountains ACEC in foreground. Cascata golf course is below, and Boulder City is in the distance.

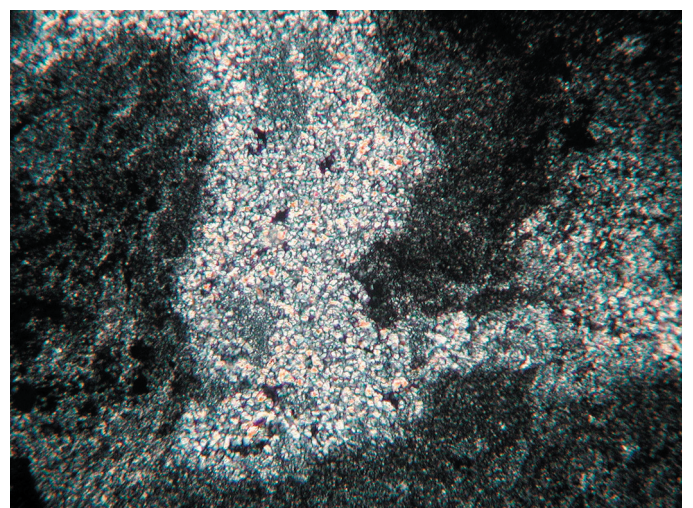


Figure 4. Nearly pure alunite in quartz-alunite rock (sample AP-216), 1.6 km south of the River Mountains ACEC. Horizontal field 1.3 mm. Cross-polarized light.

values indicative of commercially viable precious-metal ore; however sample AP-184 contains nearly 7 percent copper.

The area that is strongly altered and mineralized has an extent of more than 10 km², about a third of which is within the River Mountains ACEC (fig. 2). Most of the highly anomalous samples come from an area between US Highway 93 and the ACEC boundary, in and near Boulder City. Alteration and mineralization produced alunite-rich rock that is well exposed in an abandoned railroad cut, as well as at scattered prospects and adits. These workings expose barite+hematite+gypsum veins and, locally, copper oxide minerals. This area along U.S. 93 seems to be the most prospective for precious-metal depos-

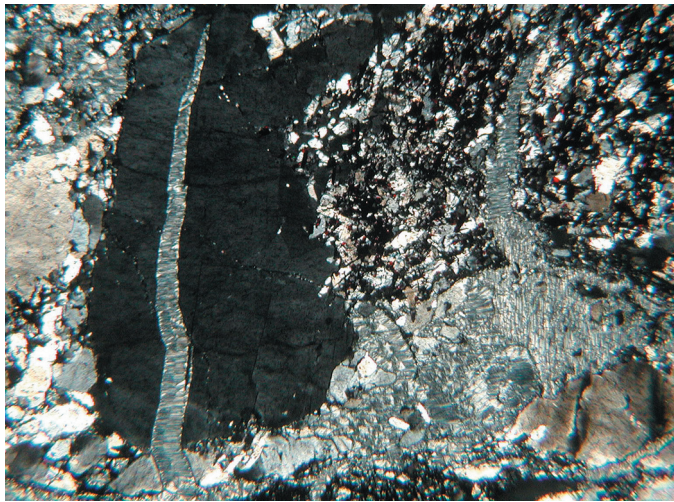


Figure 5. Barite + hematite vein cut by fibrous gypsum (sample AP-182) from a prospect 2 km south of the River Mountains ACEC. Horizontal field about 2.5 mm. Cross-polarized light.



Figure 6. Mineralized northeast-striking, northwest-dipping fault within the River Mountains ACEC near sample site AP-138. Altered rock in this area contains quartz, pyrite or limonite, feldspar, and minor alunite.

its. However, the hydrothermally altered area extends northward into the ACEC, and rock with anomalous metal contents (sample AP-233A, fig. 1, fig. 8) occurs there in association with barite veins; silicified, limonitized, and locally alunite-bearing structures; and a few prospect pits.

Sedimentary Manganese Deposits

The manganese deposits at the Three Kids Mine and nearby unnamed deposits (fig. 1) consist of local accumulations of manganese oxides in tuffaceous siltstone, sandstone, conglomerate, and tuff of the Miocene Horse Spring Formation. According to Longwell and others (1965), the manganese occurs primarily as wad (hydrous manganese oxides), but psilomelane, pyrolusite, and manganite ($Mn^{3+}O(OH)$) are also reported. In places, the wad is opalized. The manganese minerals occur mixed with clastic grains and tuffaceous and gypsiferous material. These accumulations form lenticular pods that vary in size and grade and occur in a syncline that has been deepened by graben faulting at the north end of the River Mountains, adjacent to underlying (but structurally higher) volcanic rocks (Hewett and Weber, 1931).

More modern studies have shown that the mineralized rock consists of transported clasts of colloform manganese



Figure 7. Resistant west-trending ledge of altered rock at location AP-132, about 0.5 km east of the River Mountains ACEC. The resistant rock consists mostly of quartz, with lesser feldspar and jarosite.

oxide (todorokite $[(\text{Mn}, \text{Mg}, \text{Ca}, \text{Ba}, \text{K}, \text{Na})_2 \text{Mn}_3 \text{O}_{12} \cdot 3\text{H}_2\text{O}]$ and coronadite $[\text{Pb}(\text{Mn}^{4+}, \text{Mn}^{2+})_8 \text{O}_{16}]$), manganese-oxide cement (pyrolusite), and manganese-oxide cavity infillings (cryptomelane $[\text{K}(\text{Mn}^{4+}, \text{Mn}^{2+})_8 \text{O}_{16}]$ and coronadite) (Koski and others, 1988).

In addition to manganese, the rocks in the deposit contain trace amounts of iron, lead, copper, silver, and gold, some of which were occasionally recovered during ore processing (Longwell and others, 1965).

The characteristics of the deposits suggest that manganese minerals were deposited from oxidized, low-temperature fluids in contact with unconsolidated clastic sediment on and below the floor of stratified saline lakes. Strontium isotopic ratios of evaporite and limestone that are interbedded with the manganese deposits are consistent with a lacustrine depositional environment (Koski and others, 1988). Radiometric ages of interbedded tuff units range from about 14 Ma to 12.4 Ma, about the same age as the volcanic flow rocks adjacent to the south (Koski and others, 1990) and as Horse Spring Formation rocks in the Frenchman Mountain area to the north (Castor and others, 2000). The deposits are thus of syngenetic origin, and their ultimate source was probably hot springs related to local volcanic activity (Hewett and Weber, 1931; Hewett, 1933).

Perlite Deposits

Perlite occurs in a moderately to steeply northwest-dipping tabular body about 20 m wide in the northeastern part of the River Mountains ACEC (fig. 1). This perlite is probably part of the deposit that has been staked as the Dawson perlite claims. It contains minor amounts of feldspar, quartz, and biotite phenocrysts, and the upper part of the body contains as much as 20 percent devitrified rhyolite in the form of



Figure 8. Altered and mineralized rocks at the south end of the River Mountains. In the background, the right half of the photograph shows rocks within the River Mountains ACEC.

spherulites. The perlite is light gray (fig. 9) and is of rhyolitic composition with more than 70 percent SiO_2 (sample AP-186, Ludington and others, 2005). It is contained within devitrified to glassy pumiceous rhyolitic flow rock, which is overlain to the northwest by basaltic andesite flows and debris flows. The perlite is mapped within the dacitic volcanic rocks of Powerline Road. Bell and Smith (1980) reported spherulitic and perlitic dacite in the area of the Dawson perlite claims.

Properties of a select grab sample of the perlite were measured by the New Mexico Bureau of Geology and Mineral Resources. The results of these tests indicate that the perlite sample has relatively high furnace yield, moderate expanded density, and on expansion yields a moderate amount of sinks (sample AP-186, table 1). The expanded perlite has relatively low brightness and large particle size. The test results indicate that it compares favorably with perlite from the Mackie Mine, which is an active operation in Lincoln County, Nevada, that produces expanded perlite mostly sold in horticultural markets. On the basis of the testing, perlite from the River Mountains is less suitable for many markets than perlite from the highly productive No Agua, New Mexico deposits. However, the testing procedure is specifically designed for optimum performance of the No Agua perlite, and better results might be obtained for perlite from the River Mountains using different temperature and feed particle size.



Figure 9. Perlite outcrop in the northeastern part of the River Mountains ACEC. Sample AP-186 was taken from this outcrop.

J8 Mineral Resource Assessment of Selected Areas in Clark and Nye Counties, Nevada

Table 1. Test data for perlite expanded at 1300 degrees F. without preheat using material sieved to between 50 and 100 mesh.

[Sieve analyses of expanded perlite reported as percent of sample retained on each sieve at each mesh size. Testing by New Mexico Bureau of Geology and Mineral Resources.]

Sample	Furnace Yield %	Expanded Density lbs/ft3	Average Brightness %	Sinks %	Percent Expanded Retained (Tyler Mesh)							
					20	30	50	70	100	140	Pan	Sum
AP-010A	77	1.94	52.1	22.2	1.0	9.4	30.5	14.2	10.8	11.4	22.7	100.0
AP-010B	88	2.27	55.5	9.6	1.9	17.9	41.1	10.5	7.4	6.8	12.4	100.0
AP-045	68	1.97	60.1	8.4	0.6	6.0	29.9	17.2	12.5	13.0	20.8	100.0
AP-119	92	2.06	52.5	4.8	20.1	34.0	33.7	5.6	2.5	1.3	2.8	100.0
AP-120	96	2.05	50.8	9.0	1.0	8.4	33.1	16.8	12.0	10.3	18.4	100.0
AP-121	86	2.04	52.8	12.0	2.4	16.7	34.5	16.1	9.8	2.1	17.4	99.0
AP-122	85	2.52	57.2	7.0	16.2	27.4	38.7	7.5	35.0	1.9	4.8	100.0
AP-124	96	3.05	42.4	0.6	8.1	42.1	42.9	3.2	1.1	5.0	2.1	100.0
AP-186	95	2.26	57.2	10.2	16.8	33.3	36.0	8.4	3.3	2.1	3.1	100.0
AP-301	84	3.03	56.0	26.2	1.0	12.1	35.9	16.5	11.7	7.7	15.1	100.0
AP-302	90	2.80	59.2	11.4	2.8	12.5	35.1	16.5	10.3	9.5	13.3	100.0
AP-303	90	3.79	62.3	14.2	1.6	21.8	52.0	11.4	4.0	3.0	6.2	100.0
Standard	99	1.87	72.4	6.8	9.9	41.0	37.4	2.9	2.1	4.0	2.7	100.0
Standard	99	1.54	70.6	2.4	19.4	42.5	30.7	3.2	1.9	1.5	0.8	100.0

- AP-010A Grab of fibrous perlite, Nu-Lite Mine, Clark Co., Nevada
- AP-010B 5-m chip of fibrous perlite, Nu-Lite Mine, Clark Co., Nevada
- AP-045 Select grab of granular perlite with phenocrysts, NW of Searchlight Perlite Mine, Clark Co., Nevada
- AP-119 Grab of granular perlite, Pahrock Pit, Mackie Mine, Lincoln Co., Nevada
- AP-120 Select grab of onion skin perlite, Mackie Mine underground, Lincoln Co., Nevada
- AP-121 Grab of granular perlite, main pit, Hollinger Mine, Lincoln Co., Nevada
- AP-122 Grab of granular perlite, east pit, Hollinger Mine, Lincoln Co., Nevada
- AP-124 Grab of granular perlite with obsidian cores, Lovelock perlite pit, Pershing Co., Nevada
- AP-186 Select grab of granular perlite with phenocrysts, River Mountains, Clark Co., Nevada**
- AP-301 Grab of granular perlite, main pit, Searchlight Perlite Mine, Clark Co., Nevada
- AP-302 Grab of granular perlite, northeast pit, Searchlight Perlite Mine, Clark Co., Nevada
- AP-303 Grab of granular perlite, outcrop east of main pit, Searchlight Perlite Mine, Clark Co., Nevada
- Standard Dicaperl granular perlite, No Agua, New Mexico



Figure 10. The Bootleg Canyon aggregate pit, a sand and gravel mining operation about 2 km southwest of the River Mountains ACEC.

Sand and Gravel Operations

A currently active sand and gravel aggregate mine is about 2 km east of the southern part of the ACEC, just west of Boulder City, at the mouth of Bootleg Canyon. It is called the Bootleg Canyon Pit, and is operated by Boulder Sand and Gravel (see figs. 10, 12). Three other similar operations are a few kilometers south of the ACEC along U.S. 95, the Eldorado Pit, the Gornowich Plant, and the Goldstrike Mine.

Mineral Exploration and Development

There is apparently no current exploration activity for precious metals in or near the River Mountains ACEC. However, there are three active placer claims in sections 25 and 36 of T22S, R63E. In addition, there are 5 active lode claims for perlite in section 36 of T21S, R63E, south of the Fannie Ryan manganese deposit.

Mineral Resource Potential

Locatable Minerals

The southeastern part of the River Mountains ACEC appears to have been affected by a robust hydrothermal system that altered most of the rocks to mineral assemblages containing quartz, sericite/illite, and limonite. Alunite occurs in this altered rock locally, along with rare kaolinite and pyrophyllite. These minerals are characteristic of high-sulfidation epithermal precious-metal deposits. However, on the basis of our sampling, the hydrothermal system appears to have been relatively deficient in precious and base metals, and we have designated this area (tract RVM01, fig. 11) to have moderate potential for high-sulfidation epithermal precious-metal deposits, with a moderate level of certainty. The discovery of significant amounts of mineralized rock with significantly higher metal contents could raise this potential estimate. This would probably require drilling to test the hydrothermal system at depth.

Although several small manganese deposits, similar to those exploited at the Three Kids Mine exist within and near the River Mountains ACEC, these deposits appear to be too small and too low grade to be commercially viable. Outcropping manganese deposits are relatively easy to detect, and we assign only a low potential for the occurrence of undiscovered sedimentary manganese deposits. A dramatic rise in the price of manganese could change this, but the large size of manganese deposits typically exploited throughout the world makes development of manganese deposits in the River Mountains a highly unlikely event in the foreseeable future.

Perlite of possible commercial quality occurs in the northeastern part of the River Mountains ACEC. It is not clear if the deposits can be mined economically; the perlite body that we examined is steeply dipping and would have to be mined in

narrow pits or underground. However, more extensive deposits may be present in the immediate area. We assign high potential for perlite, with a moderate level of certainty, to a small area that includes the Dawson perlite claims and our sample site (tract RVM02, fig. 11). There is no indication from our work, previous prospecting, or detailed geologic mapping (Bell and Smith, 1980) that there are more perlite deposits in the area.

Leasable Minerals

No part of the River Mountains ACEC is within the region considered by the BLM to be moderately favorable for oil and gas (Smith and Gere, 1983). There is no indication of potential for brine or evaporite deposits of sodium or potassium. The ACEC contains no known deposits of other leasable minerals, and the potential for their occurrence is judged to be low.

Salable Minerals

Crushed Stone.—We consider the fanglomerates that are exposed in the interior valley in the southern part of the ACEC to have high potential for crushed-stone aggregate, with a moderate certainty level (tract ARVM01, fig. 12). The clasts in these fanglomerates are primarily dacitic volcanic rocks that have been sorted for durability by abrasion during Pliocene fan formation. Most of the outcrop areas of volcanic rock are judged to have moderate potential, with a moderate certainty level (tract ARVM03, fig. 12). The presence of glass and microcrystalline quartz in these fine-grained volcanic rocks makes them susceptible to alkali-silica reactivity (ASR), which can cause rapid deterioration of concrete and reduces the suitability of such rocks for concrete applications. The material might be suitable as base rock or asphalt aggregate. Areas underlain by volcanic breccia and mudflow units and by fine-grained parts of the Muddy Creek Formation are assigned low crushed-stone aggregate potential, with a high level of certainty (tract ARVM02, fig. 12).

Sand and Gravel.—Alluvial sand and gravel deposits are found at the north end and in the interior valley in the southern part of the ACEC. The intermittent streams that deposited this alluvium drain northwest and empty onto alluvial fans east of the city of Henderson. Together, these areas have been designated to have high potential, with a high level of certainty (tract ARVM04, fig. 12). There are also low-potential sand and gravel deposits that have been backfilled into pits associated with the manganese mining at the Three Kids Mine site (tract ARVM05, fig. 12).

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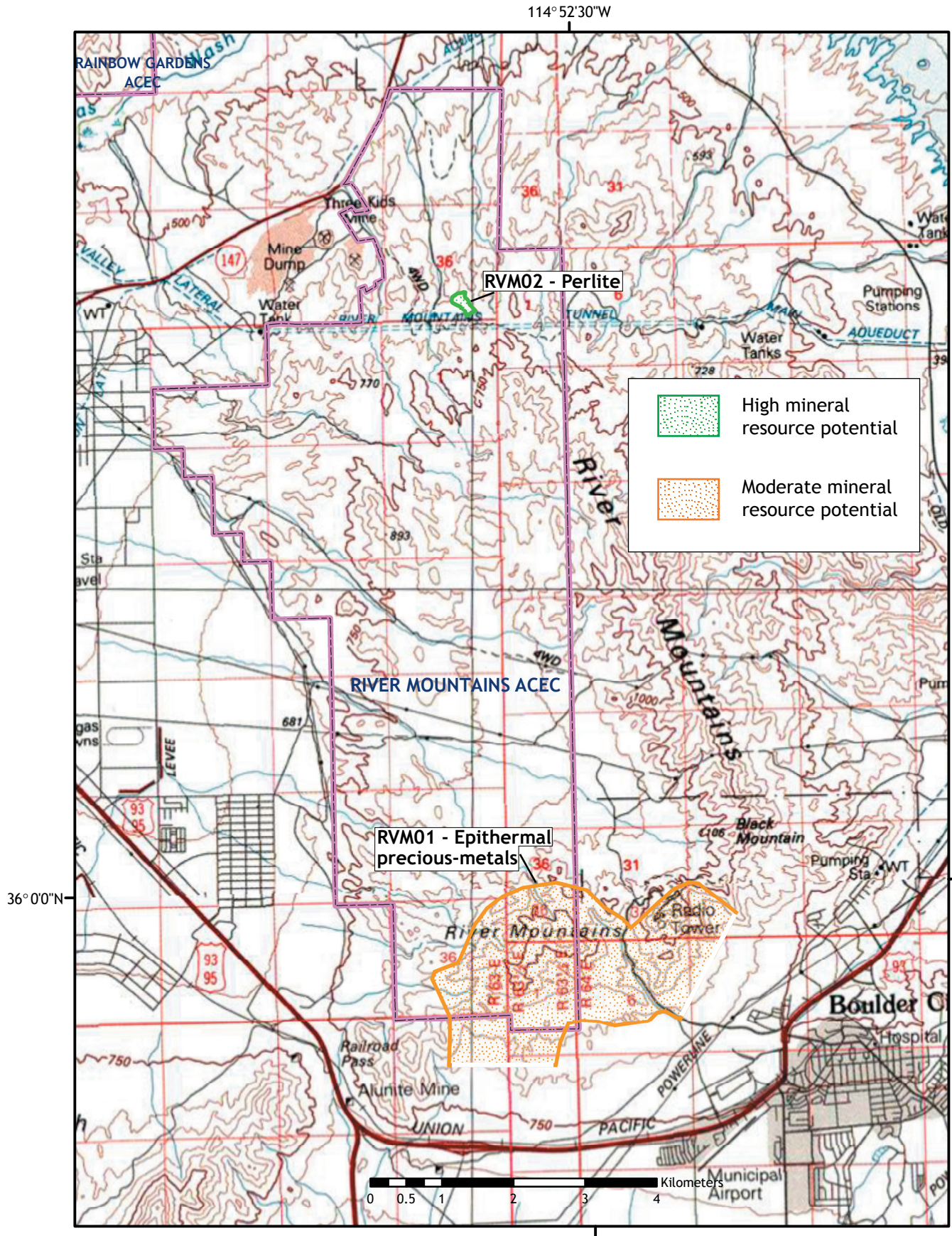


Figure 11. Mineral resource potential tracts for locatable and leasable minerals in the River Mountains Area of Critical Environmental Concern (ACEC; outlined in pink).

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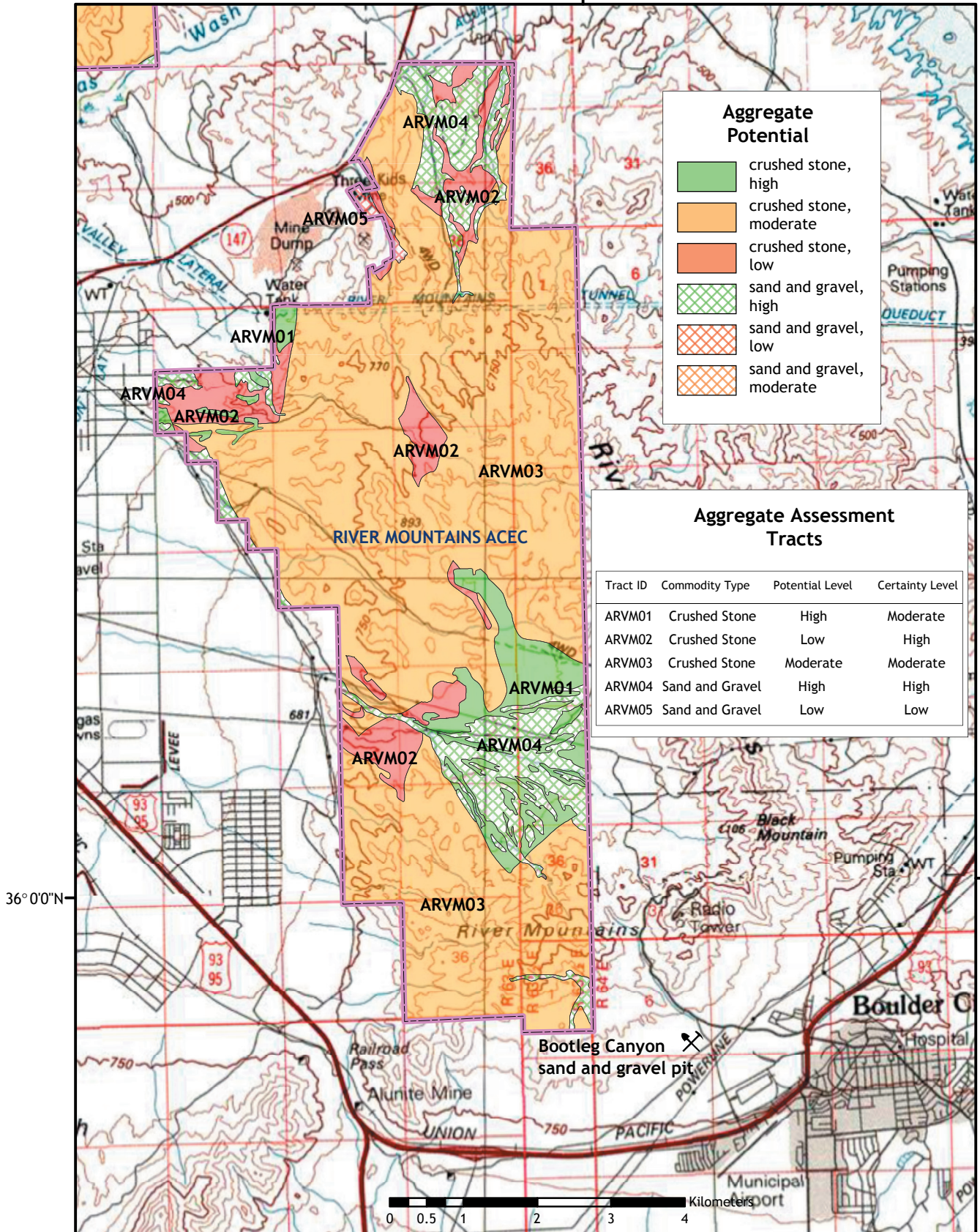


Figure 12. Mineral resource potential tracts for aggregate resources in the River Mountains Area of Critical Environmental Concern (ACEC; outlined in pink).

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