Mineral Resource Assessment of Selected Areas in Clark and Nye Counties, Nevada, Edited by Steve Ludington
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Chapter B. Mineral Resource Potential of the Piute-Eldorado Tortoise, Crescent Townsite, and Keyhole Canyon Areas of Critical Environmental Concern, Clark County, Nevada

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Summary and Conclusions

The Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC) contains areas related to the Searchlight mining district with both high and moderate potential for Searchlight-type gold-bearing vein deposits. Also related to the Searchlight mining district are areas with moderate and low potential for porphyry copper deposits. The ACEC also contains areas related to the Crescent mining district with high potential for gold-bearing polymetallic vein deposits and also additional moderate potential for detachment-fault-related gold deposits. A large area in the Piute-Eldorado Tortoise ACEC has moderate potential for perlite deposits; a very small area has high potential for perlite deposits. Potential for other deposits of locatable or leasable minerals is low.

The Piute-Eldorado Tortoise ACEC contains areas that have high, moderate, and low potential for crushed-stone aggregate deposits. It has large areas that have high potential for sand and gravel aggregate deposits, as well as smaller areas with moderate potential.

The Crescent Townsite ACEC has high mineral resource potential for gold-bearing polymetallic veins, and part of it has additional moderate potential for detachment-fault-related gold deposits. The ACEC has moderate potential for crushed-stone aggregate deposits, and high potential for sand and gravel aggregate deposits.

The Keyhole Canyon ACEC has low potential for locatable or leasable mineral deposits. The ACEC contains areas with both high and moderate mineral resource potential for crushed-stone aggregate deposits. It has high potential for sand and gravel aggregate deposits.

All three areas will likely see continued production of decorative stone from private inholdings within the ACECs.

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 on these lands.

The Piute-Eldorado Tortoise, Crescent Townsite, and Keyhole Canyon Areas of Critical Environmental Concern (ACECs) were studied in the field for several months to confirm descriptions of the geology that are published in the scientific literature. Reconnaissance mapping was conducted in the many areas that had not yet been geologically mapped at scales appropriate to this assessment. More than 200 samples were collected and analyzed (Ludington and others, 2005), and representatives of companies with mining and mineral exploration operations in and near the areas were contacted.

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

Lands Involved

This report describes three areas of critical environmental concern (ACECs), the Piute-Eldorado Tortoise, the Crescent Townsite, and the Keyhole Canyon. The small Crescent Townsite ACEC is near the western part of the Piute-Eldorado Tortoise ACEC, a few hundred meters away from the boundary. The Keyhole Canyon ACEC is about 4 km north of the north boundary of the Piute-Eldorado Tortoise ACEC. Together, these three ACECs will be referred to in this report as the Piute-Eldorado ACECs (fig. 1). A legal description of these lands is included in appendix 2.

The Piute-Eldorado Tortoise ACEC consists primarily of the valley floors of Eldorado and Piute Valleys that drain north and south, respectively, from a drainage divide near the town of Searchlight (fig. 1). A small part of Ivanpah Valley is also included, adjacent to the California border west of Crescent townsite. Two large islands of land are excluded from the Piute-Eldorado Tortoise ACEC, one in the northwest part to

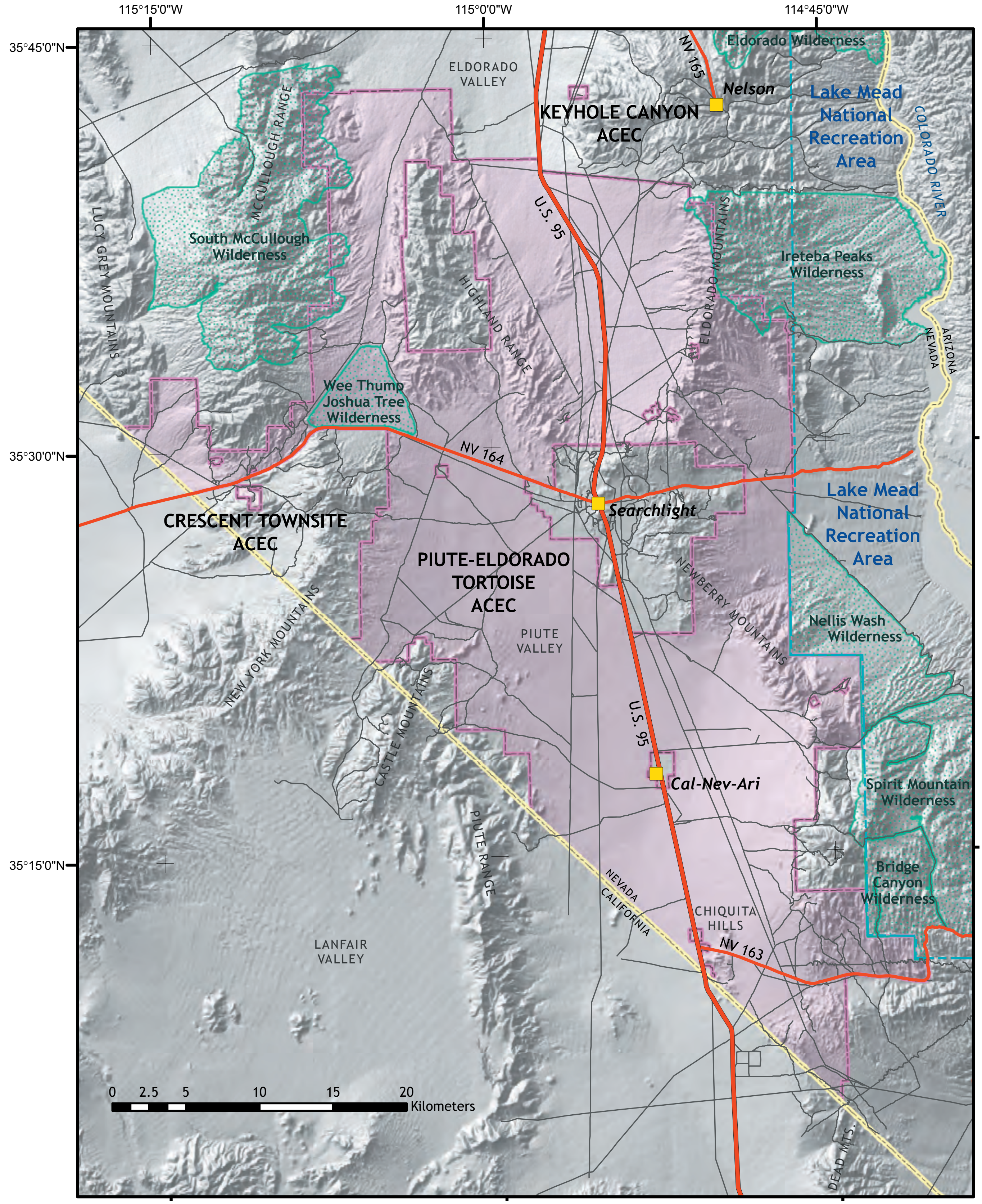


Figure 1. Index map, showing boundaries of Areas of Critical Environmental Concern (ACEC; outlined in pink), wilderness areas (outlined in turquoise), and access roads throughout the Piute-Eldorado ACECs. The boundary of the Lake Mead National Recreation Area is shown as a broken green line.

exclude the rugged peaks of the northern Highland Range, and one in the east-central part to exclude the town of Searchlight and some parts of the Searchlight mining district. The ACEC has an area of about 1,316 km^2. It is bisected in a north-south direction by U.S. Highway 95 and in an east-west direction by Nevada State Highway 164. Access is via an extensive network of secondary roads that lead to various parts of the ACEC from these highways (fig. 1).

The Keyhole Canyon ACEC has an area of slightly less than 1 km^2 and includes the mouth of Keyhole Canyon, on the west margin of the Eldorado Mountains, and a part of Eldorado Valley. It is accessed by secondary roads from U.S. Highway 95, about 3 km to the west.

The Crescent Townsite ACEC has an area of about 1.8 km^2 and is near the head of Big Tiger Wash, a tributary valley to Ivanpah Valley. It is apparently intended to preserve the historic site of the mining town of Crescent, although existing maps indicate that the townsite is mostly north of the ACEC, probably on private land. The ACEC is accessed by a secondary road off Nevada State Highway 164.

The Piute-Eldorado Tortoise ACEC is bordered on the east by the Lake Mead National Recreation Area. It also includes all or part of three existing wilderness areas and borders three more (fig. 1).

Along the northwest boundary of the ACEC, small parcels of land that are part of the South McCullough Wilderness are included within the ACEC. The U.S. Geological Survey and U.S. Bureau of Mines studied this area in the late 1980s (Close, 1987; Barton and Day, 1988; DeWitt and others, 1989).

Along the northeast boundary of the ACEC, several square kilometers of land that are part of the Ireteba Peaks Wilderness are included within the ACEC. The U.S. Geological Survey and the U.S. Bureau of Mines also studied this area in the late 1980s (Causey, 1988a,b; McHugh and others, 1989; Conrad and others, 1991).

In the western part of the ACEC, the Wee Thump Joshua Tree Wilderness was designated in 2002, without study for mineral resources.

The ACEC is bordered on the east by the Nellis Wash Wilderness, the Spirit Mountain Wilderness, and the Bridge Canyon Wilderness, all designated in 2002 without study for mineral resources. These three Wilderness Areas are within the Lake Mead National Recreation Area.

Physiographic Description

Elevations in the Piute-Eldorado ACECs range from about 550 m to more than 1,600 m. The lowest areas are along the east margin of the Piute-Eldorado Tortoise ACEC, on the alluvial fan that drops from the Newberry Mountains down to the Colorado River (about 550 m) and on the north end of Eldorado Valley and the south end of Piute Valley (about 750 m). The highest areas are the crests of the Ireteba Peaks (about 1,500 m) in the northeast part of Piute-Eldorado Tortoise ACEC and on the east flank of the McCullough Range northeast of Crescent townsite (more than 1,600 m).

The majority of the area is occupied by the Eldorado Valley that drains to the north and the Piute Valley that drains to the south. The climate is extremely dry and subject to extreme temperature variations; there are no perennial streams. The sediments that fill both the Eldorado and Piute Valleys are relatively thin compared to other valleys in the Basin and Range physiographic province (Jachens and Moring, 1990). These valleys are not grabens, and the alluvial fill in the Piute Valley is no deeper than about 700 m. The northern part of the Eldorado Valley (outside the ACEC) is somewhat deeper, but large parts of the east margin of the valley are covered by less than 1,000 m of alluvium. Pediments are relatively wide, especially on the west flank of the Eldorado and Newberry Mountains, and in Big Tiger Wash (fig. 2). In the south half of the ACEC, most of the Piute Valley is covered by less than 500 m of deposits.

The vegetation is strongly zoned according to altitude, and the lower parts of the area are typical of much of the desert southwest of the United States. Some details about the vegetation can be found in Longwell and others (1965).

Geologic Setting

The areas studied are located in the northern Colorado River extensional corridor, a term first used by Faulds and others (2001). The corridor is characterized by closely spaced normal faults that originally formed as near-vertical tensile fractures and then rotated to low angles during progressive extension. This region occupies the area between the tec-

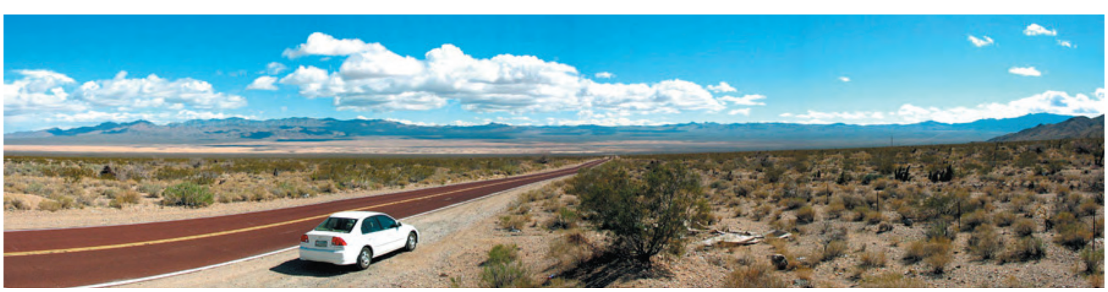


Figure 2. View of McCullough Range from the west, looking toward Big Tiger Wash, showing subdued topography and pediment surface.

tonically stable Colorado Plateaus region to the east and the Mojave Desert province to the west, which is bounded by two large strike-slip fault zones, the Garlock and the San Andreas. The rocks exposed in the Piute-Eldorado area include large areas of Proterozoic metamorphic and igneous rocks that are overlain by varied late Tertiary volcanic and sedimentary rocks. Cretaceous granitoid rocks were emplaced into the Proterozoic rocks and Miocene intrusions cut both the Proterozoic and Tertiary rocks.

Geology

Rocks and mineral deposits in the Piute-Eldorado ACECs range in age from Early Proterozoic to Recent. Proterozoic sedimentary and volcanic rocks were probably deposited between about 1.7 and 1.8 Ga and then deformed and metamorphosed between about 1.76 and 1.68 Ga (Wooden and Miller, 1990; Howard and others, 2003; Hook and others, 2005). Although no Paleozoic rocks are exposed in the area, it is likely that they were present but stripped off by erosion from early Eocene to middle Miocene time, when the area was uplifted as a broad arch (Bohannon, 1984). Tertiary volcanic rocks (and minor sedimentary rocks) range in age from the 18.5 Ma Peach Springs tuff (Nielson and others, 1990) to about 11 Ma (mafic rocks of the Mt. Davis volcanics; Faulds, 1995).

Proterozoic Rocks

Proterozoic rocks, mostly schists, gneisses, and granitoid rocks, are exposed in the McCullough Range and the northern New York Mountains, on the west margin of the Piute-Eldorado Tortoise ACEC, and in the Eldorado and Newberry Mountains, on the east margin of the ACEC. On the basis of sparse regional isotopic ages, Volborth (1973) speculated that the schists and gneisses in the Piute-Eldorado area formed at 1.7 Ga, but he also reported younger isotopic ages that he believed were reset during recrystallization in Cretaceous and Tertiary time. Volborth described the schists and gneisses in the Eldorado, Newberry, and Dead Mountains as granulite facies rocks containing almandine, sillimanite, cordierite, feldspar, quartz, and some pyroxene and biotite. He further noted the presence of numerous small gabbroic and ultramafic intrusions, as well as abundant pegmatite and aplite masses in some areas.

Figure 3. Proterozoic gneiss outcrop in Eldorado Mountains.

Anderson and others (1985) mapped and described Early Proterozoic metamorphic rocks in the McCullough Range as low-pressure granulite-facies paragneisses with garnet, sillimanite, and cordierite. The gneiss also includes abundant coarse leucogranite bodies and local masses of amphibolite and meta-ultramafic rock that is reportedly similar to that in the Virgin Peak-Gold Butte area. It is intruded by Proterozoic granitic to dioritic rocks that were emplaced late in the metamorphic history of the region. Regional research in the eastern Mojave Desert (Wooden and Miller, 1990), which included sampling in the McCullough Mountains, has shown that the oldest supracrustal Proterozoic rocks give minimum ages of 1.9 to 2.3 Ga, and these were intruded by 1.72 to 1.76 Ga plutons. The metamorphism and deformation were named the Ivanpah orogeny by Wooden and Miller (1990, 1991), who also reported age data for 1.63- to 1.69-Ga postorogenic intrusive rocks in the region. Mapping of these Proterozoic rocks in the New York Mountains and the south end of the McCullough Mountains (Miller and Wooden, 1993) showed that Early Proterozoic gneiss exposed along the west border of the Piute-Eldorado Tortoise ACEC is complexly mixed with postorogenic intrusive rock along the eastern border of an extensive area of plutonic rocks. Miller and Wooden (1993) subdivided these postorogenic rocks, which are mostly composed of granodiorite and leucocratic granite, into the 1.68- to 1.69-Ga New York Mountain complex in California and the subcircular 1.66- to 1.68-Ga Big Tiger Wash complex in the Crescent region.

Large areas of porphyritic Precambrian granitic rocks (hornblende-biotite monzogranite and syenogranite), commonly partially crushed and recrystallized, were mapped in the Eldorado and Newberry Mountains by Volborth (1973) and correlated with the Gold Butte Granite 70 km to the northeast. Volborth referred to these rocks as “pseudo rapakivi” granites, on the basis of their resemblance to similar Precambrian rocks in Finland. Bingler and Bonham (1973) mapped a large mass of similar rock, which they called augen gneiss, in the north part of the Lucy Gray Mountains. Kwok (1983) and Anderson and Bender (1989) studied some of the porphyritic granites in the Newberry and Dead Mountains, confirming Volborth’s correlation. They proposed that the hornblende-biotite granitoids in the Newberry, Dead, and Lucy Gray Mountains, along with the Gold Butte granite, were part of a transcontinental 1.45-Ga zone of anorogenic granitic plutonism. They also included abundant occurrences of similar granitic rock in nearby southeastern California and western Arizona in this zone. The Eldorado Mountains also contain some strongly foliated felsic gneisses that appear to be the host rock for the porphyritic granites (fig. 3) and can be presumed to be older than 1.4 Ga.

Cretaceous Plutonic Rocks

Three Cretaceous plutons occur in or near the Piute-Eldorado ACECs: the White Rock Wash pluton, the Ireteba pluton, and an unnamed intrusion in the Crescent mining district (fig. 4).

White Rock Wash Pluton

The White Rock Wash pluton is located on the east flank of the Newberry Mountains, along the Colorado River a few kilometers east of the Piute-Eldorado ACEC (fig. 4). It has been dated by Rb-Sr methods at about 65 Ma (Haapala and others, 2005) and by U-Pb methods at 68.5 Ma (Miller and others, 1997), and its age may actually span the Cretaceous-Paleocene time boundary. It is a medium- to coarse-grained two-mica granite, consisting of plagioclase more abundant than orthoclase, quartz, biotite, and muscovite. Accessory

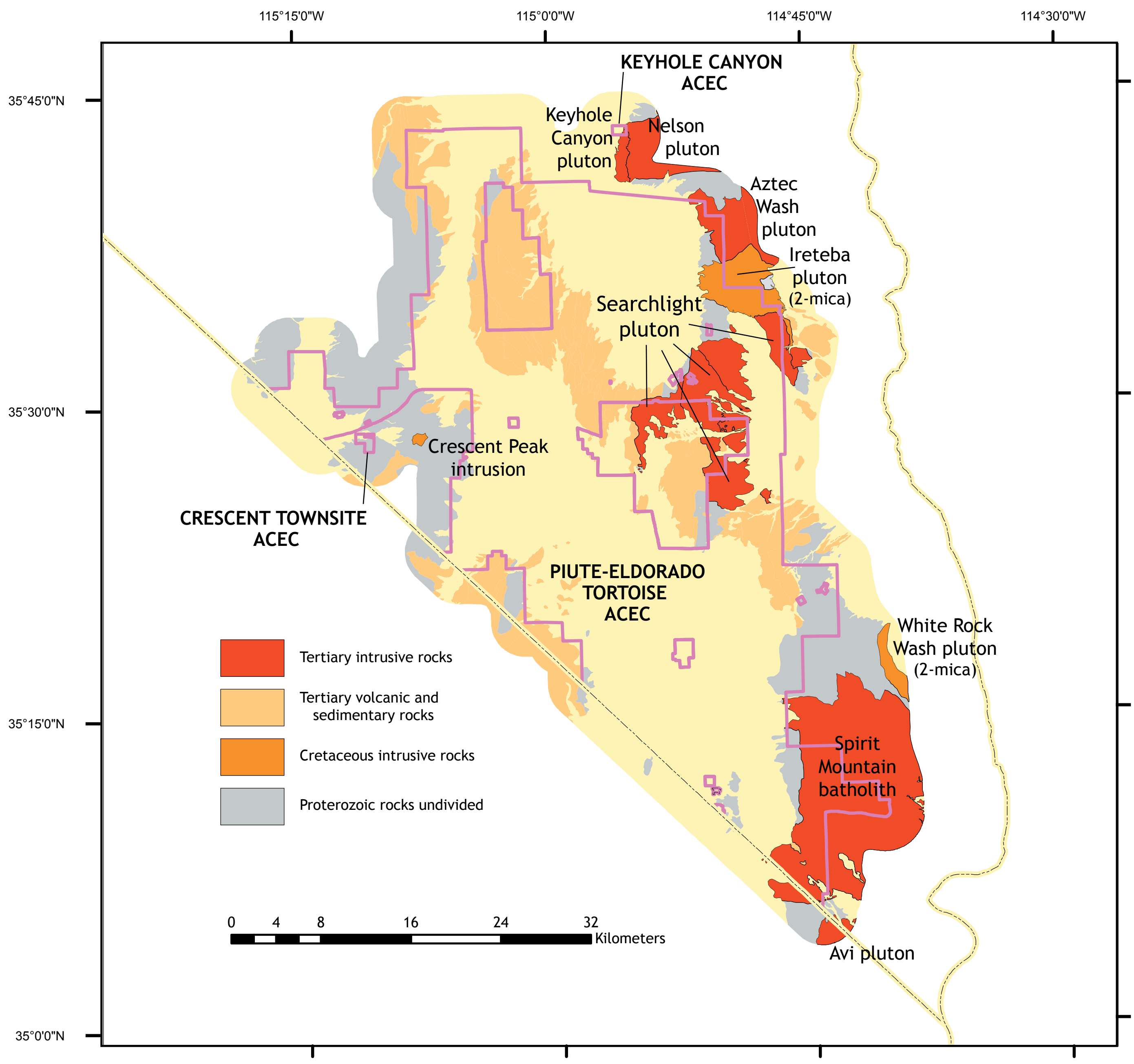


Figure 4. Index map showing named plutons exposed in Piute-Eldorado Areas of Critical Environmental Concern (ACECs; outlined in pink). Miocene plutons are in red, Cretaceous plutons are in orange.

minerals include magnetite, apatite, zircon, and rare garnet. Both neodymium and strontium isotopic studies indicate the pluton formed from melting of Proterozoic crustal rocks (Haapala and others, 2005). It is part of a suite of peraluminous granites of latest Cretaceous age found throughout the Cordillera that show a strong crustal isotopic signature and probably formed by melting of the crust at depths greater than 35 km (Miller and Bradfish, 1980; Miller and Barton, 1987; Miller and others, 2003).

Ireteba Pluton

The Ireteba pluton is located north of Searchlight, where it occupies the crest of the Eldorado Mountains, intruding Proterozoic metamorphic rocks (fig. 4). Dates obtained by U-Pb methods constrain the age of the pluton to be 69 to 64 Ma, nearly the same as the White Rock Wash pluton (Kapp and others, 2002). Most of the rock is granite, between about 72 and 77 percent SiO_2. The major minerals of the granite are plagioclase, quartz, K-feldspar, biotite, primary muscovite, and garnet. Accessory minerals include magnetite±ilmenite, apatite, zircon, and monazite. In the southeastern part of the pluton, abundant mafic dikes and inclusions indicate a zone of extensive interaction with mafic magmas. Neodymium and strontium isotope studies show the same crustal signature as the White Rock Wash pluton (Kapp and others, 2002).

Granodiorite in Crescent Mining District

A medium-gray equigranular biotite granodiorite that is exposed in limited outcrops in the Crescent mining district (fig. 4) has a hypabyssal texture, and it may be related to the porphyry copper prospect at Crescent Peak. Biotite from this rock was dated by conventional K-Ar methods at about 94 Ma (Miller and Wooden, 1993), but little more is known about this rock.

Tertiary Volcanic and Sedimentary Rocks

The stratigraphy of the northern Colorado River extensional corridor is characterized by thick sections (generally >3 km) of Tertiary volcanic and sedimentary strata that rest directly on Proterozoic and Late Cretaceous metamorphic and plutonic rock. Although preserved to the north, east, and west of the region, Paleozoic and Mesozoic strata are missing from all but the northernmost part of the corridor. Wherever Tertiary rocks can be observed in contact with Proterozoic basement, they are separated by a profound nonconformity that reflects a relatively subdued topography that had been created by Miocene time. Tertiary sections in the bulk of the northern Colorado River extensional corridor are dominated by Miocene volcanic rocks, including felsic to mafic lavas, volcanic breccia, and ash-flow tuffs, which are interlayered with lesser amounts of clastic sedimentary rocks and rock avalanche deposits.

Conglomerate (Pre-Peach Springs Tuff)

The oldest Tertiary rocks in the area consist of a thin layer of poorly sorted arkosic conglomerate that is found sporadically throughout the area (Faulds and others, 2001). This unit varies in thickness from 0 to no more than about 100 m. Its age is bracketed between about 24 and 18.3 Ma (Beard, 1996; Faulds and others, 1995, 2001). Nearby, in other parts of the Colorado River Extensional Corridor, there are pre-Peach Springs Tuff mafic and intermediate-composition lavas (Faulds and others, 2001), but none of these crop out within the Piute-Eldorado ACECs.

Peach Springs Tuff

The 18.5 Ma Peach Springs Tuff is widely distributed throughout western Arizona and the eastern part of the Mojave Desert (Glazner and others, 1986; Nielson and others, 1990). It is a massive moderately welded rhyolitic ash-flow tuff characterized by abundant large sanidine phenocrysts that commonly exhibit blue adularescence. In the study area, it is a distal outflow facies tuff whose source, although a matter of much discussion, is still unknown. The source was interpreted to be in the Colorado River trough near the south tip of Nevada by Glazner and others (1986), on the basis of systematic variations in thickness. A study of magmatic anisotropy as an indicator of flow direction in the tuff reached the same conclusion (Hillhouse and Wells, 1991). It is an important marker bed because of its wide distribution.

Volcanics of the Highland Range

A volcanic and sedimentary sequence of early to middle Miocene rocks as thick as 4 km makes up the Highland Range in the northern part of the Piute-Eldorado Tortoise ACEC. These rocks have been mapped and studied extensively by Faulds and others (2002a, b). They mark the site of the Miocene Searchlight volcanic center, and host the important gold deposits of the Searchlight district.

Lower Intermediate-Composition Unit.—Lying directly on Peach Springs Tuff or Proterozoic basement rocks is a 1.5-km-thick sequence of trachydacite and trachyandesite lavas that range in age from 18.5 to about 16.3 Ma (Faulds and others, 2002a,b). The rocks range from about 55 percent to about 67 percent SiO_2 (Faulds and others, 2002a; Ludington and others, 2005) and straddle the boundary between alkaline and subalkaline compositions. Grain size ranges from coarse to fine (fig. 5); some, but not all, of the rocks are porphyritic, most commonly with phenocrysts of plagioclase, with some phenocrysts of hornblende. It is seldom possible to map individual flows more than about 100 m, but scattered measurements of layering indicate that the attitudes are consistent within any one area.

Middle Felsic Unit.—Above the intermediate-composition rocks is a sequence of rhyolite flows, tuffs, and tuffaceous sediments, as much as 1 km thick. The unit also contains

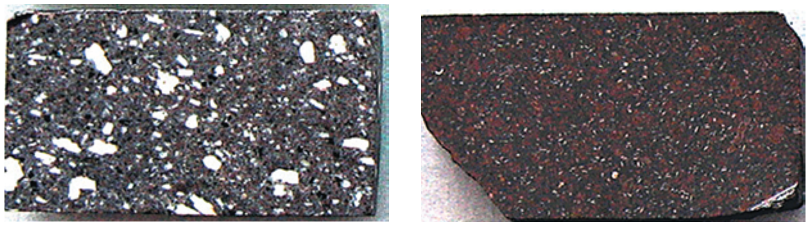


Figure 5. Unaltered trachyandesite, coarsely porphyritic on the left (sample 5-061106); finer-grained on the right (sample 5-061108). Images are approximately actual size.

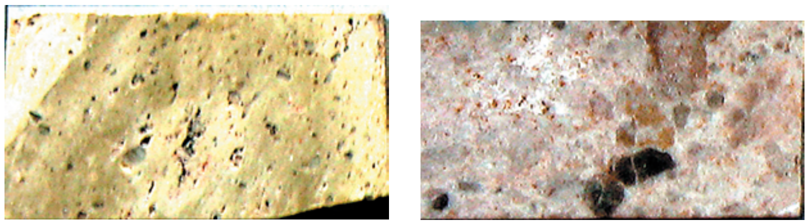


Figure 6. Rhyolite, unaltered flow on the left (sample 4-050511); alunite-altered breccia on the right (sample 4-043006). Images are approximately actual size.

some subvolcanic intrusions. The silica content of these rocks ranges from about 67 percent to more than 77 percent SiO_2, with most analyses between 73 and 77 percent (Ludington and others, 2005; Faulds and others, 2002a). Age dates obtained by $^{40}Ar/^{39}Ar$ methods (Faulds and others, 2002b) indicate the unit was emplaced between about 16.3 and 16.0 Ma, whereas more recent U-Pb dates (Dodge and others, 2005) are as young as 15.9 Ma. North of the Searchlight district, some outcrops of glassy rhyolite vitrophyre occur, but most of the rhyolite is crystalline (fig. 5). In the hills immediately west of the Searchlight district, most of the rhyolite has been hydrothermally altered to quartz and alunite (figs. 6, 7).

Figure 7. Rhyolite outcrops on hills in the western part of the Searchlight district. Most of these rocks bear abundant alunite.

Upper Mafic Unit.—Overlying the felsic unit is a unit that is as much as 1.2 km thick, composed mostly of basaltic trachyandesite flows (fig. 8). The unit thickens northwestward toward the central part of the Highland Range where apparent remnants of a small stratovolcano that was the source of these flows are exposed. These rocks generally contain between about 56 and 60 percent SiO_2 and have ages between about 16.0 and 15.2 Ma (Faulds and others, 2002a,b).

Patsy Mine Volcanics

Originally defined by Longwell (1963), this sequence of rocks is correlative with the volcanics of the Highland Range, with dates ranging from 18.5 to 15.3 Ma (Gans and Bohrson, 1998). The name, Patsy Mine Volcanics, was originally applied to the volcanic rocks exposed in the northern Eldorado Mountains, on the north side of the Nelson mining

Figure 8. Basaltic trachyandesite of upper part of the volcanics of the Highland Range overlying rhyolite of the middle part, directly north of the Searchlight district, within the Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC).

district. Within the Piute Eldorado ACECs, these rocks are found in the McCullough Range south of McCullough Pass. There are also exposures about 3 km beyond the northeast margin of the Piute-Eldorado Tortoise ACEC and about 4 km northeast of the Keyhole Canyon ACEC. These rocks were divided by Hansen (1962) and Anderson (1971) into three informal parts, the lower, middle, and upper. The lower part is up to about 2,700 m thick and consists of andesite and basaltic andesite lava flows, flow breccias, and explosion breccias. The middle part is predominantly rhyolite lava flows and is about 300 to 800 m thick. The upper part is relatively thin (about 500 m) and consists mostly of dark basaltic andesite flows (Anderson, 1971).

The petrology and age of these rocks are similar to that of the volcanics of the Highland Range, and whereas the lower part of the sequence probably had a local source, possibly the Nelson pluton, the uppermost part of both sequences may have had some of the same source areas in the central Highland Range (Faulds and others, 2002a).

Tuff of Bridge Spring and Tuff of Mount Davis

The 15.2 Ma tuff of Bridge Spring and the 15.0 Ma tuff of Mount Davis are compositionally similar, regionally extensive ash-flow tuffs that are exposed in the northwestern part of the Piute-Eldorado Tortoise ACEC. The tuff of Bridge Spring was first distinguished and described by Anderson (1971), whereas the tuff of Mount Davis was not described until the report of Faulds (1995). The two tuffs are both rhyolitic in composition and can be confused in the field, because the tuff of Mount Davis commonly lies directly on the tuff of Bridge Spring. Together, they form an important marker horizon in the area. The source of the tuff of Bridge Spring is interpreted to be a caldera in the northwestern part of the Eldorado Mountains, about 15 km northwest of Nelson (Gans and others, 1994). The source of the tuff of Mount Davis is unknown, but it may have been erupted from the same caldera (Faulds and others, 2002a,b). Both tuffs are rhyolitic in composition, and some outcrops of the tuff of Bridge Spring exhibit distinctive fiamme (flattened pumice fragments) (fig. 9).

Figure 9. Tuff of Bridge Spring on McCullough Pass road, near the northwest corner of the Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC). Note prominent large (up to 10 cm) fiamme (flattened pumice fragments) on rock face.

Conglomerate, Megabreccia, and Sandstone

Megabreccias (landslide deposits) that commonly contain abundant clasts derived from Proterozoic rocks are found throughout the synextensional part of the volcanic section. Such rocks are found directly beneath the tuff of Bridge Spring, between the tuff of Bridge Spring and the tuff of Mount Davis, and within a thick unit of conglomerate and sandstone that overlies the tuff of Mount Davis. Conglomerate and sandstone in the Highland Range appear to be the distal part of a large fanglomerate sheet that was partly derived from the southern McCullough Range.

Younger Volcanic Rocks

The Mount Davis Volcanics were first described by Anderson (1971) and consist of synextensional and late extensional basalt and basaltic andesite flows interbedded with minor amounts of sedimentary rocks (sandstones and conglomerates). They are exposed just east of the northeastern part of the Piute-Eldorado ACECs in the northern part of the McCullough Range and in a few localities in the central and northern Highland Range. Their age is bracketed between 15.2 and 12.8 Ma (Faulds, 1995; Faulds and others, 1995; 2002a,b).

In the surrounding area, younger volcanic rocks include tholeiitic basalts with ages between 11.9 and 8.9 Ma, basaltic andesites with ages between 10.6 and 8.0 Ma, and alkalic basalts with ages between 6.0 and 4.5 Ma (Faulds and others, 2001). These young rocks do not crop out within the Piute-Eldorado ACECs, but an 11-Ma basalt flow is exposed directly to the east on the east flank of the southern Eldorado Mountains.

Tertiary Intrusive Rocks

A series of Miocene intrusive bodies are emplaced into the Proterozoic basement and Miocene volcanic rocks in the Black, Newberry, and Eldorado Mountains. From south to north, they are designated the Avi pluton, the Spirit Mountain batholith, the Searchlight pluton, the Aztec Wash pluton, the Keyhole Canyon pluton, and the Nelson pluton (fig 4).

Avi Pluton

This pluton is located just to the south of the Piute-Eldorado Tortoise ACEC (fig. 4), and it has not been studied in detail, nor dated. We took one sample (4-101201) that has a silica content of about 67 percent (Ludington and others,

2005) and is classified as a quartz monzonite. We infer that it is about the same age as the Spirit Mountain batholith, or slightly older. No apparent mineralization was associated with the emplacement of this pluton.

Spirit Mountain Batholith

The Spirit Mountain batholith has an outcrop area of about 250 km^2 (figs. 10, 11) and consists of Miocene intrusive rocks that were emplaced over a 2 million-year time span (17.4 to 15.3 Ma) (Walker and others, 2005; Walker, 2006). Rämö and others (1999) determined a whole-rock Rb-Sr age of about 20 Ma for the granite. The compositions range from high-silica granite (about 77 percent SiO_2) near the roof of the body (fig. 12) to quartz monzonite (about 63 percent SiO_2) in the interior. Most of the batholith is composed of granite that was emplaced in a somewhat more restricted time interval between about 17.0 and 16.0 Ma (Walker, 2006). Fine- to medium-grained diorite is common in the eastern part of the batholith, occurring as dikes and pod-like intrusions. No hydrothermal mineralization can be directly attributed to the emplacement of the Spirit Mountain batholith.

Figure 10. Outcrops of massive granite of Spirit Mountain batholith, near the southernmost tip of the Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC).

Figure 11. Spirit Mountain, at the north end of the Spirit Mountain batholith.

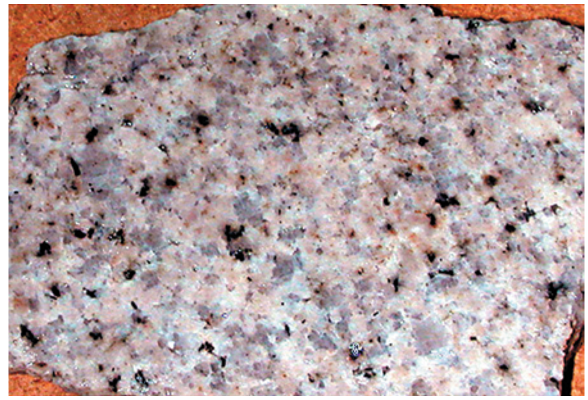


Figure 12. Granite from near the roof of the Spirit Mountain batholith. Sample 4-101103 has about 76 percent SiO_2 (Ludington and others, 2005). Image is approximately actual size.

At about 15.3 Ma, numerous granitic dikes were injected into the Spirit Mountain batholith. These have been called the Newberry Mountains dike swarm, and they represent the last pulse of the magmatic system that formed the Spirit Mountain batholith (George and others, 2005). These dikes all strike nearly north, and dip east at 40 to 60 degrees. They have been rotated westward 30 to 50 degrees from their original near-vertical attitude. This rotation has been documented using paleomagnetic techniques by Faulds and others (1992). Because tectonic tilting in the region is documented to have begun as early as 16 Ma (Faulds and others, 2001), the Newberry Mountains dike swarm may have been emplaced very rapidly during the tectonic extension.

Searchlight Pluton

The Searchlight pluton has a surface outcrop area of about 80 km^2 in the southern Eldorado and northern Newberry Mountains (fig. 4) and consists of Miocene intrusive rocks that were emplaced over a period of at least 1 million years (16.9 to 15.7 Ma) (Cates and others, 2003). The pluton has been classified into three lithologically distinct units by Bachl and others (2001).

Upper Quartz Monzonite Unit.—The uppermost unit is primarily relatively fine-grained quartz monzonite (fig. 13) that generally contains about 64 to 68 percent SiO_2 but ranges from a low of about 58 percent to a high of about 70 percent (Ludington and others, 2005). This unit intrudes the lower intermediate-composition unit of the volcanics of the Highland Range and lies in all cases just below the productive precious-metal veins of the Searchlight district. The major minerals are plagioclase, potassium feldspar, quartz, biotite, and hornblende. Accessory minerals include titanomagnetite, sphene, apatite, allanite, and zircon (Bachl and others, 2001).

In the roof zone of the upper unit, porphyritic rocks with a very fine-grained groundmass are common (fig. 14).

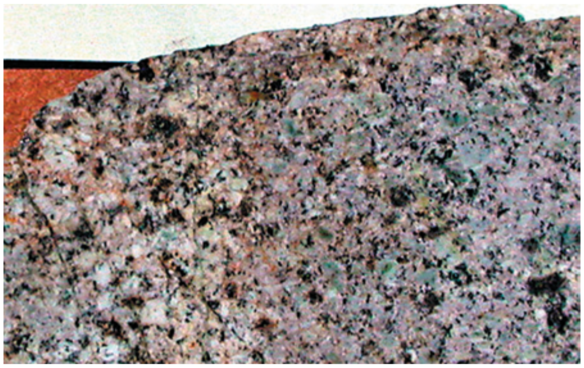


Figure 13. Quartz monzonite from very near the roof of the upper unit of the Searchlight pluton. This is sample 4-031004, which contains about 64 percent SiO_2 (Ludington and others, 2005). Note the faint green color of some of the plagioclase crystals, indicating mild hydrothermal alteration to illite and/or clay minerals. Image is approximately actual size.

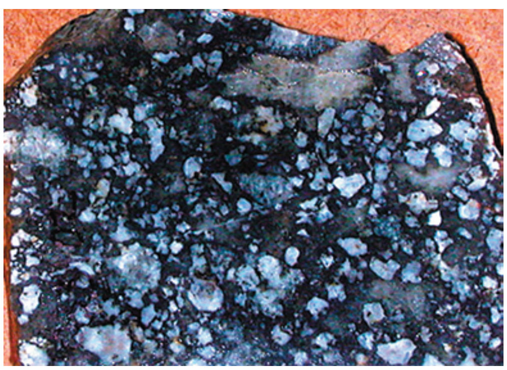


Figure 14. Fine-grained porphyritic phase of upper unit of the Searchlight pluton. Sample 4-033102 contains about 58 percent SiO_2 (Ludington and others, 2005). Image is approximately actual size.

Outcrops are generally poor in this region, and it is usually impossible to observe crosscutting relationships. However, a few contacts were observed, and this fine-grained rock appears to always be cut by the phaneritic quartz monzonite and to intrude the volcanic rocks of the roof. This earliest intrusive phase of the Searchlight pluton may be representative of the composition of the original magma.

Middle Granitic Unit.—Structurally below the quartz monzonite is a coherent unit of granite that contains about 70 to 77 percent SiO_2. Much of this granite formed as a cumulate and it exhibits a weak magmatic foliation in some exposures (fig. 15). The major minerals are potassium feldspar, plagioclase, quartz, and biotite. Accessory minerals include titanomagnetite, sphene, apatite, zircon, and allanite (Bachl and others, 2001).

Lower Unit.—The lowermost unit of the Searchlight pluton crops out in the eastern part of the Piute-Eldorado Tortoise ACEC, and consists primarily of coarse-grained mafic quartz monzonite that contains the same mineral assemblage as the upper unit but in different proportions. Hornblende is commonly as abundant as biotite, and large euhedral sphene crystals are particularly prominent and abundant. The lower unit is characterized by a magmatic planar fabric defined by subparallel arrangement of all elongate minerals (Bachl and others, 2001), which is overprinted by a subsolidus, mylonitic fabric. Pods of mafic rock (mostly diorite) are present throughout the unit, commonly with dimensions of meters to hundreds of meters. The field evidence, coupled with paleomagnetic studies (Faulds and others, 1998) and hornblende geobarometry clearly indicate that the entire plutonic complex is steeply tilted to the west, and that the rocks in the lower mafic unit represent the floor of the pluton at a paleodepths of about 13 km (Bachl and others, 2001).

The overall composition of the pluton is closely similar in composition to the lower intermediate-composition and middle rhyolitic parts of the volcanics of the Highland Range, and the various parts of the pluton appear to represent the preserved subvolcanic magma bodies that fed the volcanic rocks. However, only limited parts of the pluton were fluid and erupting at any one time. The overall time span exhibited by the rocks is more than 2 million years, and the complex pluton and the various layers of volcanic rock are the end result of a long series of individual magmatic events.

Faulds (1999) and Faulds and others (2002a) suggested that the altered and mineralized rocks of the Searchlight mining district represent the hydrothermal halo around the roof of the Searchlight pluton within a stratovolcano complex. The middle and lower units, in general, were not affected by hydrothermal alteration, but the upper parts of the upper unit, near the roof, commonly exhibit varying degrees of alteration, primarily of the feldspars to illite and clay minerals, and of the mafic minerals to chlorite and epidote (fig. 13). All the rocks of the pluton have been tilted steeply to the west during extension.

Aztec Wash Pluton

The Aztec Wash pluton has a surface outcrop area of about 50 km^2 in the northern Eldorado Mountains (fig. 4) and consists of Miocene intrusive rocks that were emplaced and crystallized over a somewhat shorter time period than the two large plutons to the south (about 15.8 to 15.5 Ma) (Cates and others, 2003; Koteas and others, 2003). Although there are a multitude of rock types in this pluton, it is convenient to divide it into three units (Falkner and others, 1995).

About 30 percent of the pluton is composed of the main granite, a medium-grained granite that is mostly between about 70 and 74 percent SiO_2. The major minerals are sodic plagioclase, quartz, potassium feldspar, and biotite. Accessory minerals include sphene, apatite, allanite, zircon, and opaque oxide minerals. Small miarolitic cavities characterize the unit, and they are most common at the pluton margins (Falkner and others, 1995).

Figure 15. Foliated outcrops of the granitic middle unit of the Searchlight pluton. The sample taken here (4-100802) contains about 73 percent SiO_2 (Ludington and others, 2005).

The heterogeneous zone constitutes nearly 70 percent of the pluton and is composed of diverse rocks that range in composition from mafic gabbros to felsic granites. These different rock types are interspersed on centimeter to 100-meter scales, and they locally grade into each other. The unit appears to have formed by the deposition of prograding tongues of mafic material into partially solidified granite. It occupies the interior of the pluton and is largely enclosed in older granite (Harper and others, 2005).

A third lithologic type is present as a north-trending dike swarm that is most prominent in the eastern part of the pluton. These dikes were described by Falkner and others (1995) to be bimodal in composition, but most are granitic and may be originally horizontal sheets that have been tilted into a steep attitude.

The Aztec Wash pluton contains the trace of the Black Mountain accommodation zone as delineated by Faulds and others (2002b). The pluton is divided into two parts by the Tule Wash Fault of Volborth (1973); the northeastern part of the pluton has been tilted to the east during Miocene extension, whereas the southwest part of the pluton has been tilted to the west (Falkner and others, 1995). The only mineral deposit that may be related to the Aztec Wash pluton is the silver-rich breccia zone at the Bmb No. 1 claim (see below), which appears to have been localized by the Tule Wash Fault.

Nelson Pluton

The Nelson pluton is an elongate intrusion that is mostly quartz monzonite in composition. It is located about 1 to 2 km north of the northeast boundary of the Piute-Eldorado Tortoise ACEC (fig. 4). The elongate outcrop pattern of the pluton is due to repetition by west-dipping low-angle faults that have rotated it and the volcanic section on its north side to near-vertical attitudes. This pluton is the host for many of the epithermal precious-metal deposits in the Eldorado district and may be the source of the metals (Hansen, 1962). The age of the Nelson pluton has not been studied extensively by modern radiometric methods, although Faulds and others (1992) determined a conventional K-Ar age of 16.9 Ma on biotite, and Lee and others (1995) report an age of 16.3 Ma. The pluton is older than the Aztec Wash pluton on the basis of intrusive relationships. It appears to intrude a volcanic section that includes the upper parts of the Patsy Mine Volcanics, which may be as young as 15.3 Ma (Gans and Bohrson, 1998); however, these may be mostly fault contacts. It seems likely that the Nelson pluton was emplaced during the time interval between about 17 and 15 Ma, nearly contemporaneous with the Searchlight pluton.

Keyhole Canyon Pluton

The Keyhole Canyon pluton has been studied petrologically only by Hansen (1962). It is a relatively homogenous leucocratic granite that consists of orthoclase (commonly greater than 50 percent by volume), quartz, and plagioclase. Biotite is commonly no more than 1 percent of the rock, therefore qualifying as an accessory mineral along with magnetite and sphene. This pluton is tilted to the east. The western (lower) part of the pluton is less leucocratic and has more biotite. The upper (eastern) part of the pluton is characterized, like parts of the granitic unit of the Aztec Wash pluton, by abundant miarolitic cavities. It intrudes the Nelson pluton, and two samples were dated with conventional K-Ar methods by Armstrong (1970) at 15.4 and 14.9 Ma. The Keyhole Canyon ACEC includes the northernmost tip of this pluton (fig. 16), which is not associated with any known hydrothermal mineral deposits.

Dike Swarms

Three voluminous swarms of Miocene dikes generally postdate all of the plutonic rocks described above. These dike swarms represent continued magma production and intrusion during brittle extension.

Figure 16. Massive outcrops of granite of the Keyhole Canyon pluton in the Keyhole Canyon Area of Critical Environmental Concern. Note geologist (sitting, with red shirt) in the center of photograph for scale.

A swarm of dozens of mostly felsic dikes, termed the Eldorado dike swarm by Steinwinder and others (2004), extends from the Aztec Wash pluton nearly 20 km south, where the dikes cut the Searchlight pluton (fig. 17). These dikes trend a few degrees west of north and are typically 2 to 5 m thick. Individual dikes can be traced for at least a few kilometers. Most of these dikes, particularly in the north, are nearly vertical and have not been tilted significantly. Farther south, near the Searchlight pluton, some of the dikes have been rotated westward at least 45 to 55 degrees, as evidenced by paleomagnetic studies (Faulds and others, 1992; 1998). Many of these dikes are granitic in composition (about 73 percent SiO_2), but some are as mafic as diorite (see Steinwinder and others, 2004; and analyses in Ludington and others, 2005). A single U-Pb date of 15.5 Ma has been reported by Cates and others (2003). This dike swarm is almost entirely within the northeast part of the Piute-Eldorado Tortoise ACEC.

A contrasting swarm of generally west-trending dikes is found in the upper part of the Searchlight pluton and the lower intermediate-composition unit of the volcanics of the Highland Range, southeast of the town of Searchlight, in the eastern part of the Piute-Eldorado Tortoise ACEC (Ruppert, 1999; Ruppert and Faulds, 1998). These consist of both trachydacite porphyry dikes dated at about 16.6 Ma and rhyolite dikes dated at about 16.0 Ma (Hodge and others, 2006). Analyses in Ludington and others (2005) show that the rhyolite dikes range in composition from about 68 to 77 percent SiO_2 and have compositions similar to the middle granitic unit of the Searchlight pluton. These dikes record a short period prior to the major east-west extension when the least principal stress in the region was oriented north-south during the emplacement history of the Searchlight pluton. The rhyolite dikes were emplaced at about the same time that the gold mineralization at Searchlight was occurring, that is, just before major east-west extension.

To the south, the Newberry Mountains dike swarm that cuts mostly rocks of the Spirit Mountain batholith has been described by George and others (2005) as synextensional granite (about 73 percent SiO_2) dikes that are commonly rotated westward about 30 to 50 degrees. This swarm was emplaced at about 15.3 Ma. Some of these dikes extend into the Proterozoic metamorphic rocks as much as 5 km north of the Spirit Mountain batholith.

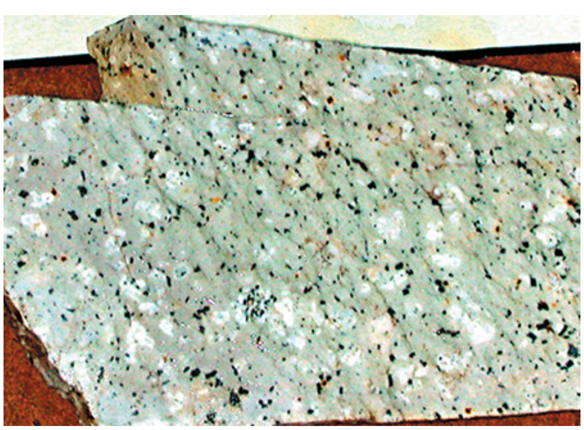


Figure 17. Granite porphyry dike from the Eldorado swarm that cuts the middle unit of the Searchlight pluton. Sample 4-043007 contains about 73 percent SiO_2 (Ludington and others, 2005). Image is approximately actual size.

Structure

The Piute-Eldorado ACECs are mostly within the northern Colorado River extensional corridor, a 70- to 100-km-wide region of moderately to highly extended crust along the eastern margin of the Basin and Range Province in southern Nevada and northwestern Arizona. The Colorado River extensional corridor was first recognized by Howard and John (1987), and the distinct nature of the northern part, which extends from about the latitude of the south tip of Nevada to the Lake Mead area, was first highlighted by Faulds and others (1990). Recent and ongoing research on the structural and magmatic history of the region now permits a major reinterpretation of the mid-Miocene hydrothermal mineralization and its structural framework in the study area. The discussion that follows is based largely on a summary of the Cenozoic evolution of the region by Faulds and others (2001), as well as incorporation of ongoing work in the area. Figure 18 illustrates the structural setting of the area.

Magmatism swept northward through the Piute-Eldorado area beginning before 18 Ma (for example, the Avi pluton) in the south and at about 13 to 15 Ma (for example, the Boulder City pluton and volcanic rocks in the River Mountains-Hoover Dam area) in the north. Much of the area experienced simultaneous and nearly continuous igneous activity between about 17.5 Ma and about 15 Ma (Spirit Mountain batholith, Searchlight pluton, Aztec Wash pluton, Nelson pluton, Keyhole Canyon pluton, volcanics of the Highland Range, and Patsy Mine Volcanics). As evidenced by the east-west orientation of several early Miocene dike swarms and mineralized veins, much of the early magmatism coincided with mild north-south extension.

Major east-west extension followed the inception of magmatism by 1 to 4 million years, beginning at the south tip of Nevada at about 19 Ma, at about 16 Ma in the vicinity of Searchlight, and at about 14 Ma in the Boulder City area, north of the Piute-Eldorado ACECs. Throughout the region, the extension has resulted in the steep tilting of Miocene volcanic and sedimentary strata (commonly as much as 90 degrees, sometimes overturned) (Faulds and others, 2001). In much of the southern part of the area, rocks older than 16 Ma dip steeply west. The Black Mountains accommodation zone extends across the northern part of the Piute-Eldorado ACEC, dividing west-dipping rocks to the south from east-dipping rocks to the north. Here, oppositely dipping normal fault systems and their resulting tilt-block domains terminate in a belt of overlapping fault tips and extensional anticlines and synclines. The area north of the Black Mountains accommodation zone is termed the Lake Mead domain and the area to the south is termed the Whipple domain.

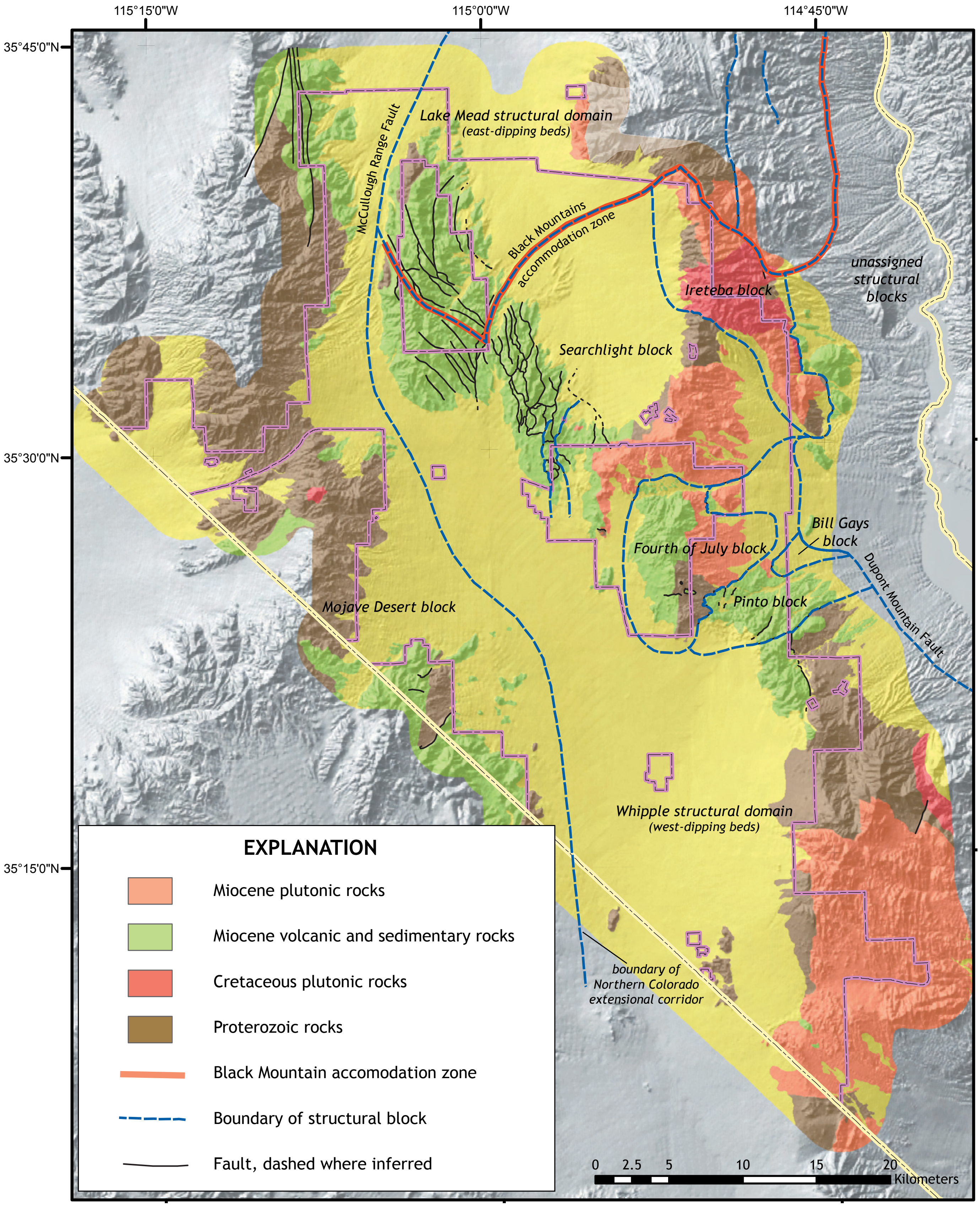


Figure 18. Map showing structural blocks and Black Mountains accommodation zone in relation to generalized geology in Piute-Eldorado Areas of Crical Environmental Concern (ACECs).

Because major east-west extension and associated tilting postdated emplacement of most of the plutons, the plutons in the Piute-Eldorado ACECs are also appreciably tilted. They are exposed from top, where they generally have intruded their own volcanic ejecta, to bottom, where they are exposed at paleodepths of 10 km or more, in what was the ductile middle crust.

The McCullough Range Fault is a poorly exposed east-dipping fault zone that essentially bounds the extensional corridor on the west. South of the study area, it links with a major breakaway zone that forms the west boundary of the extensional corridor in California (Spencer, 1985). To the west of this fault, the rocks are not steeply tilted; the southern Eldorado and Newberry Mountains and part of the Highland Range are the upthrown eastern parts of west-tilted fault blocks in the hanging wall of the McCullough Range Fault.

For convenience in discussing structural features of the study area, we have informally named a number of structural blocks, shown on figure 18. In the southern part of the area, in the Whipple domain, the boundaries of these blocks are east-dipping normal faults. These faults separate the uppermost crust of the area into discrete west-dipping structural entities. From west to east, they are here referred to as the Searchlight block, the Fourth of July block, the Pinto block, and the Bill Gays block. In the order named, each block is structurally higher than the previous one. The Searchlight, Fourth of July, and Pinto blocks each expose the upper contact of the Searchlight pluton in cross section, with each section having been east of the other prior to extension. Many additional east-dipping faults have been mapped by Faulds and others (2002a) in the Searchlight block; each of these is downthrown on the east and locally repeats parts of the stratigraphic section. Two of these are portrayed in dashed blue lines on figure 18; their northern and southern extensions pass under alluvial cover and the entire boundaries of the blocks they bound cannot be reconstructed, but they played an important role in increasing the number of exposures of the mineralized rocks above the Searchlight pluton in the Searchlight mining district.

Mining History

The history of mining within and near the Piute-Eldorado ACEC extends as much as 700 years into the past and includes prehistoric Native American activity and Spanish (or Mexican) mining that likely predated the 19th century. Except for Native American mining, the earliest mining was focused on deposits near the Colorado River, the most well traveled route at the time. The history of each of the five mining districts in this large area is given separately below in order of discovery.

Crescent District

The earliest activity in this district was prehistoric mining of turquoise by Native Americans. Turquoise is the most important commodity that has been produced in the district, and Morrissey (1968) estimated that its total value (excluding prehistoric mining) may have been in excess of $1 million. Although gold, silver, lead, and copper were mined here between 1894 and 1941, the total recorded value of metal production is small, at about $62,000 (Longwell and others, 1965).

In more modern times, turquoise was discovered in 1889 or 1890 on the south flank of Crescent Peak (about 3 km southeast of the Piute-Eldorado ACEC) by George Simmons who picked up blue rock fragments but discarded them after they failed to give strong indications of copper (Morrissey, 1968). However, following a visit to a turquoise mine in New Mexico, Simmons recognized the value of his find and returned for more thorough prospecting. He found that the turquoise source was a vein in an abandoned prehistoric mine, complete with stone tools and a primitive lapidary shop. Later work by archeologists put the date of abandonment at about A.D. 1300 (Morrissey, 1968). Most of the turquoise produced at Crescent Peak was mined from this property (known as the Toltec or Simmons Mine) between 1894 and 1906. In 1906, a 320-carat stone valued at $2,600 was found (Vanderburg, 1937). In later years, mining became sporadic because of rising mining costs and lower turquoise prices and ceased as a commercial enterprise in the 1960s. The Morgan (Iron Door) Mine, which is inside the Crescent Townsite ACEC, was worked around 1906, but produced much smaller amounts of turquoise than the Toltec Mine (Morrissey, 1968).

Early metal mining in the Crescent district took place sporadically between 1894 and 1932, followed by more consistent production between 1934 and 1941 (Longwell and others, 1965). Early metals production, between 1905 and 1907, was mostly from the Nippeno, Big Tiger, Calavada (Lily), and Double Standard Mines (Vanderburg, 1937). However, Ransome (1907), who visited the district in the winter of 1905-06, described only the Big Tiger and Calavada properties, and reported the presence of the "little settlement of Crescent, consisting of a dozen tents and wooden buildings…7 miles southeast of Nipton, on the road to Searchlight." During the 1930s, the Nippeno, Budget, Double Standard, and Colonel Sellers Mines were active (Vanderburg, 1937). Vanderburg reported that mining at the relatively remote Double Standard Mine was done by hand methods in the 1930s and the ore was packed, at the rate of three tons per day, for a mile down a steep mountain by burros and then trucked to Searchlight for treatment. On the basis of data in Longwell and others (1965), the Nippeno was the largest Crescent district producer at about $20,000, followed by the Double Standard at an estimated $15,000, and the Budget at about $10,000. However, Vanderburg (1937) reported that "production from the Nippeno property is said to have been about $40,000, mostly in shipping ore."

Two major mining companies explored the area near Crescent Peak in search of porphyry copper deposits in the late 1950s and early 1960s, and they drilled at least 6 core holes (Archbold and Santos, 1962). Prospecting for gold during the 1980s and 1990s included exploration programs for detachment-fault-related gold deposits by major mining companies, but that work has yielded no important discoveries despite the report of platinum-group elements (PGEs) by Lechler (1988).

Several former gold mines are now being exploited for decorative stone for landscaping. Current or recently active operations include those at the Lucky Dutchman, Modoc, and Nipton Red Mines and in Big Tiger Wash.

Eldorado District

Based on recorded production, about 2.3 million ounces of silver and 100,000 ounces of gold were produced from mines in the Eldorado district, mainly between 1915 and 1920 and again between 1926 and 1943 (Hansen, 1962; Longwell and others, 1965). Total value of this production was about $4.6 million, including minor copper, lead, and zinc credits. Ransome (1907) estimated production from the 19th century to the time of his visit in 1906 at $2 million to $5 million, and Vanderburg (1937) believed that most of this mining took place between 1864 and 1900. Vanderburg further noted that, based on a compilation by Yeoman Briggs, of Nelson, Nevada, production from the area was about $10 million. However, Vanderburg warned that "Briggs obtained his data from many sources, and due allowances must be made for old production figures, which have a way of increasing with time." The same caution might be applied to Ransome's (1907) estimate.

Old arrastras and prospect holes found in the 1860s were reported as evidence that the Spanish were mining in the Eldorado district prior to the recorded discovery of precious metals in 1857 at the Honest Miner claim. A mining district was organized in 1861, and the most important property, the Techatticup Mine, opened in 1863 and had produced an estimated $3.5 million by the mid 1930s (Vanderburg, 1937; Hansen, 1962). Mining continued there until 1942, but production records for the property are not available (Longwell and others, 1965). Longwell and others (1965) reported two other significant properties in the district, the Wall Street and Eldorado Rand Mines, with estimated productions of $1.75 million and $1.0 million, respectively. Vanderburg (1937) reported at least 12 other mines or prospects in the district and cited a production figure encompassing 11 mines in 1935. In addition, 1:24,000-scale topographic maps show several hundred workings scattered over an area of more than 100 km^2 in the district.

The Eldorado district is centered on the small village of Nelson, which was once an active mining town with a reputation for lawlessness. The town and most of the productive gold mining sites in the district are in Eldorado Canyon, a steep-sided canyon that empties eastward into the Colorado River. As noted by Ransome (1907), "It is a little surprising that a district once alive with activity should have attracted so little outside notice. This, however, is partly accounted for by the overshadowing performance of…other districts noted in the early history of mining in Nevada and by the isolation of Eldorado Canyon." Ransome also noted that rich ore was shipped down the Colorado River by boat during the district's early days, and that even by 1906 there were no regular means of communication with the district except for a road from Searchlight. Prior to the turn of the century, the Eldorado district was dominated by the Southwestern Mining Company, which owned nearly all of the productive properties (including the Techatticup and Wall Street Mines), along with several mills, and operated its own fleet of river boats (Vanderburg, 1937).

According to Smith and Tingley (1983) the Eldorado district was actively explored during the "1981 gold rush;" however, these authors saw no major exploration activity in the area in late 1982. Reports by the Nevada Bureau of Mines and Geology (Nevada Mineral Industry) show that the area was subject to local speculation and development during the 1980s and 1990s, but no gold production has was reported in that period, or since. Exploration during that period was carried out by Intermountain Exploration, Amselco, Exxon, Weaco, Homestake, Zephyr Resources, and Alta Gold (Robinson, 1996). In 1993, a bulk-mineable deposit with a resource of about 1.2 million short tons at a grade of 0.044 opt (troy ounces/short ton) was drilled out near the sites of the old Wall Street and Black Hawk Mines, but the deposit was not developed (Robinson, 1996).

Newberry District

The Newberry district is larger and less focused than any of the other districts in the Piute-Eldorado ACEC area. The history of mining in the area has been sketchily recorded, but 1:24,000-scale topographic maps show several widely spaced areas that contain concentrations of two to 20 individual workings. Longwell and others (1965) included some mines northeast of Searchlight in the district, but Tingley (1992) assigned these properties to the Searchlight or Eldorado districts and constrained the Newberry district to the area southeast of Searchlight. Production was estimated by Vanderburg (1937) at about $170,000, with $150,000 coming from mines of the Homestake group. This figure is based entirely on hearsay and is probably generous.

The mines of the Homestake group, which are on the east slope of the Newberry Mountains, 32 km southeast of Searchlight, were reported by Vanderburg (1937) to have been discovered and worked in the early 1860s by soldiers from Fort Mohave, Arizona. The mines were later active intermittently on a small scale between 1910 and 1937. The mines at Camp Thurman were discovered in 1906. Mines in the Roman Mine area were active in the 1930s. The history of other properties, such as the Juniper and Cottonwood Mines and the extensively prospected Superfluous-Gibraltar area in the Chiquita Hills, are not known.

The Roman Mine is being operated at present as a source of decorative stone, although the claims were apparently originally located primarily for silver.

Searchlight District

On the basis of recorded production, the Searchlight district was the second leading precious-metal mining district in Clark County (behind the Goodsprings district) with total production of about 250,000 ounces of gold (table 1). However, the Eldorado district may have been more productive if estimates of unrecorded early production of gold and silver are correct, as discussed above. Silver, copper, and lead were also produced at Searchlight, but they were relatively insignificant in terms of value. Longwell and others (1965) reported total recorded production for Searchlight at about $7 million.

In a U.S. Geological Survey bulletin on the Searchlight district, Callaghan (1939) reported production from 12 mines in the main part of the Searchlight district (which he mapped at a scale of 1:24,000) and in its extension as much as 8 km to the east. Callaghan provided detailed descriptions of many of the mines along with the carefully executed plan maps and cross sections typical of mining district publications of the era; consequently, Searchlight district gold deposits are the most thoroughly documented deposits in and near the Piute-Eldorado ACEC. Reid (1998) wrote a detailed history of the Searchlight area, with information on mining activity to nearly the present time.

The Searchlight district was discovered relatively late in the mining history of Clark County. According to Ransome (1907), who visited the district in 1906, ore was discovered in 1898 at the site of the Duplex Mine, but Callaghan (1939) reported 1897 as the discovery year. Reid (1998) noted that early settlers and their descendants claim discovery took place in 1896. The original discoverer of Searchlight ore was apparently J.C. Swickard, who was grubstaked by F. Dunn of Needles, California (Reid, 1998). The first recorded production in the Searchlight district was in 1902 (Longwell and others, 1965). However, Ransome (1907) reported that the Duplex Mine was the first to ship ore, although the Quartette Mine had opened in 1898. In 1902, the Quartette erected a stamp mill on the Colorado River that was shortly thereafter connected to the mine by 15 miles of narrow-gauge railway. In 1903, water was encountered in the mine workings and a new mill constructed near the mine, leading to abandonment of the riverside mill and of the railroad, which operated for less than 2 years. During his visit in 1906, Ransome reported production from the Quartette, Duplex, and Blossom Mines, and noted the presence of several other mines in various stages of exploration or development.

This was the era of maximum growth in the district, and activity was intense, even in mines whose names and locations have not survived. The population of Searchlight probably peaked prior to the 1910 census when it held 613 souls, and figures as high as 1,500 were reported in 1906 (Reid, 1998). The following quotations, from “The Mining World” (Anonymous, 1906) give an indication of the emotional state of the district at the time. “During the past week sinking in the main shaft of the Searchlight Treasurer has disclosed definite walls, the shaft being all in ore. This shaft, which was started at a 45-degree dip, following the ledge, is materially straightening up. Considerable copper stained sugar quartz has been struck at 50 feet, which runs $42 per ton… The shaft of the Venus is all in ore, and tracts have been let to sink to the 400-foot level. Stations are to be cut at the usual intervals, and a 15-h.p. hoist will supplant the whim now in use. Drifting both east and west will be continued on the 100-foot level, to determine the length of the ore body.” The identity of the Searchlight Treasurer and the Venus are unknown.

The Quartette Mine was the largest producer in the Searchlight district, particularly of gold and copper, and Callaghan (1939) estimated the total at $2.8 million, mainly between 1903 and 1910, the boom years of the district. Relatively low production came from the Quartette after 1910, and leasers operated the mine after 1917. Except for relatively high production in 1917 and the late 1930s (the latter increase was likely due to the higher gold price), annual district production never approached that attained during the district’s heyday years. According to Callaghan (1939), the Duplex Mine was the district’s second leading producer (gold, silver, and lead) at about $1 million, mostly during the early 20th century boom period. The Blossom Mine was probably the third leading district producer at a reported $325,000, mostly before 1906, and the Big Casino and Good Hope Mines had significant but lesser production (Longwell and others, 1965).

During the mining resurgence in the 1930s, a custom mill was built in Searchlight for the treatment of ore from mines in Searchlight and elsewhere in the region. In addition, a new cyanide plant was erected to treat tailings from the Quartette Mine (Vanderburg, 1937). There is little information about productivity of individual mines during this period, but ore was mined from the Quartette, Duplex, and Blossom Mines on the basis of information from Vanderburg (1937) and Callaghan (1939), with minor production from other mines.

Searchlight district production declined during the gold-mining ban of World War II (WW II) and rebounded weakly between 1948 and 1952. Little or no metal mining has taken place in the district since then. Longwell and others (1965) reported small but unspecified amounts of gold production until 1962, most likely from the Quartette Mine where Reid (1998) reported production until the 1960s. More recently, there was exploration by at least one major company and some minor activity by local individuals and at least one small company. During 1979–82, Felmont Oil (later Homestake Mining Company) conducted an exploration program designed to locate a large low-grade gold deposit in the western part of the Searchlight district. No gold resource was found, but the results led Homestake to suspect that a porphyry copper deposit might lie under the western part of the district. This target was not pursued at the time. Also in the late 1970s and early 1980s, a surge in development and exploration activity by private owners and independent operators took place, particularly at or near the Duplex, Blossom, Good Hope, and Big Casino Mines, but no production resulted (Smith and Tingley, 1983).

During the 1990s, development work was conducted on several claims (Blossom Consolidated, Whist, John, and

Table 1. Recorded production from the Searchlight district (reproduced from Callaghan, 1939).

Year	Ore (short tons)	Gold (ounces)	Silver (ounces)	Copper (pounds)	Lead (pounds)
1902	10,910	6,147	1,175	0	0
1903	19,522	19,275	27,691	0	0
1904	16,750	18,400	13,498	0	0
1905	38,069	19,329	28,528	22,808	12,064
1906	45,668	25,145	11,543	11,182	9,655
1907	45,921	23,441	7,494	37,063	38,113
1908	52,193	13,137	10,883	14,954	44,857
1909	68,931	16,237	13,544	22,916	36,209
1910	27,331	10,406	11,489	93,848	45,847
1911	1,850	966	2,136	12,095	7,659
1912	4,158	2,237	2,562	10,126	10,032
1913	5,989	6,654	5,903	53,971	61,006
1914	3,057	3,999	2,855	5,556	21,919
1915	7,766	4,985	3,546	20,970	35,562
1916	6,322	3,903	4,340	24,392	9,951
1917	12,866	3,445	9,073	98,923	59,453
1918	1,700	2,649	8,395	44,477	77,863
1919	6,980	2,854	5,502	18,074	39,307
1920	2,131	3,432	5,275	44,941	91,436
1921	1,182	3,601	9,877	31,128	98,048
1922	1,441	1,661	5,024	12,847	44,375
1923	1,142	1,007	2,708	22,150	47,651
1924	850	830	1,267	5,801	46,050
1925	2,833	3,314	2,586	14,974	86,768
1926	1,881	1,879	1,720	7,430	81,977
1927	106	335	306	1,429	10,415
1928	77	224	252	2,968	9,464
1929	184	105	58	654	2,743
1930	124	19	27	0	0
1931	20,855	3,276	5,826	6,022	274,687
1932	2,973	2,018	4,853	4,353	355,458
1933	2,996	913	1,182	2,261	12,040
1934	6,701	1,746	8,478	2,237	4,951
1935	29,617	3,829	12,317	9,195	72,271
1936	16,705	6,403	36,116	5,580	53,857
1937	5,692	5,456	28,688	500	12,600
1938	4,646	4,066	6,871	3,000	9,400
1939	2,035	1,471	1,682	9,400	14,200
1940	3,565	3,815	6,462	18,000	14,000
1941	4,092	3,908	4,524	2,100	5,000
1942	1,017	897	2,205	0	200
1943	117	139	1,454	3,000	4,100
1944	52	21	308	5,200	2,100
1945	401	852	5,708	2,000	1,200
1946	393	785	5,937	6,000	4,000
1947	405	737	2,768	20,300	7,500
1948	13,436	1,582	1,487	7,800	100
1949	16,399	1,007	4,109	700	4,500
1950	18,967	1,620	4,152	1,700	600
1951	24,850	2,041	5,352	4,800	800
1952	14,466	667	2,405	5,800	2,400

Sanford) near the Blossom Mine by Coyote Mines, Inc., which is controlled by the descendants of William S. Shuler, who bought the claims in 1906. A resource of nearly 100,000 short tons was estimated, with a gold content of about 13,000 oz (400 kg) of gold and about 19,000 oz (590 kg) of silver. Small amounts of this material were produced from 2 underground levels at that time, but the mine is currently inactive.

Perlite was discovered north of Searchlight about 1946 by B.L. Tanner, who operated a mine and a small perlite plant under the name Searchlight Insulation Products until the early 1960s. Perlite was also mined from 1948 to 1954 at the Nu-Lite Mine just outside the Piute-Eldorado Tortoise ACEC near the California border.

More recently, a number of mining claims that were patented for precious-metals are being exploited for decorative stone, which is sold for landscaping in metropolitan Las Vegas. A relatively large operation is conducted at the north end of the district, at the site of the Pompeii Mine, by Startel, Inc.

Sunset District

According to Smith and Tingley (1983) The Sunset district was established in 1897, when the Lucy Gray Mine, the only productive property in the district, was opened. However, Hewett (1956) reported discovery of the Lucy Gray in 1903, and Vanderburg (1937) reported it in 1905. Several other workings and prospects are shown in the area on the 7.5-minute topographic map, but information on their history could not be found.

Production for the district was estimated at about $50,000 (Vanderburg, 1937). Hewett (1956) reported that the mine was active between 1905 and 1918. Recorded production from 1911 to 1941 was about $13,000 (Longwell and others, 1965). According to Smith and others (1983), a small cyanide-leaching plant was operating by 1912 and production continued until 1919. Minor, intermittent operation took place between 1919 and 1941. Some exploration at the property took place in the early 1980s (Smith and Tingley, 1983), and again in 1991 by Golden Sunset Mining Co., but the property remains idle.

Hart District, California

Recent large-scale gold mining took place in the Hart district in California, about 8 km southwest of the Piute-Eldorado Tortoise ACEC. Gold was discovered in the Hart district in 1907 during the heyday of Searchlight mining, and mining continued until 1913, producing an estimated $10,000 (Hewett and others, 1936). Clay was mined from the district beginning in the 1920s; and, as at Searchlight, gold mining resumed in the 1930s and ended during WW II.

In the 1980s, the Hart district was explored extensively, and the Viceroy Gold Mine commenced production in 1992 (Reid, 1998). Announced reserves by the Viceroy Gold Corp. were about 2 million ounces of gold in about 34 million metric tons of ore in a cluster of six deposits (Crowe and others, 1996). The mine operated for 10 years, and it was California's largest gold producer for several years, producing a total of about 1.2 million ounces. The mine has been inactive for several years, and closure obligations are expected to be met in 2006 (Quest Capital Corp., 2005).

Mountain Pass District, California

Since 1954, rare-earth minerals and chemicals have been produced from Molycorp's Mountain Pass Mine and plant, which is about 25 km west of the Piute-Eldorado ACECs (Castor and Nason, 2004). Rare-earth minerals were discovered in the district in 1949 by uranium prospectors in samples from the small Sulphide Queen Gold Mine, which had been worked on a small scale in the 1930s (Olson and others, 1954). In terms of value, the Mountain Pass operation has been the most important mineral producer in the region. For at least 30 years, Mountain Pass was the world's leading supplier of rare-earth elements, which were mined from a unique Proterozoic carbonatite orebody. However, mining ceased in 2001 because of environmental problems and competition from China, and only minor amounts of rare earths are currently being sold from stockpile. The company, now a subsidiary of Chevron Corporation, may reopen the mine in the future.

Mineral Deposits

There are numerous mineral deposits within and near the three ACECs. The area contains part or all of 5 Nevada mining districts as defined by Tingley (1992), the Searchlight, Eldorado, Newberry, Crescent, and Sunset districts. In addition, there are a number of deposits that are not within defined districts, and a number of deposits of leasable and salable minerals that are unrelated to established mining districts.

Classification of Deposits

The area contains several different types of metallic mineral deposits. Because specification of deposit models is important in mineral potential assessment, we discuss a number of pertinent mineral-deposit models below.

Porphyry Copper Deposits

The generalized porphyry copper deposit model includes various subtypes, all of which contain chalcopyrite in stockwork veinlets in hydrothermally altered porphyritic intrusions and adjacent country rock. Copper is generally the most important commodity produced, but the deposits may contain important amounts of Mo, Au, Ag, Pb, and Zn. The deposits are associated with high-level intermediate-composition and felsic intrusions or cupolas of batholiths contemporaneous with volcanism along convergent plate boundaries. Surficial exposures in the southwestern United States are generally leached to barren hematite/limonite outcrops that may locally contain copper carbonates or silicates and secondary copper sulfide minerals, such as covellite and chalcocite. Hydrothermal alteration patterns associated with porphyry copper deposits commonly exhibit zoning outward from sodic or potassic alteration (feldspar and biotite) through phyllic (sericite and pyrite) zones to distal propylitic alteration.

Porphyry copper deposits can be very large and productive; there are nearly 100 in the United States. The majority of them are Laramide (late Cretaceous and Paleocene) in age, but a few, including the giant Bingham Canyon deposit in Utah, are middle Tertiary. The nearest deposits to the Piute-Eldorado area are the modest Mineral Park (about 1,360 metric tons of copper production per year) and large Bagdad (about 91,000 metric tons per year) deposits (both of Laramide age) about 50 km east and 150 km southeast of the Piute-Eldorado ACECs, respectively. The closest Tertiary-age deposits are the Oligocene Copper Canyon deposit and a few Oligocene porphyry copper prospects, about 600 km north of the Piute-Eldorado ACECs, in northern Nevada.

Epithermal Precious-Metal Deposits

Epithermal precious-metal deposits are veins or groups of veins that formed near the surface of the Earth, contain significant amounts of gold and silver, and occur primarily in volcanic rocks. They are extremely common throughout the Basin and Range Province, where they formed from about 40 Ma to the present. These deposits are commonly subdivided into several types. The most widely agreed upon subdivision of epithermal deposit types is into low sulfidation (quartz-adularia) and high-sulfidation (quartz-alunite) types. Low-sulfidation deposits are typified by the presence of quartz fissure veins that may exhibit banded and crustiform textures, commonly with carbonate or lamellar quartz after carbonate, and K-feldspar (adularia) as an alteration product in wall rock or as a vein mineral. Alteration may also include clay minerals and propylitic mineral assemblages. Ore minerals include electrum and acanthite, with variable amounts of base-metal sulfides with or without silver sulfosalts. Pyrite may be common or sparse, but it is generally present. In addition to gold, silver, and base metals, low-sulfidation epithermal deposits may have elevated concentrations of As, Sb, Hg, Tl, Mo, W, Bi, and Te.

High-sulfidation epithermal deposits may contain quartz fissure veins, but they are generally typified by resistant “ledges” of country rock replaced by quartz. Carbonate is not present in main-stage mineral assemblages. Primary sulfate minerals, such as barite and alunite-group minerals, are typically present, and other vein and alteration phases may include pyrophyllite, diaspore, andalusite, and topaz. Clay mineral alteration is typified by the presence of kaolinite and dickite, and widespread propylitic alteration is generally present. Ore minerals include gold, enargite-group minerals, silver sulfosalts, telluride minerals, and base-metal sulfides. Pyrite is generally abundant. Some deposits, such as Goldfield, Nevada, have low silver contents; others, such as Paradise Peak, Nevada, are high in silver. In addition to gold and silver, high-sulfidation deposits typically have elevated concentrations of Cu, Pb, Zn, As, Sb, Bi, Te, and Sn.

The vein deposits in the Searchlight district have been termed epithermal in the past, but several characteristics of these deposits are significantly to somewhat different than classic epithermal deposits. Veins at Searchlight (1) contain more base metals than many epithermal deposits, (2) have higher gold to silver ratios than many epithermal deposits, (3) are closely related spatially to the Searchlight pluton, and (4) are characterized by hematite as the chief iron-bearing mineral, rather than pyrite. For these reasons, in this report, we classify the Searchlight veins as gold-rich polymetallic veins, even though we are quite certain that they formed relatively close to the surface.

Adularia (an important indicator of low-sulfidation epithermal deposits) was reported in the veins in the northern part of the district by Callaghan (1939). We have determined that there is abundant secondary K-feldspar and albite in the wall rocks of these veins, and that minor amounts of adularia are also present in some of the veins. Studies are underway to determine the age of this adularia by the $^{40}Ar/^{39}Ar$ method.

The vein deposits in the Eldorado district near Nelson are much closer to the classic definition of epithermal precious-metal deposits, being relatively silver-rich and base-metal-poor. We consider them to be low-sulfidation epithermal deposits. On the basis of production records, the mines at Nelson produced similar amounts of ore to Searchlight, but only about half as much gold, nearly ten times as much silver, and less than one-tenth the amount of copper and lead. They are, however, closely associated spatially with the Nelson pluton.

Other nearby epithermal precious-metal deposits include the Katherine Mine (Lausen, 1931), about 15 km east of the Piute-Eldorado Tortoise ACEC, and the Oatman district (DeWitt and others, 1991), about 20 km to the southeast.

The large Mesquite deposit, about 230 km south of the Piute-Eldorado ACECs, near the Salton Sea in California, produced nearly 3 million ounces of gold (about 90 metric tons). At one time, it was thought to be a detachment-fault-related deposit (see below), but it is now considered an epithermal deposit that formed during strike-slip faulting (Willis and Tosdal, 1992). It consists of Oligocene quartz-adularia and carbonate veins in metamorphic and granitic rocks. It contains native Au associated with rutile, hematite, arsenopyrite, magnetite, pyrite, and chalcopyrite (Frost and Watowich, 1989; Mine Development Associates, 2004). Available data indicate deposition from boiling, low-salinity fluids largely controlled by moderately to steeply dipping faults that were later cut by shallowly dipping faults (Frost and Watowich, 1989).

Gold-Bearing Polymetallic Vein Deposits

Polymetallic vein deposits consist of quartz or quartz-carbonate veins with gold and silver and associated base metals (Cox, 1986). They occur in sedimentary and metamorphic rocks and are commonly associated with hypabyssal igneous intrusions. Many small vein-type precious-metal and base-metal deposits have been assigned to this group, which has become a convenient catch-all model for vein type deposits of varied mineralogy, geochemistry, and geologic setting. The model was defined on the basis of many small deposits (maximum size about 5 million tons) in the western United States and Canada (Bliss and Cox, 1986), and there appear to be two subtypes, one with significant precious-metal values and one without. Vein mineralogy includes gold (or electrum) with pyrite and sphalerite; other base-metal sulfides, hematite, acanthite, and silver sulfosalts may be present. Vein textures suggest that some polymetallic veins are of epithermal origin, but associated deposit types may include porphyry deposits and other pluton-related deposits. Alteration generally consists of widespread propylitic alteration and restricted near-vein envelopes of sericite and clay alteration.

Detachment-Fault-Related Gold Deposits

Gold deposits related to detachment faults were mined in California and Arizona, mainly during the 1980s and 1990s. The best-known deposits assigned to this model are probably Picacho (0.6 million oz gold), which is about 280 km south of the Piute-Eldorado area, and Copperstone (0.5 million oz gold, 270 km southeast), both in Arizona. A number of smaller deposits occur in the Whipple Mountains of California, about 190 km south. The Mesquite Mine, near the Salton Sea in California, produced nearly 3 million oz of gold and at one time was widely believed to be related to extension, but this relationship has now been largely discredited (Willis and Tosdal, 1992). Information on detachment-fault-related deposits used in the following discussion comes primarily from Drobeck and others (1986), Spencer and Welty (1986), Mine Development Associates (2000, 2004) and Losh and others (2005). The state of knowledge at the time was summarized by Long (1992), but the model remains controversial, and questions have been raised about the classification of many examples of the type.

The deposit model is mostly based on descriptions of small (less than 1 million short tons of ore) base- and precious-metal deposits in California and Arizona that generally contain specular or earthy hematite, copper oxide minerals such as chrysocolla, native gold or electrum, and manganese oxides (Wilkins and Heidrick, 1982; Long, 1992). Copper, lead, and zinc sulfide minerals may be present, generally in chlorite-altered rocks beneath the fault surfaces. Upper-plate rocks are typically affected by potassium metasomatism and oxidized, yielding the characteristic red color. Oxide minerals such as specular hematite are considered primary. The deposits generally have nearly equal amounts of gold and silver, but otherwise have variable mineralogy and trace element chemistry. Fluid inclusion data indicate variable fluid temperatures (110° to 350°C) and salinities (1 to 23 equivalent weight percent NaCl).

At Copperstone, the gold occurs in quartz-hematite veins and in breccias containing quartz, hematite, magnetite, barite, calcite, and chrysocolla (Durning and Hillemeyer, 1986). In addition, calcite, siderite, manganese oxides, adularia, sericite, and fluorite were reported, as well as banded open-space fillings of quartz + specular hematite (Mine Development Associates, 2000). The Copperstone Fault, which dips 25 to 45 degrees, was the main ore control, but steep faults in its hanging wall may also have controlled mineralization.

The Picacho Mine exploited four orebodies in metamorphic rocks and granite associated with a regional detachment fault (Drobeck and others, 1986). The ore mineral is gold-bearing pyrite and the deposit is characterized by high Sb, Hg, and As, with low Cu and base metals (Losh and others, 2005). Fluid-inclusion data indicate that it was formed by low-salinity fluids somewhat different from those reported for the model. However, like most of the detachment-fault-related deposits, it does contain primary specular hematite.

The model for gold deposits related to detachment faults was developed primarily during exploration in the 1970s and onward. Geologists noted the association of some gold deposits with detachment faults with shallow dips in the desert regions of southern California and Arizona and formulated an exploration model that was vigorously pursued for about a decade. More recently, the failure to find many large economic deposits of this type has cooled interest, but many smaller low-grade deposits were found in the last 20 years. Deposits of this type are presently being explored in the Dead Mountains in California, about 50 km south of the Piute-Eldorado Tortoise ACEC.

Deposits in the Eldorado District

Most of the mineral deposits in the Eldorado district are from 1 to 10 km north of the Piute-Eldorado Tortoise ACEC and 3 to 15 km east of the Keyhole Canyon ACEC. The geology of the district is dominated by the late Miocene Eldorado pluton, which is composed primarily of quartz monzonite and granodiorite. On the north side of the pluton, the wall rocks are primarily Miocene volcanic rocks, whereas Proterozoic igneous and metamorphic rocks make up the south wall of the pluton. This area is north of the Black Mountains accommodation zone (Faulds and others, 1990), and the rocks have been tilted steeply to the east, so that the deepest exposures in the district are at the west end and the shallowest at the east. The deposits here are emplaced in Proterozoic metamorphic rocks, Miocene volcanic rocks, and, most commonly, in the Eldorado pluton. Craw and McKeag (1995) studied some veins in the district and suggested that meteoric waters were the source of the mineralizing fluids, but the fluid inclusions they studied were all secondary, and this inference is not reliable.

Deposits in the Southern Eldorado Mountains Between Aztec Wash and Searchlight

Mines in this area were mostly located in the early part of the 20th century, and most have no recorded production. Those in the northernmost part of the area are usually considered to be part of the Eldorado district, while those farther south have been described as belonging to either the Searchlight or

Newberry districts. The St. Louis Mine (fig. 19) produced a few thousand troy ounces of gold between 1921 and 1948, and mines in the Camp Dupont area may have produced similar small, but unrecorded, amounts of gold (Causey, 1988a). The northern part of the area consists of Proterozoic gneiss intruded by the Miocene Aztec Wash pluton, whereas the south part consists of Proterozoic gneiss intruded by the Miocene Searchlight pluton. A large part of the center is occupied by the Cretaceous peraluminous granite of the Ireteba pluton. Deposits in this area are primarily of two types, gold-bearing polymetallic veins (St. Louis Mine area) and detachment-fault-related gold deposits (Sazarac and Cobalt claims).

Four entries in the MRDS (Mineral Resource Data System) database (U.S. Geological Survey, undated) (Eldorado Mine, Eldorado project, West We Go, and Willoro project) have reported locations on the floor of Eldorado Valley, near U.S. Highway 95. Cactus Gold Corp. (see section on mineral exploration) maintains a facility near some of these locations,

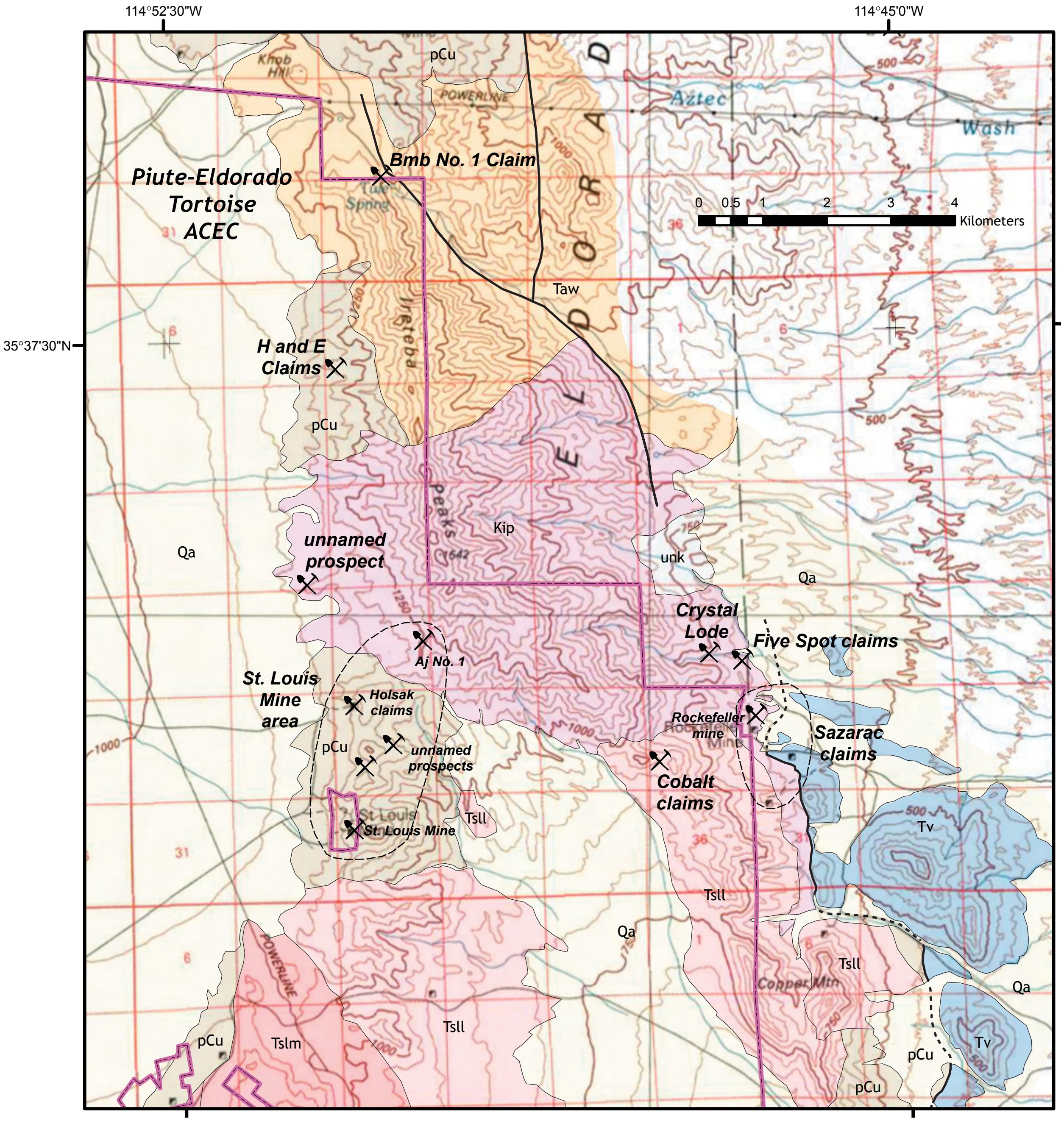


Figure 19. Mineral deposits in and near the Piute-Eldorado ACECs between the Eldorado and Searchlight mining districts. Geology compiled for this report: pCu—undivided Proterozoic rocks; Kip—Cretaceous granite of the Ireteba pluton; Taw—Miocene Aztec Wash pluton; Tslm—Miocene Searchlight pluton, middle unit; Tsll—Miocene Searchlight pluton, lower unit; Tv—Miocene mafic volcanic rocks; Qa—Quaternary alluvium.

but we do not know if all of the database records refer to this installation. All were compiled from the Directories of Mine Operations for 1987, 1988, and 1991 produced by the Nevada Division of Mine Inspection.

Bmb No. 1 Claim

This mineral deposit is on the northeastern border of the Piute-Eldorado Tortoise ACEC. It also appears to be within the Ireteba Peaks Wilderness. On the 1:24,000-scale topographic map, it is designated the Belmont-Phoenix Mine, but it appears certain that the Belmont-Phoenix (formerly the Oro Plata) is about 2.5 km north, in the Eldorado mining district. The Bmb No. 1 is at the head of the deep canyon that drains south-eastward from Tule Spring, and consists of a breccia zone in granite of the Aztec Wash pluton, cemented by quartz and calcite. During study of the Ireteba Peaks Wilderness, Causey (1988b) collected samples that contained as much as 665 ppm (parts per million) silver, as well as large amounts of lead and zinc, and low, but anomalous, amounts of gold. He inferred that subeconomic resources of silver are present on the claim. The high silver to gold ratio at this deposit suggests it is more closely related to the Eldorado district to the north than to the Searchlight district. However, the fact that the mineralized rock is hosted in fault breccias related to the Tule Wash Fault suggests that it formed after major extension and thus may not be directly related to the Eldorado district deposits.

H and E Claims

This area consists of a number of small pods of copper- and gold-bearing quartz that both cut and are concordant with the metamorphic foliation of the Proterozoic gneiss. Malachite and chrysocolla are visible, along with iron-oxide minerals. Many of the grab samples reported by Causey (1988a) contained more than 1 percent copper, and several contained anomalous molybdenum (> 60 ppm). One sample contained 1.4 ppm gold. The mineralized rock is exposed over an area of about 250 m by 30 m, elongate in a north-south direction and parallel to the foliation of the metamorphic host rock.

Unnamed Prospect

About 3 km south of the H and E claim block, a small unnamed prospect at the range front is hosted in granite of the Ireteba pluton. No description exists, and we did not visit it, but Causey (1988a) collected samples that contained as much as 400 ppm copper and 500 ppm zinc, though no significant gold or silver was detected.

St. Louis Mine Area

The St. Louis Mine (fig. 20) is on the west side of the Eldorado Mountains, about 12 km northeast of Searchlight and about 4 km southwest of the high point of the Ireteba Peaks (fig. 19). Patented claims cover the specific site, which is excluded from the Piute-Eldorado Tortoise ACEC, but mine workings extend north along the range front for more than 2 km and include the Holsak claims of Causey (1988a). At the St. Louis Mine, Causey reported a quartz vein with hematite pseudomorphs after pyrite and minor malachite that trends N35W. We suspect this is a transcription error, as we measured the 1.5-m-wide vein's strike at N35E. Causey's two samples contained as much as 13 ppm gold, with abundant copper and lead. Our sample of the vein (4-030901) contained 1.6 ppm gold and 3 ppm silver and about 1,000 ppm copper, 2,000 ppm lead, and 1,700 ppm zinc (Ludington and others, 2005). A sample collected by Tingley (1998) about 200 m north of the mine contained 1.6 ppm gold, 1,500 ppm copper, 2,000 ppm lead, and 400 ppm zinc. Samples collected on the Holsak claims about 1,600 m north of the St. Louis Mine contained as much as 0.4 ppm gold, 5 ppm silver, and 1,200 ppm copper (Causey, 1988a). Samples collected by Causey (1988a) at the AJ No. 1 claim, about 1,200 m northeast of the Holsak claims, contained no more that 0.07 ppm gold.

The country rock is Proterozoic gneiss, intruded by numerous dike-like bodies of granite that probably correspond to the middle part of the Searchlight pluton. The veins here are not associated with a detachment fault, and they are probably best characterized as polymetallic veins. The vein we observed

Figure 20. Portal of St. Louis Mine.

at the St. Louis Mine strikes northeast and is near-vertical, although the host rocks appear to have been tilted at least 45 degrees to the west since the beginning of extension; thus, this vein may be younger than the veins in the Searchlight district.

Sazarac Claims

The Sazarac block of patented claims includes the Rockefeller Mine; the area is about 17 km northeast of Searchlight, along the northeast boundary of the Piute-Eldorado Tortoise ACEC and the south boundary of the Ireteba Peaks Wilderness (fig. 19). Longwell and others (1965) refer to the entire area, including the Cobalt claims and the 5 Spot claim, as the Camp Dupont group. Thirty-five short tons of ore were produced in 1935. The seven claims were patented in 1913 and have been the subject of sporadic exploration since that time. During study of the Ireteba Peaks Wilderness, Causey (1988a) collected samples that contained as much as 7.6 opt (260 ppm) gold in a 9-ft chip sample, but only weakly anomalous amounts of silver, copper, molybdenum, copper, lead, and zinc. Tingley (1998) reported 21 ppm gold from a sample about 100 m west of the area. Causey described the area as containing many small veins and iron-oxide stained faults and fractures, filled primarily with quartz and some barite. Chrysocolla and malachite are common, and free gold was noted. The area is within the Dupont Mountain detachment fault zone, and the geology has not been mapped in detail, but the veins seem to occur in both the hanging wall (Miocene mafic and intermediate-composition volcanic rocks) and the footwall (granite of the Ireteba pluton and lower part of the Searchlight pluton). Most veins, however, are cut by the detachment fault. The geochemical signature (high gold to silver ratio, low base metals other than copper) and the structural setting suggest that the appropriate mineral deposit model for much of this area may be detachment-fault-related deposits.

Cobalt Claims

About a kilometer west of the Rockefeller Mine area, a number of precious- and base-metal-bearing quartz and quartz-barite veins crop out over an area of less than 1 km^2. A large claim block was established here in 1983 and an exploration program carried out during the 1980s. When the U.S. Bureau of Mines studied the mineral resources of the area, Causey (1988a) collected samples that contained as much as 6.6 ppm gold, 7 ppm silver, as well as anomalous amounts of lead and zinc, and copper. The principal vein, hosted in granodiorite and diorite of the lower Searchlight pluton, trends about N40W and extends for about 500 m.

5 Spot Claim

This area adjoins the Sazarac claim block on the northwest. Causey (1998a) found only low gold values in the samples he took.

Crystal Lode Claim

About 700 m northwest of the Sazarac claim block, the Crystal Lode claim area is within the granite of the Ireteba pluton, and Causey (1988a) did not find high gold values in the samples he took.

Searchlight District

Mineral deposits in the Searchlight mining district are a group of Au-bearing veins that are hosted primarily in Miocene volcanic rocks. These veins occur in zones that are draped over the top of the Searchlight pluton. The most important mines in the main part of the district occur in a narrow band about 6 km long from north to south, just to the west of U.S. Highway 95 (fig. 21).

The productive parts of almost all known veins are in the lower intermediate-composition part of the volcanics of the Highland Range, within a few hundred meters above the upper contact with the Searchlight pluton (fig. 22). The J.E.T. vein, in the northern part of the district, is in the upper part of the Searchlight pluton, and small veins and stockwork zones are common within the upper part of the Searchlight pluton, but none of them produced important amounts of gold.

Major Mines of the Searchlight District

At Searchlight, the most important mine by far was the Quartette, which produced nearly half the gold from the entire district. The Duplex and the Blossom were the other productive mines. As far as is known, other mines shown on figure 21 produced relatively minor amounts of ore, and most are now in disrepair (fig. 23). However, individual mine production records are almost nonexistent.

Of the mines distant from the main part of the Searchlight district, in the Fourth of July and Pinto structural blocks, only the Big Casino is known to have had substantial production. Although our samples show that it apparently contains substantial gold, the Chief of the Hills is not recorded to have produced much ore. Many of the mines received a large initial investment and then closed when the first excavations failed to yield profitable ore.

Although detailed production records for most individual mines have not been preserved, relationships among the various metals produced vary widely, both between the various mines and within individual mines. For example, ore from the Quartette commonly contained 3 times as much gold as silver, but these relationships were reversed for ore from some parts of the mine (Callaghan, 1939). Only the Quartette, Duplex, Good Hope, and Big Casino produced considerable lead and copper. Copper predominated in the Quartette, whereas lead was dominant in the Duplex. Further details are in Callaghan (1939). The results of sampling during this study (Ludington and others, 2005) are discussed below, in the section on geochemical zoning.

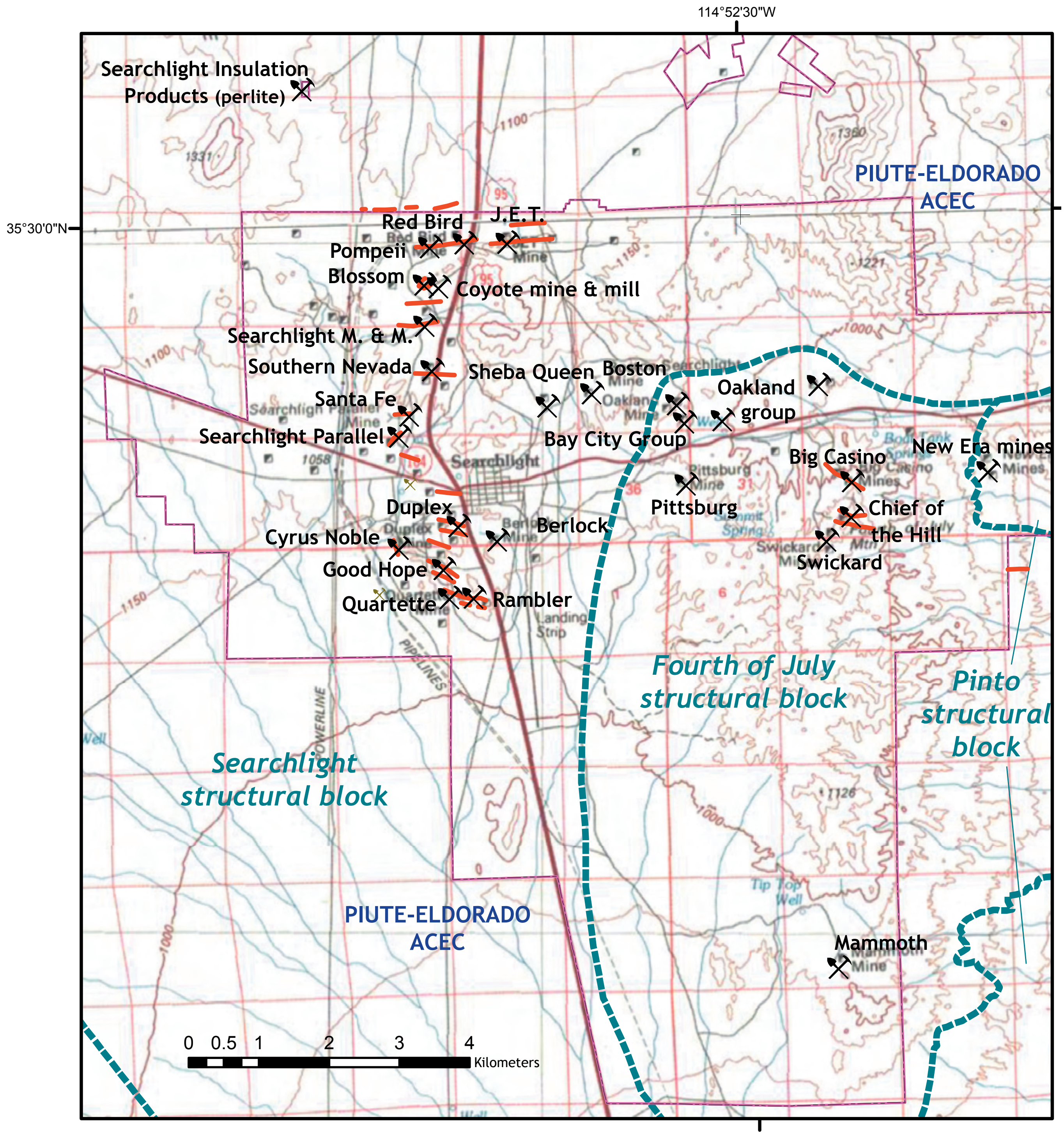


Figure 21. Location map of major mines of the Searchlight district. Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC; boundary outlined in pink). Boundaries of structural blocks are in heavy teal broken lines. The traces of productive veins, modified from the map of Callaghan (1939), are shown as heavy red lines.

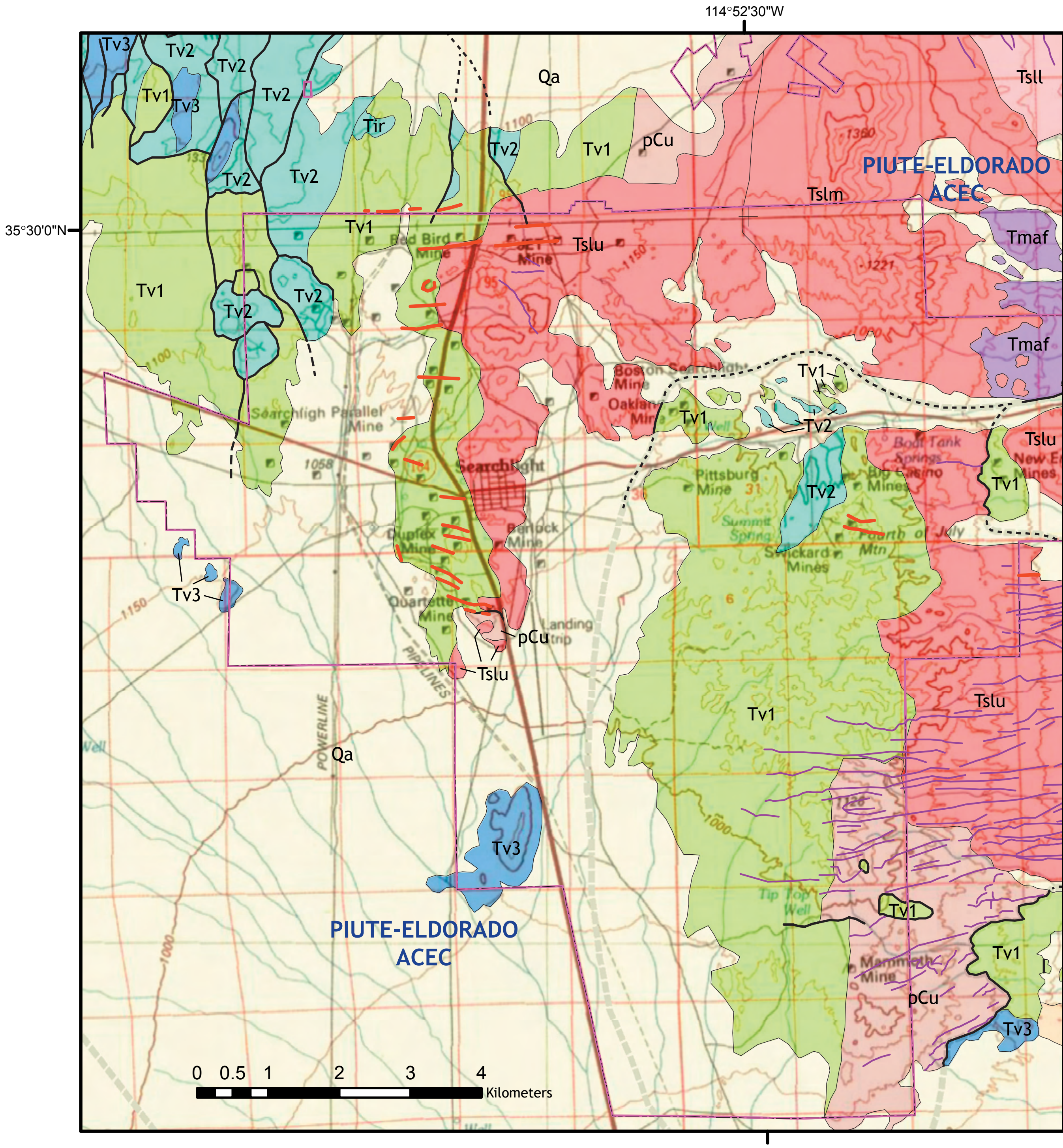


Figure 22. Generalized geology of the Searchlight district, compiled for this report. Units as follows: pCu—undivided Proterozoic schist, gneiss, and metaplutonic rocks; Tv1—lower intermediate-composition unit of volcanics of the Highland Range; Tv2—middle felsic unit of volcanics of the Highland Range; Tir—intrusive rhyolite; Tv3—upper mafic unit of volcanics of the Highland Range; Tslu—upper part of Searchlight pluton; Tslm—middle part of Searchlight pluton; Tsll—lower part of Searchlight pluton; Tmaf—mafic pod in Searchlight pluton. Qa—Quaternary alluvium. Heavy black lines are faults, dashed where concealed.

Vein Mineralogy and Structure

An excellent description of the veins, one that is still valid for most of the veins in the Searchlight district, was given by Ransome (1907), "The lodes contain very little solid quartz and do not outcrop prominently. Toward the west they either pinch out or pass beneath alluvium. They are essentially mineralized fault zones in which the original character of the mineralization has been obscured by repeated movement and by oxidation. The lode material is generally a soft mass of shattered or crushed country rock colored by chrysocolla and oxides of iron and carrying free gold as its valuable constituent. Quartz is common in vugs, druses, and veinlets."

According to Ransome (1907), cerussite was a characteristic constituent of the ore and was associated with wulfenite, cuprodescloizite, and leadhillite. Other lode minerals are specular hematite, malachite, azurite, and calcite. The only sulfides noted at that time were chalcocite, galena, and pyrite, which are present only in small quantities.

Visible copper minerals, primarily chrysocolla, were important guides to gold ore, and copper grades of several percent and lead and zinc grades near one percent were common in some parts of the veins. Today, virtually no base-metal sulfide minerals are present at the surface; we observed only pyrite and galena macroscopically, and have identified sphalerite and covellite microscopically. These sulfides were found at only three sites in the entire district. The most common gangue is quartz and specular hematite (fig. 24), sometimes accompanied by epidote. Historic published accounts of the vein mineralogy are cursory, as no geologist appears to have studied the mines between Ransome's short visit in 1906 and Eugene Callaghan's equally brief visits in 1931 and 1934. Callaghan (1939) prepared a summary of all earlier work and listed 17 ore minerals, including gold, chrysocolla, cuprite, chalcocite, leadhillite, wulfenite, vanadinite, and rarely, galena. It appears that sulfides were rare, not just at the surface, but to depths as great as 260 m below the present ground surface.

Figure 23. Remains of mining equipment at Southern Nevada Mine.

On the basis of petrographic studies of thin sections and analysis with a scanning electron microscope (SEM) using energy-dispersive X-ray analysis (EDX), we identified galena, anglesite ($PbSO_4$), cerussite ($PbCO_3$), plumbogummite ($PbAl_3[(OH)_5|(PO_4)_2]\bullet H_2O$), pyromorphite ($Pb_5[Cl(PO_4)_3]$), and covellite in partially oxidized ore from the Quartette Mine. We also found small (<50 microns) blebs of chalcopyrite adjacent to primary specular hematite in quartz veins in samples from the Quartette Mine (fig. 25), as well as galena and sphalerite blebs as much as 100 microns across.

The deposits in the northern part of the Searchlight district, including the Blossom and Searchlight M&M areas, differ from those in the Quartette Mine area. They contain thin quartz veins that consist mostly of granular to comb quartz and often occur in stockworks. Ransome (1907) stated that the Blossom Mine ore, which was mostly mined from a nearly horizontal blanket of stockwork veins, was generally not visibly mineralized but that the best ore contained free gold associated with limonite and specularite. Copper minerals are rare, although we found small amounts of blue secondary copper minerals at the Blossom Mine, and sparse chalcopyrite in quartz veins from dumps at the Searchlight M&M Mine.

During SEM examination, we noted that pyrite is partially to wholly replaced by hematite, galena, and electrum in a sample from the Blossom Mine. The electrum, which has weight percent Au:Ag of about 60:40 on the basis of semi-quantitative SEM/EDX analysis, seems to have been deposited late as irregular grains and flakes along quartz grain boundaries and fractures (fig. 26).

As noted by Callaghan (1939), adularia is an abundant alteration product in the wall rock near veins in the north part of the Searchlight district, and poorly formed overgrowths of

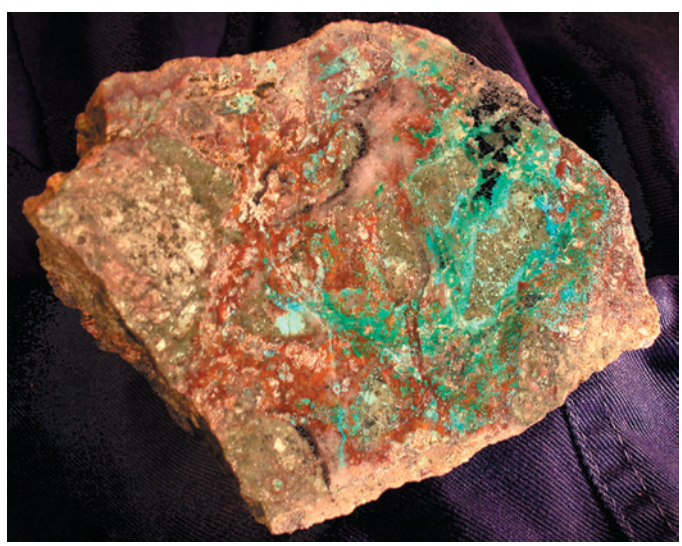
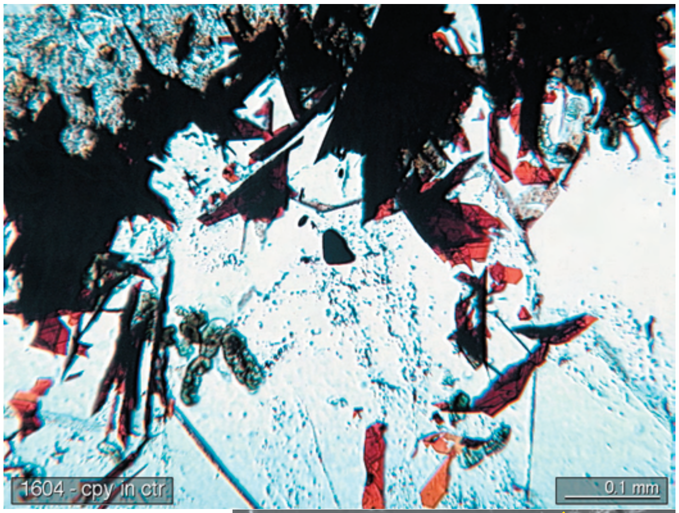


Figure 24. Sample of ore from dump of Rambler Mine, demonstrating abundant bright greenish-blue chrysocolla. Note also specular hematite and quartz in upper central part of photograph. Sample is about 8 cm across.

clear adularia occur in some veins and veinlets (fig. 27). However, on the basis of our samples, adularia occurs only rarely within the veins from the north part of the Searchlight district as sharp rhomb-shaped crystals as much as 0.5 mm across (fig. 28). Callaghan reported lamellar calcite in the Searchlight M&M and Blossom veins, but we did not see it there. However, we did observe ghost blade texture (quartz after bladed calcite) in a sample from the Chief of the Hills Mine, about 5 km east of the main part of the Searchlight district, in the Fourth of July structural block.



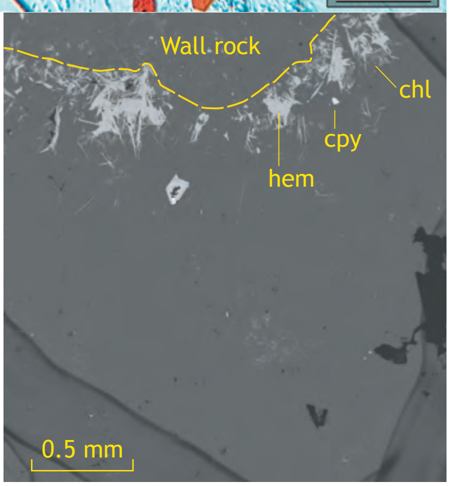


Figure 25. Top: Plane-polarized photomicrograph of specularite (pale red to black) blades and chalcopyrite (rounded opaque mineral in center of photo) in a quartz vein sample from the Quartette Mine. ▸ Right: Back-scattered electron scanning electron microscope image of the same specimen showing specularite (hem), chalcopyrite (cpy), and chlorite (chl) in quartz vein adjacent to wall rock.

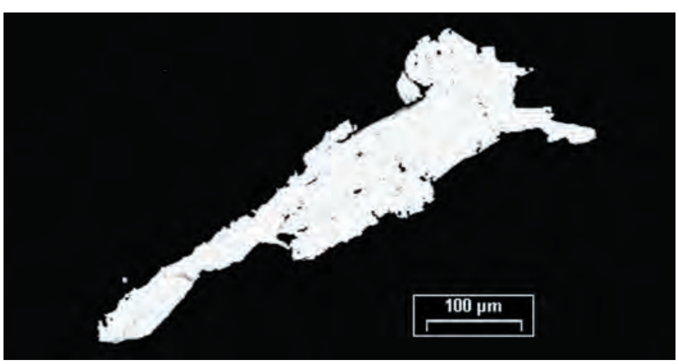


Figure 26. Secondary-electron SEM image of relatively coarse electrum in a quartz vein from the Blossom Mine (Sample AP-254A). The electrum occurs as irregular grains along grain boundaries and cracks in comb quartz.

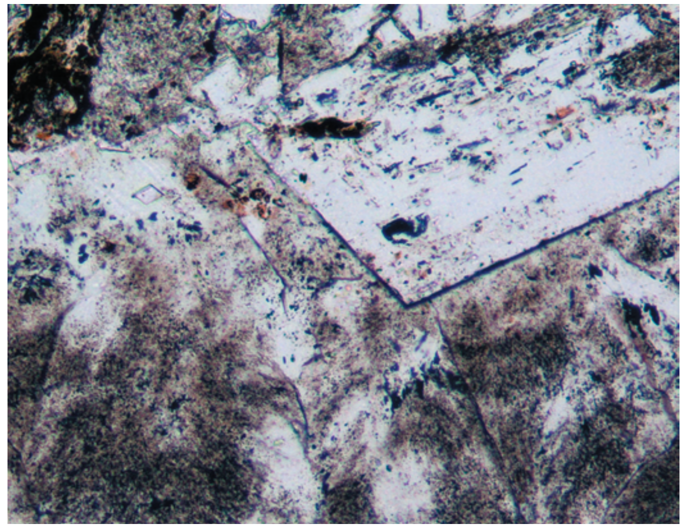


Figure 27. Plane polarized photomicrograph of a quartz-adularia veinlet from the Blossom Mine (sample 5-031601). Overgrowths of clear adularia as much as 200 microns across occur along the border of the quartz vein, and the wall rock contains large amounts of secondary K-feldspar. The quartz-adularia vein is cut by a brown limonitized fracture. Horizontal field of view is about 0.6 mm.

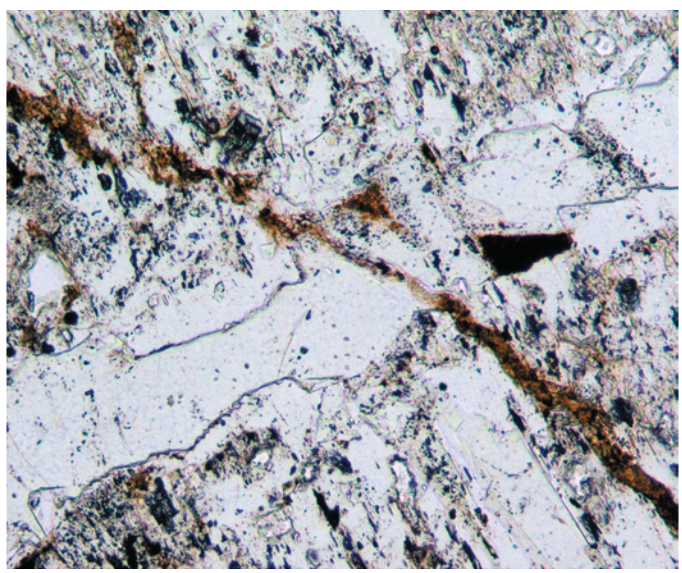


Figure 28. Plane-polarized photomicrograph of relatively clear rhombs of adularia in inclusion-crowded comb quartz near the border of a quartz vein from an unnamed prospect about 1 km west of the main part of the Searchlight district (sample 4-050601). The large adularia rhomb on the right is about 0.4 mm long; the tiny rhomb to the left of it is about 30 microns long. Vein border is at upper left.

The fact that the veins have the same spatial relationship to the upper contact of the Searchlight pluton, no matter which structural block they are in, suggests strongly that the extension-related low-angle faults that separate the structural blocks were active after the mineralized veins were formed, in other words, that the district was dismembered after it formed and that mineralization largely preceded extension (Faulds and others, 2002a). Most veins strike west or slightly north of west and have varying but fairly steep dips. This is probably not their original attitude. All the rocks in the district appear to have been tilted steeply to the west as a result of middle Miocene extension. The result of this rotation is that the east-west elongate surface exposures of the veins in the district are tilted cross sections, with tops to the west. The veins, which in map view appear to be peripheral to the Searchlight pluton, actually occur in a zone that arcs above its roof. The exposures in the Fourth of July block (Big Casino, Chief of the Hills, and Swickard) may simply be the eastern part of the Duplex, Good Hope, and Quartette mineralized structures, and the New Era Mines may be the eastern fringe of these same structures. The nearly horizontal mineralized zone at the Blossom Mine would have been a vertical, north-striking structure. These relations suggest that the Searchlight district provides a cross-sectional view of a hydrothermal system that is genetically related to the Searchlight pluton, as originally surmised by Faulds and others (2002a).

Sympathetic movements during this extensional faulting appear to have reactivated the mineralized structures and contributed to their crushed and disrupted state. Callaghan (1939), although not cognizant of the rotation, emphasized the brecciation of the veins by post-mineral movements, particularly in the mines in the southern part of the district.

Callaghan (1939) noted a difference in mineralization style between the deposits north and south of State Highway 164. The mines south of the highway, particularly the Quartette, Cyrus Noble, Good Hope, and Duplex, are characterized by significant amounts of the base metals copper, lead, and zinc, whereas the mines to the north of the highway did not produce important amounts of these metals. The mines in the south were the main source of the base-metal oxide minerals described above.

Hydrothermal Alteration

Three principal types of hydrothermal alteration are present in the district—(1) propylitic alteration and hornfels formation adjacent to the Searchlight pluton, (2) hydrothermal alteration peripheral to the gold-bearing veins, and (3) supergene alteration and oxidation.

Within a few hundred meters of the contact with the Searchlight pluton, the volcanic rocks have been recrystallized into a rock that can be termed hornfels. The original minerals in the andesite and dacite have largely been converted to quartz, epidote, magnetite, biotite, and chlorite, and much of the original texture of the rock has been destroyed. Callaghan (1939) has an extended discussion of this alteration type.

Superimposed on this metamorphic imprint is a hydrothermal alteration assemblage associated with the gold-bearing veins. Although Callaghan (1939) did not map hydrothermal alteration zones in detail, he noted that alteration was negligible in the southern part of the district, specifically at the Quartette Mine, whereas adularia was a significant alteration mineral in the northern mines. He also stated that propylitic alteration (chlorite + albite + epidote + pyrite) is found in a few places in the north half but is difficult to separate megascopically from the metamorphism adjacent to the pluton. He also noted that pyrite is unusually rare in the altered rocks of the district.

We studied the distribution of hydrothermally altered rock with ASTER (Advanced Spaceborne Thermal Emission and Reflectance), which is a 14-band multispectral satellite imaging system (Rowan and others, 2003). Figure 29 shows an image of the district that shows the areas containing alteration minerals that can be detected with ASTER. The areas enclosed with dashed lines are interpreted to be hydrothermally altered rock, and samples from these areas were analyzed by X-ray diffraction (XRD) and portable infrared mineral analysis (PIMA) to confirm the nature of the alteration. Table 2 summarizes the spectral characteristics of each of the areas designated on figure 29, and tabulates their alteration characteristics. Petrographic studies are continuing in order to characterize the various alteration zones in more detail. The figure clearly shows abundant hydrothermal alteration in the north half of the main part of the district, and almost none in the southern part.

The bright pink colors indicate the areas characterized by alunite-bearing assemblages. This large area of quartz-alunite alteration was previously unreported in the geologic literature and occurs in an area as much as 1.5 km wide and 3 km long in the western part of the Searchlight district, as well as in a smaller area to the east of Searchlight. On the basis of XRD and PIMA, this alteration is characterized by the presence of alunite and kaolinite-group clay minerals (including dickite), along with locally strong quartz flooding and locally abundant topaz and pyrophyllite. The altered rock is typified by bleached white to orange and red colors, with the latter colors due to the presence of abundant jarosite and hematite. Alunite separates prepared from three samples have sulfur isotope ($\delta^{34}S$) ratios of 14.6 to 15.9 per mil, which is consistent with a magmatic-hydrothermal or magmatic steam origin. These alunites will be dated using $^{40}Ar/^{39}Ar$ to determine the age relationship between the high-sulfidation quartz-alunite alteration and low-sulfidation quartz-adularia mineralization to the east.

The turquoise color indicates the style of alteration characteristic of the productive veins in the north half of the main part of the district. For the purposes of this assessment, areas 1 and 2 are particularly significant, as they show that the alteration type that is characteristic of productive veins has been repeated by normal faulting and is exposed to the west of the alunite-bearing rhyolite hills, within the Piute-Eldorado Tortoise ACEC (fig. 30).

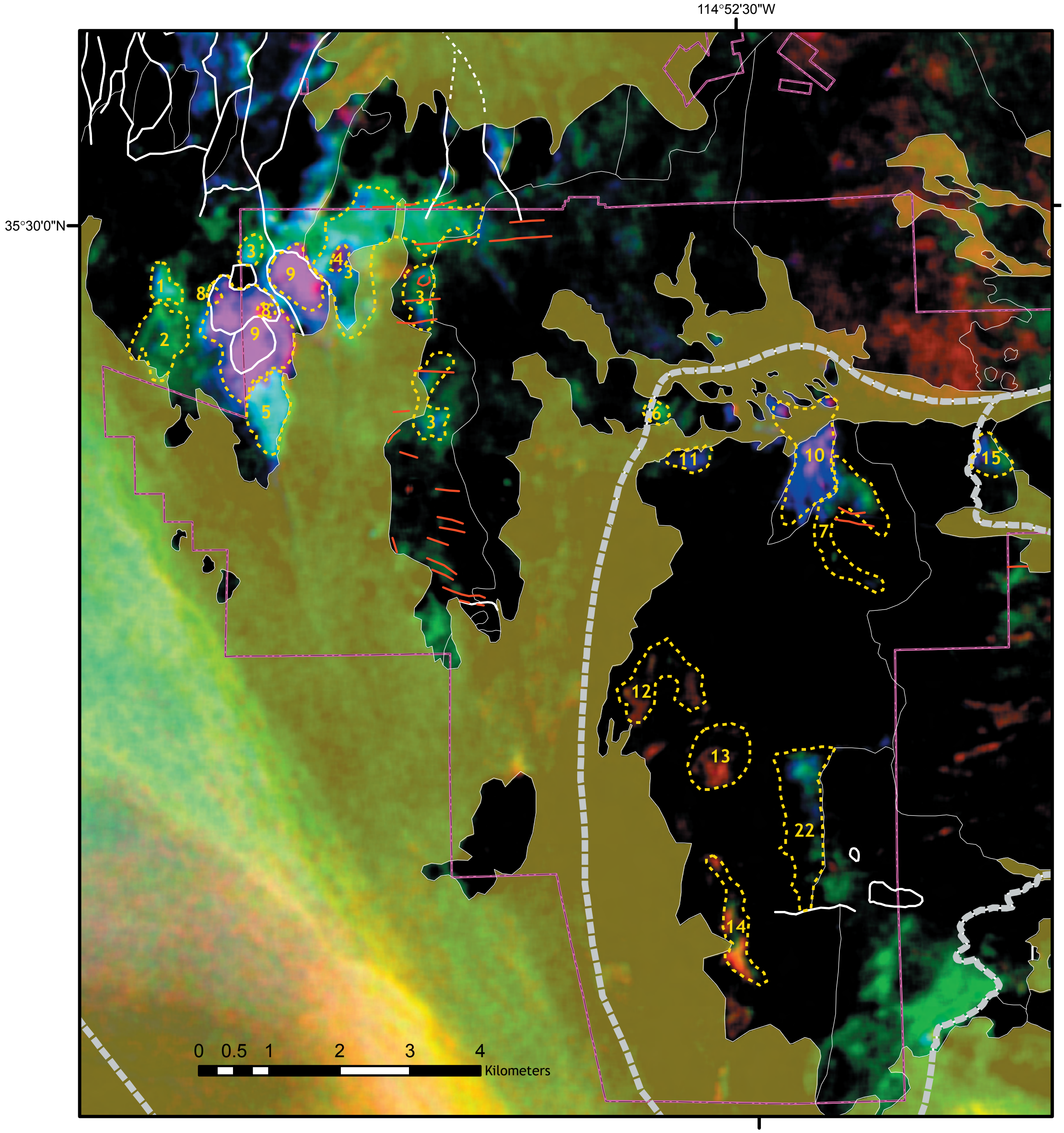


Figure 29. Advanced Spaceborne Thermal Emission and Reflectance (ASTER) image of the Searchlight district using bands 7 (red), 5 (green), and 4 (blue). The numbered areas outlined in yellow dashed lines are discrete hydrothermally altered areas described in table 2. Heavy gray dashed lines are structural block boundaries—see figures 18 and 21. Medium-weight red lines are trace of productive veins, modified from the map of Callaghan (1939). Yellow overprint indicates areas covered by Quaternary alluvium. Fuschia line is the boundary of the Piute-Eldorado Tortoise Area of Critical Environmental Concern. Image covers same area as figures 21 and 22.

Table 2. Description of hydrothermally altered areas mapped in figure 25.

[PIMA is portable infrared mineral analysis; XRD is X-ray diffraction.]

Area	Description	Spectral Character
1	Two samples characterized by PIMA and XRD to have smectite and illite	Strong adsorption in bands 6, 8, and 9
2	Two samples characterized by PIMA and XRD to have smectite and illite	Strong adsorption in band 8; moderate adsorption in band 6
3	Multiple samples characterized by PIMA and XRD to have smectite and illite	Strong adsorption in band 8; moderate adsorption in bands 6 and 9
4	No samples; spectral similarity to area 9 suggests advanced argillic alteration with alunite	Strong adsorption in bands 5 and 6
5	Two samples characterized by PIMA and XRD to have smectite and illite	Strong adsorption in bands 6, 8, and 9
6	No samples; possibly mostly smectite	Moderately strong adsorption in bands 7 and 8
7	No samples; possibly mostly smectite	Strong adsorption in bands 7 and 8
8	No samples; possibly advanced argillic alteration without alunite	Strong adsorption in band 5; moderate adsorption in band 6
9	Multiple samples characterized by PIMA and XRD to contain abundant alunite	Strong adsorption in bands 5, 6, and 8
10	No samples; spectral similarity to area 9 suggests advanced argillic alteration with alunite	Strong adsorption in bands 6 and 8; moderately strong adsorption in band 5
11	No samples; spectrum is unlike any others	Strong adsorption in bands 6; moderately strong adsorption in bands 7 and 8
12	No samples; spectrum is unlike any others and may represent unaltered rhyolite (?)	Moderately strong adsorption in band 9; moderate adsorption in band 8
13	No samples; spectrum is unlike any others and may represent unaltered rhyolite (?)	Moderately strong adsorption in band 9; moderate adsorption in band 8
14	No samples; spectrum is unlike any others and may represent unaltered rhyolite (?)	Moderately strong adsorption in band 9; moderate adsorption in band 8

Figure 30. View of alunite-bearing rhyolite hills from the west. Altered rocks of lower intermediate-composition unit of volcanics of Highland Range in foreground.

Geochemical Zoning

As noted above, we and others have drawn a contrast between the northern and southern parts of the Searchlight district, based on vein mineralogy and the nature and intensity of associated hydrothermal alteration. The geochemistry of altered and mineralized rocks reflects these and other distinctions. Table 3 records some simple statistics for geographic subgroups of mineralized samples from the district. Figure 31 shows the location of these subgroups.

Table 3. Summary statistics for mineralized samples from main part of Searchlight district.

[All data in parts per million (ppm). Complete data is in Ludington and others (2005). All values rounded to 2 (or 3) significant figures.]

	Ag	Au	Cu	Pb	Zn	Bi	Cd	Mo	As	Sb	SO_3	Cu+Pb+Zn	Au/Au+Ag
Bill Gays structural block (n=1)													
	<0.5	0.01	8	21	10	<0.05	<0.1	1.6	5.0	0.3	1.70	39	ND
Fourth of July structural block (n=6)													
Median	23	3.3	420	23	63	0.14	1.30	7.6	9.5	3.1	0.07	466	0.22
Mean	17.3	5.4	650	340	130	0.14	1.30	14.3	16.2	5.4	0.17	1,110	0.19
SD	14.4	7.1	740	490	200	0.08	1.27	20	17.8	6.0	0.27	1,310	0.17
Max	28	15	1,730	1070	540	0.25	2.2	51	52	14.3	0.72	2900	0.35
Min	1	0.01	20	13	4	0.04	0.40	0.3	5	0.5	0.02	108	0.01
Pinto structural block (n=3)													
Median	NA	0.00	23	27	49	0.83	NA	2.0	15	1.8	0.17	96	NA
Mean	NA	0.01	24	27	47	0.83	NA	1.9	15.3	1.8	0.36	98	NA
SD	NA	0.00	5	3	16	0.51	NA	0.6	3.5	0.2	0.41	12.5	NA
Max	NA	0.01	30	30	62	1.19	NA	2.4	19	2.0	0.82	112	NA
Min	NA	0	20	23	31	0.47	NA	1.3	1	1.7	0.07	88	NA
Northern Searchlight district (n=36)													
Median	4.2	0.45	61	85	123	0.13	0.58	1.6	10	2.3	0.10	300	0.28
Mean	15.1	12.3	104	250	340	0.54	2.8	3.0	11	3.6	0.49	690	0.31
SD	30	25	128	300	430	0.89	5.6	3.8	7	4.7	0.74	750	0.26
Max	150	95	570	950	1,560	2.9	26	16.4	29	23.5	2.3	2,700	0.79
Min	1	0	4	6	4	0.02	0.10	0.3	2	0.1	0.01	31	0.00
Searchlight pluton (n=7)													
Median	5	0.02	48	80	105	0.53	0.50	1.1	11	4	0.02	230	NA
Mean	15.3	0.07	320	2,700	430	4.4	0.70	7.6	12.9	6.5	0.05	3,400	NA
SD	21	0.13	630	6,700	690	9.1	0.72	11.3	6.7	6.8	0.05	7,400	NA
Max	39	0.34	1,740	17,800	1,950	25	1.90	30	23	20	0.15	20,000	0.01
Min	2	0	1	11	36	0.05	0.10	0.5	3	1.1	0.01	48	NA
Rhyolite of Searchlight district (n=22)													
Median	NA	0.00	26	30	9	0.53	0.15	3.4	9.5	0.8	5.4	77	NA
Mean	NA	0.01	29	33	33	1.54	0.20	6.2	18	1.2	7.4	92	NA
SD	NA	0.01	21	23	40	2.9	0.14	9.6	23	1.3	7.4	60	NA
Max	NA	0.02	80	110	112	13.2	0.40	47	93	6.9	24	230	NA
Min	NA	0.00	5	2	1	0.04	0.10	0.8	3	0.4	0.12	17	NA
Southern Searchlight district (n=13)													
Median	6	0.18	670	290	161	2.6	4	11.6	8.5	1.0	0.62	1,260	0.02
Mean	53	0.43	8,300	11,400	1,320	24	5.9	28	8.5	7.0	3.0	21,000	0.06
SD	63	0.60	19,900	24,000	2,600	39	6.7	37	4.7	15.8	3.9	32,000	0.08
Max	150	1.63	73,000	79,000	8,400	119	20	119	15.0	57	9.8	83,000	0.18
Min	0.90	0.00	13	12	14	0.05	0.50	1.1	1.7	0.2	0.02	44	0.00
Western Searchlight district (n=16)													
Median	2.0	0	46	23	68	0.24	0.20	2.5	14.0	1.2	0.15	176	NA
Mean	3.3	0.02	1,310	25	69	0.73	0.19	3.6	18.9	2.5	0.70	1,400	NA
SD	3.2	0.06	4,900	10	58	0.97	0.08	3.4	16.9	4.3	1.57	4,900	NA
Max	7.0	0.22	19,700	45	179	3.5	0.30	12.5	59	18.3	6.3	19,800	NA
Min	1.00	0.00	5	8	1	0.04	0.10	0.6	3	0.8	0.01	19.5	NA

The data from the northern Searchlight district are dominated by a number of gold-rich vein samples from the Blossom Mine. These samples have the highest gold and some of the highest silver values in the district but relatively low amounts of the minor elements molybdenum and bismuth. The Au:Au+Ag ratio in strongly mineralized samples ranges from about 0.4 to 0.8. The combined base-metal content (Cu+Pb+Zn) is also low, generally less than 2,000 ppm. Samples in this area also contain somewhat more potassium than the less-altered samples in the southern part of the district, probably reflecting the adularia present in many of the samples.

The southern Searchlight district data include only 13 samples, and 7 of them are from the Quartette Mine and its eastern extension, the Rambler. These samples are characterized by higher silver values and much higher base-metal contents than samples from the other parts of the district. The

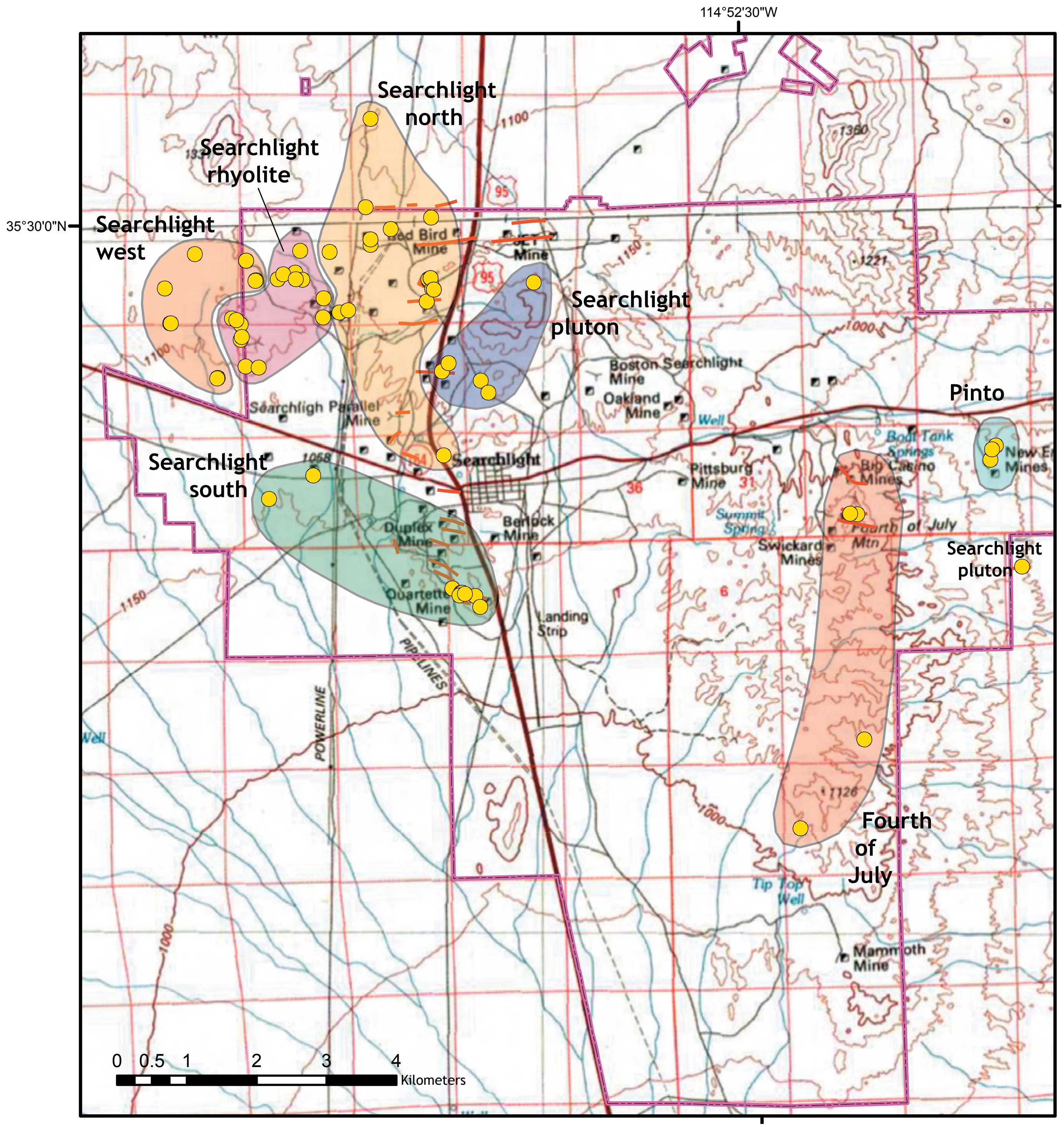


Figure 31. Location of samples summarized in table 3 and used to construct figure 32.

combined base-metal contents of many of the mine samples is in excess of 2 percent. They also contain distinctly more bismuth, molybdenum, and cadmium, and they are also modestly enriched in arsenic, antimony, tellurium, and tungsten. The Au:Au+Ag ratio in strongly mineralized samples is much lower than in the north, ranging up to only about 0.2. Four samples from the western part of this area have between 4 and 9 percent SO_3, and apparently represent the southernmost exposures of the alunite-altered rocks to the north. Three of these rocks were determined to contain alunite by PIMA.

The data for rhyolites show much different patterns than either of the areas related to the productive veins. These samples come from the large area of alunite alteration west of the northern Searchlight district. Silver was not detected in any of the samples, and gold does not exceed 0.02 ppm. Combined base-metal values are almost all less than 200 ppm. The sulfate contents are, however, quite high, with many samples containg more than 10 percent SO_3. The presence of abundant alunite also results in generally elevated K_2O contents. Phosphorous is elevated in these rocks, being generally higher than 1,000 ppm, and iron is locally high due to the presence of hematite, limonite, and jarosite. Rubidium was strongly depleted during the hydrothermal alteration.

The western Searchlight district data are important because they demonstrate that alteration and mineralization typical of the productive part of the district are found to the west of the alunite area. It is possible that these rocks are in a lower, as-yet undelineated structural block. Two samples have 2 ppm silver or more, and two samples have more than 0.01 ppm gold. Except for one sample, all these rocks have low base metals and trace metals.

The data for samples from the Searchlight pluton and related dike rocks are quite varied, although most have elevated gold contents greater than 0.02 ppm. Two samples have high total base metals, and several have elevated trace metals, with bismuth contents as high as 25 ppm and molybdenum as high as 30 ppm.

The data for samples from the Fourth of July structural block are highlighted by two samples from the Chief of the Hills Mine that are quartz-rich vein material with very high gold contents and relatively high Au:Au+Ag. They are geochemically quite similar to the samples from the Blossom Mine, except that they have high molybdenum contents (13 and 51 ppm) and moderate bismuth contents (about 0.2 ppm).

The data for the three samples from the Pinto structural block (all taken near the New Era Mines) are only weakly mineralized, with both precious and base metal contents being relatively low. One sample does contain nearly 1 percent SO_3. These samples are of hydrothermally altered material but were not taken from mine dumps.

The single sample from the Bill Gays structural block is from an oxidized rhyolite breccia. It appears to be significantly enriched only in sulfur.

A study by Al-Shaieb (1969) yields additional information about the differing alteration and mineralization styles in various parts of the district. The study was designed to examine the distribution of ore and trace elements in the wall rocks of veins from the district, but because the samples were collected from underground exposures that are no longer accessible, the research provides important information about the geochemistry of the veins. Traverses were made, collecting samples from the veins and at regular intervals away from the veins. Samples were analyzed for gold, silver, copper, lead, and zinc.

The Al-Shaieb samples were collected from underground at both the Chief of the Hills and Duplex Mines. The samples from the vein at Chief of the Hills had compositions closely similar to the ones we collected at the surface, with total base-metal contents of a few hundred ppm, gold contents of 10 to 30 ppm, and Au:Au+Ag of 0.3 to 0.5. The Duplex Mine samples had total base-metal contents of 1 to 5 percent, gold contents of 1 to 10 ppm, and Au:Au+Ag of 0.1 to 0.4, compositions similar to those we report for the Quartette-Rambler vein system.

In summary, as shown in figure 32, the veins in the northern part of the Searchlight district have low base metals, high gold contents, and high Au:Au+Ag; their wall rocks are generally altered to adularia and, farther from the vein, to smectite-illite assemblages. The veins in the southern part of the district have high base metals, moderate gold contents, and low to moderate Au:Au+Ag; their wall rocks are not strongly altered. Our geochemical results generally confirm the descriptions made by Callaghan (1939), except for the low gold contents and metal ratios of our Quartette and Rambler samples. Much of the ore mined from the Quartette had extremely high gold contents, and Callaghan (1939) reports that "the product of the Quartette Mine was highly variable but mostly contained three times as much gold as silver by weight."

A possible implication of this contrast between the two areas might be that there are several hydrothermal systems present at Searchlight, each of a different age and mineralization style. Based on limited evidence, Callaghan (1939) discarded this idea, saying that "there appears to be a gradual transition from one to the other." More detailed mapping and radiometric dating will be necessary to determine if a single hydrothermal system was responsible for mineralization in the Searchlight district. If the transition from south to north represents simple zoning, it is decidedly eccentric with respect to the upper contact of the Searchlight pluton. It is possible that the northern and southern parts of the district are also in two structural blocks. It is also possible that the deposits in the northern part of the district may be more intensely weathered. This could account for the enhanced Au:Au+Ag, but the absence of visible supergene minerals and the presence of unoxidized pyrite south of the Blossom Mine argue against this.

The north-to-south variations discussed above are important because they are related to the metallogeny of gold-bearing veins. More important to understanding the hydrothermal system as a whole is the east-to-west (originally bottom-to-top) zoning. In the uppermost part of the Searchlight pluton and in the first few hundred meters above the pluton, alteration is primarily to illite and other clay minerals, and sulfur-bearing minerals are not abundant, although small amounts of jarosite are common. About 700 to 1,500 m higher in the section, and coinciding with the appearance of rhyolitic lithologies, the alteration assemblage changes abruptly to one characterized by alunite, and sulfur contents of these rocks are several percent (Ludington and others, 2005). This upper alteration zone is characteristic of high-sulfidation epithermal deposits, but the scarcity of pyrite in the lower clay-illite zone is not. Overall, the distribution and amount of hydrothermal alteration is similar to that in large pluton-related mineral deposits such as porphyry copper deposits, but the specific mineral assemblages present at Searchlight do not correspond well to any accepted deposit models. Nevertheless, it seems clear that the gold-bearing veins are the result or hydrothermal fluids derived from the cooling Searchlight pluton.

Our interpretation of the original geometry of and zoning patterns in the Searchlight district, while critical to an assessment of the possibilities for new discoveries, is far from settled. Additional work is underway that should lead to a great improvement in our picture of this enigmatic mineral district.

Newberry District

The deposits grouped into the Newberry district are probably unrelated. Most of them can be classified as polymetallic vein deposits, although quartz veins do not occur at all sites. They are structurally controlled, primarily by steep west-trending shear zones and faults. The absolute age of the deposits is unknown, as most of them cut only Proterozoic rocks, but we presume that they are of Miocene age and generally contemporaneous with the deposits in the Searchlight district. The hydrothermal alteration assemblage associated with the deposits is most commonly quartz, specular hematite, and illite. In at least 2 of the locations, the alteration and mineralization persists over strike lengths of several kilometers. Viewed in the context of the structural tilting that characterizes this area,

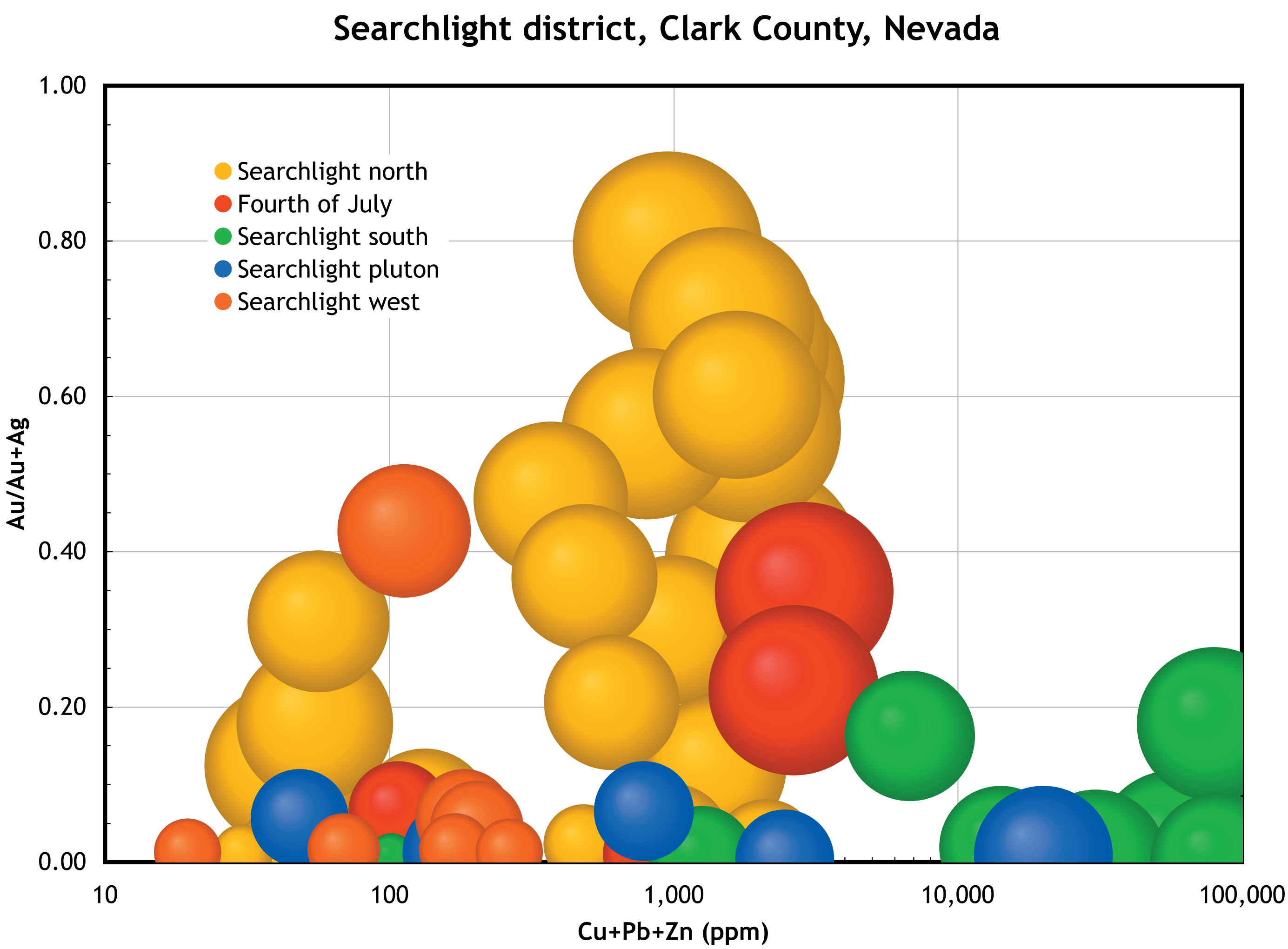


Figure 32. Plot showing contrast in metallogenic character of samples from different areas of the Searchlight district. Size of symbols is proportional to the logarithm of the gold content of samples, in parts per billion.

the suggestion is that some of these structures exhibit mineralized rock over a vertical range of at least 3 km.

The Rare Metals Corporation mill (fig. 33) was reportedly located on the floor of Piute Valley about 12 km southeast of Searchlight (Nevada Division of Mine Inspection, 1990), but there is neither any trace of any activity at the site, nor the remains of any road construction near this area.

Goldenrod Mine

The Goldenrod Mine is located at the point where Nellis Wash issues from the Eldorado Mountains, and it is in an inholding of private land within the Piute-Eldorado Tortoise ACEC (fig. 33). Longwell and others (1965) mislocated this mine, putting it at the site of the Roman Mine (see below).

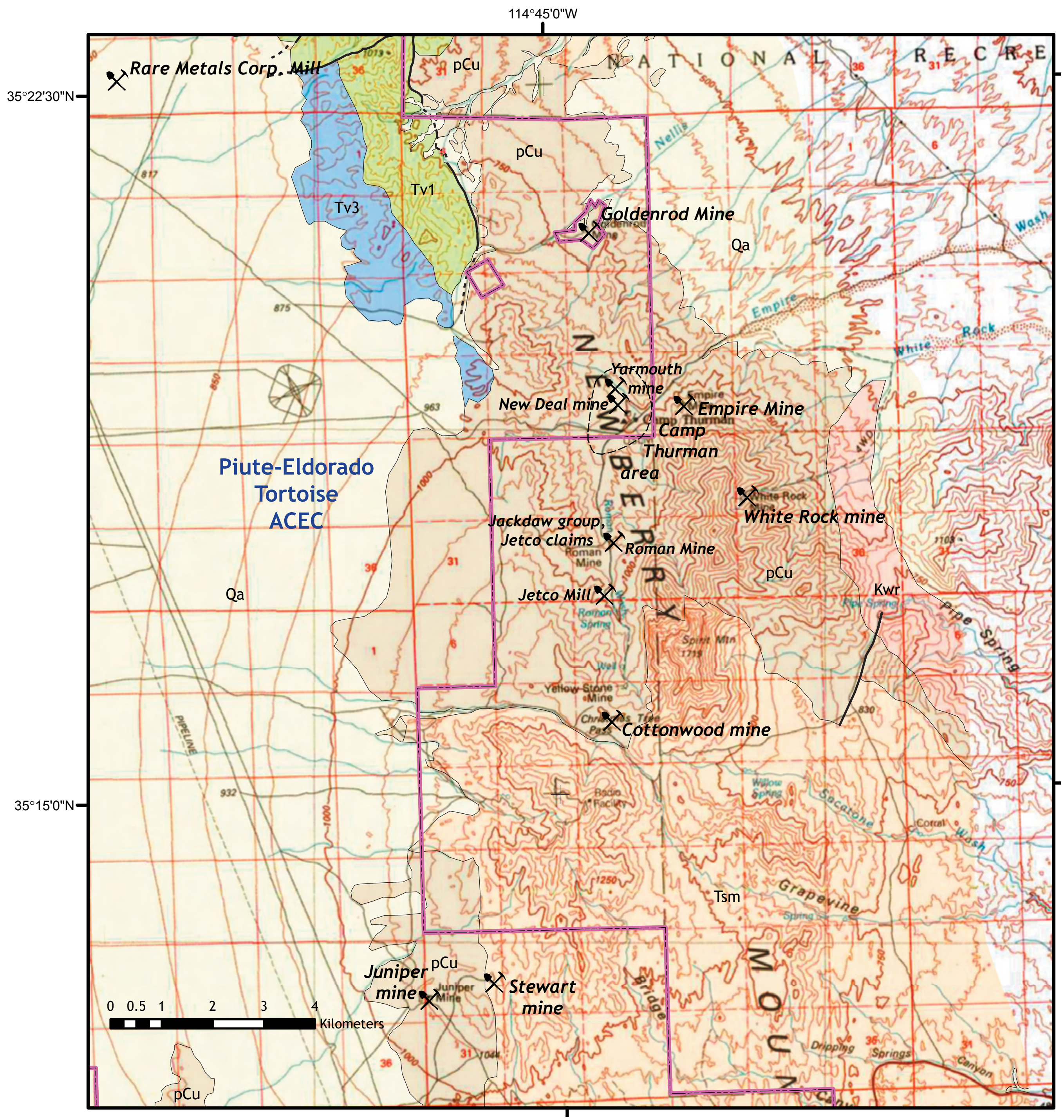


Figure 33. Mineral deposits in and near the Piute-Eldorado Areas of Critical Environmental Concern (ACECs; boundaries in pink) that are assigned to the Newberry mining district. Geology compiled for this report: pCu—undivided Proterozoic rocks; Kwr—Cretaceous granite of White Rock Wash pluton; Tv1—Miocene intermediate-composition volcanic rocks; Tv3—Miocene mafic volcanic rocks.

Vanderburg (1937) described two shafts and stated that a "small amount" of ore had been mined and treated locally. He also described a near-vertical quartz vein that cuts Proterozoic granite, strikes N60E, and is about 10 to 40 cm wide. We did not see this vein, but we sampled some 1-cm wide quartz veins that appeared to have oxidized casts of former sulfide minerals. This sample (5-061003; Ludington and others, 2005) did not yield anomalous values of precious or base metals. Another small private inholding is about 2 km southwest of the Goldenrod Mine, but we saw no evidence of mineralized or altered rock there.

Camp Thurman

The area called Camp Thurman on topographic maps is shown on 1:24,000-scale topographic maps to contain the workings of the Potential Mine (fig. 33). Claims in this area were designated by Longwell and others (1965) to be the Jackdaw Group of claims, which were described by Vanderburg (1937). However, Vanderburg clearly stated that the Jackdaw Group was formerly known as the Old Roman Mine, which is likely to be the Roman Mine shown 2.5 km to the south on topographic maps. Thus, the only description of mines at this location seems to be that of Lawrence (1963), who describes the New Deal (or Polyanna) Mine and the Yarmouth Mine at this location. The mines were reportedly located 18 miles southeast of Searchlight and 2 miles northeast of Newberry Peak in sec. 21(?), T30S, R65E. This questionable legal location puts the property in the Camp Thurman area; however, the other location data suggest that it might be a few kilometers southwest of Camp Thurman. The workings at Camp Thurman consist of three shafts that were driven down a near vertical vein that strikes N65E and has been segmented by displacement along vertical faults that strike N25W. The deposits are described as being last worked in 1933, for silver, lead, antimony, and probably zinc. The antimony is described as occurring in tetrahedrite. We took two samples at this site, AP-047 (a 65-cm chip sample) and 4-050304 (Ludington and others, 2005). AP-047 contained only weakly anomalous values of precious or base metals, but 4-050304 contained 9.1 ppm gold, 3 ppm silver, and about 1,700 ppm lead (table 4). We also visited the Empire Mine, about 1 km to the east, but saw no signs of significant mineralized rock.

On ASTER images, there is a linear feature that extends about N70W from the Camp Thurman area to the range front in Piute Valley (fig. 34). The signature is similar to the illite- and smectite-bearing rocks in the Searchlight district, and this alteration style was confirmed by PIMA analysis. The country rock here is Proterozoic gneiss, and there is abundant limonite. Three samples were taken within this area (5-103002, 5-103003, 5-103004; Ludington and others, 2005). Sample 5-103003 contains visible pyrite and is weakly anomalous in barium, lithium, molybdenum, and zinc, whereas 5-103004, which contains small quartz-specular hematite veins, is mildly anomalous in phosphorous, tin, and yttrium. All of these samples have low gold and silver contents; 5-103004 contains 3 ppb (parts per billion) palladium.

Roman Mine Area

About 2.5 km to the south of Camp Thurman, but outside the Piute-Eldorado Tortoise ACEC, the Roman Mine (also known as the Jetco claims and the Jackdaw group) is presently being worked for decorative stone instead of precious metals. The Jackdaw group was described by Vanderburg (1937), who reported a quartz vein with malachite and azurite. At that time, the mine was being worked on a small scale and recent production was estimated at $15,000.

Samples from the Roman Mine area have elevated gold, as well as the highest silver, copper, and base-metal values in the Newberry district. A quartz vein sample with malachite and azurite from the Roman Mine was reported by Smith and Tingley (1983) to contain high Au, Ag, Cu, Pb, Zn, As, and Sb (sample 1342, table 4). We did not sample this site.

The Roman Mine is near the eastern part of another area of hydrothermal alteration inferred from ASTER imagery (fig. 34) that extends to the west and northwest from the mine area to the range front, inside the Piute-Eldorado Tortoise ACEC.

About one kilometer south and southwest of the Roman Mine are unnamed prospects shown as a shaft and tunnel on the 1:24,000-scale topographic map. Smith and Tingley (1983) collected three samples in this area (samples 1338, 1339, and 1341, table 4), and reported values as high as 11 ppm gold, with high silver, copper, lead, and zinc. The shaft is about 300 m east of the altered area.

Cottonwood Mine Area

Longwell and others (1965) described the Cottonwood Mine as being located in section 18 of T31S, R65E, and as being hosted by Proterozoic gneisses. No Proterozoic rocks crop out in section 18, and there are no workings at the location indicated. On the basis of the geologic description, we believe the area referred to is in section 9, where Smith (1982a) described the Christmas Tree Pass workings as exploring a steeply dipping west-trending shear zone in Proterozoic gneiss with small quartz veins and oxidized sulfide minerals. The Yellow Stone Mine is shown on the 1:24,000 scale topographic map about a kilometer to the northwest. Samples from the Cottonwood Mine area and about 2 km to the west contain 2.5 and 3.4 ppm gold, respectively, with high silver, molybdenum, and lead (Smith and Tingley, 1983; table 4). Like the Roman Mine area, this area is also outside the ACEC boundary (fig. 33).

Stewart Mine

This mine is referred to in the literature only by a listing in Nevada Division of Mine Inspection (1977), where it is reported to have been a silver deposit, with minor lead. A small pit in the uppermost part of the Spirit Mountain pluton exposes granite that is pervasively stained with manganese oxides in an area about 100 m across. Our sample of this material (4-030703,

Table 4. Precious- and base-metal contents of mineralized samples from the Newberry district.

[Analyses of samples 1333 through 1343 are from Smith and Tingley, 1983; Ag, Ba, Bi, Cu, Mo, and Pb by semi-quantitative emission spectroscopy; As, Au, Sb, and Zn by atomic absorption. Other analyses are from Ludington and others, 2005. All analytical data are in ppm, nd = no data.]

Sample no.	Location	Ag	As	Au	Bi	Cu	Mo	Pb	Sb	Zn	Description
5-061003	Goldenrod Mine	<1	1	0.00	0.0	4	1	6	0.3	13	Quartz vein
AP-047	Camp Thurman	<1	2	0.03	0.3	30	1	68	0.3	19	Quartz vein, 65-cm chip
AP-048	Camp Thurman	1	3	<.01	0.1	24	0	66	0.7	44	Pegmatite, grab
1343	Camp Thurman	2	<10	0.30	<10	70	<5	100	4.0	20	Quartz vein with Fe-oxide after pyrite and Mn-oxide
4-050304	Camp Thurman	3	2	9.09	0.3	134	16	1732	0.5	41	Quartz vein with pyrite
5-103002	West of Camp Thurman	<1	1	0.00	0.0	4	0	27	0.4	14	Quartz veins
5-103003	West of Camp Thurman	<1	2	0.00	0.1	8	15	22	0.8	161	Quartz veins
5-103004	West of Camp Thurman	<1	2	0.01	0.2	8	2	10	0.2	54	quartz-hematite vein
1342	Roman Mine	200	110	0.90	<10	1000	<5	5000	840	250	Quartz vein with Cu-oxide
1338	South of Roman Mine	10	<10	0.55	<10	15000	10	1000	5.0	600	Sheared intrusive with Fe-Mn-oxide and Cu-oxide
1341	South of Roman Mine	200	<10	11.0	15.0	5000	<5	15000	3.0	>2000	Quartz vein with py, cpy, ga, and Cu-oxide
1339	South of Roman Mine	<1	<10	<.05	<10	200	<5	70	2.0	10	Quartz vein with sulfides and Mn-oxide
1336	Cottonwood Mine area	15	<10	2.50	<10	30	5	500	4.0	40	Quartz vein and sheared rock with pyrite and chalcopyrite
1337	West of Cotton-wood Mine	3	<10	3.40	<10	20	500	70	4.0	35	Silicic rock with pyrite and quartz vein
1340	Yellow Stone Mine	<1	<10	<.05	<10	10	<5	50	nd	nd	Quartz vein and sheared rock with limonite
4-030703	Stewart Mine	2	<1	0.12	2.6	322	5	2160	0.1	9990	Granite with Mn-oxide
5-050703	North of Juniper Mine	<1	1	0.01	0.1	31	3	11	0.5	35	Quartz vein stockwork
AP-049	Juniper Mine East shaft	<1	<1	1.07	<.04	14	1	18	0.2	35	Quartz vein, grab
AP-050	Juniper Mine ore pile	<1	<1	0.18	0.4	31	47	32	0.3	94	Quartz vein in altered gneiss, ore pile grab
4-030704	Juniper Mine	<1	3	0.01	0.5	1	1	134	1.0	136	Granite with Fe-oxide
1335A	Juniper Mine	70	<10	60.0	<10	7	<5	20	3.0	45	Quartz vein with oxidized pyrite
1335B	Juniper Mine	1	<10	0.20	<10	200	<5	200	3.0	60	Siliceous dike with oxidized pyrite
4-030701	Prospect southeast of Juniper Mine	<1	1	0.28	0.1	7	2	136	0.3	32	Aplite with Fe-oxide
1334	Superfluous claims	1	<10	10.0	<10	70	<5	200	3.0	80	Quartz vein and sheared rock with specular hematite, Mn-oxide
AP-051	Gibraltar claims	1	25	0.92	0.2	42	14	166	5.9	191	Hematized shear zone in granite, 1-m chip
1333	Gibraltar claims	7	90	6.60	<10	30	70	1000	4.0	130	Siliceous dike with Fe-Mn-oxide
4-033103	Unknown	2	14	0.03	3.0	73	50	20	0.2	6	Quartz veins

table 4) contains high Ag, Au, Bi, Cu, Pb, and Zn, as well as elevated beryllium, cadmium, and nearly 6 percent manganese (Ludington and others, 2005). The style of mineralization is enigmatic; no structures were observed, and the association of beryllium with precious metals is uncommon.

Juniper Mine

The Juniper Mine is about 12 km south of Camp Thurman on the west flank of the Newberry Mountains (fig. 33), and consists of two shafts along a west-trending structure that apparently dips steeply north. The west shaft is 30 m deep or more. Some minor veins with similar orientations are exposed in shallow surface diggings between the shafts. The veins cut Proterozoic granite and fine-grained metamorphic rock. Grab samples of loose vein material contain as much as 1 ppm Au (sample AP-049; Ludington and others, 2005). A sample collected by Smith and Tingley (1983) from the dump of the Juniper Mine contains 60 ppm gold and 70 ppm silver, and a second sample has moderately elevated gold, copper, and lead (samples 1335A and 1335B, table 4).

White Rock Mine

The White Rock Mine is shown on both 1:100,000 and 1:24,000-scale topographic maps, about 2 km southeast of the Camp Thurman area, outside the Piute-Eldorado Tortoise ACEC, and inside Lake Mead National Recreation Area. The USGS's MRDS database (U.S. Geological Survey, undated) lists the major commodities as copper, gold, and silver. This database also gives Volborth (1973) as a reference, but there is no mention of the mine in that report. It seems likely that

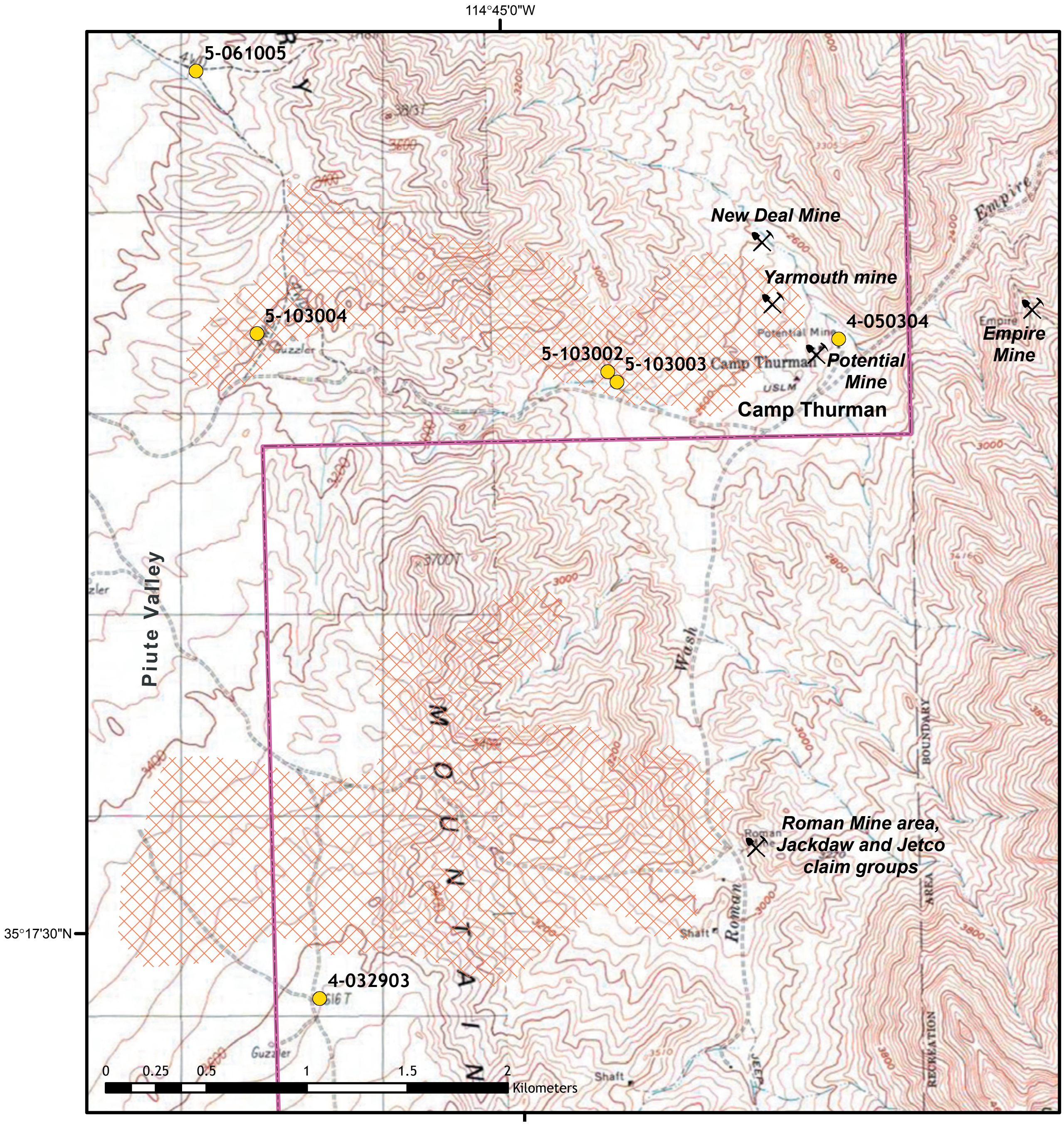


Figure 34. Map showing location of hydrothermally altered rocks identified by Advanced Spaceborne Thermal Emission and Reflectance (ASTER) imagery near Camp Thurman and Roman Mine areas (red cross hatch). Analyzed samples shown by yellow circles.

this is the site described by Vanderburg (1937) as the Homestake Group, 9 miles north of Hiko Springs. Vanderburg reported that there were 3 east-west veins, the largest being as wide as 6 m, dipping about 50 degrees to the north, and that the major commodities were gold, with small amounts of silver (no mention of copper). He also reported that the mine had been worked intermittently from 1910 until the middle 1930s. We did not visit the White Rock Mine.

Superfluous and Gibraltar Claims

The Superfouous and Gibraltar claims are in the Chiquita Hills, immediately east of U.S. Highway 95 at the junction with Nevada State Highway 163 (fig. 35). Both sites are characterized by gold-bearing vein deposits similar to others in the Newberry district, and both contain shear zones in Proterozoic gneiss with hematite. They are briefly described by Smith (1982b,c).

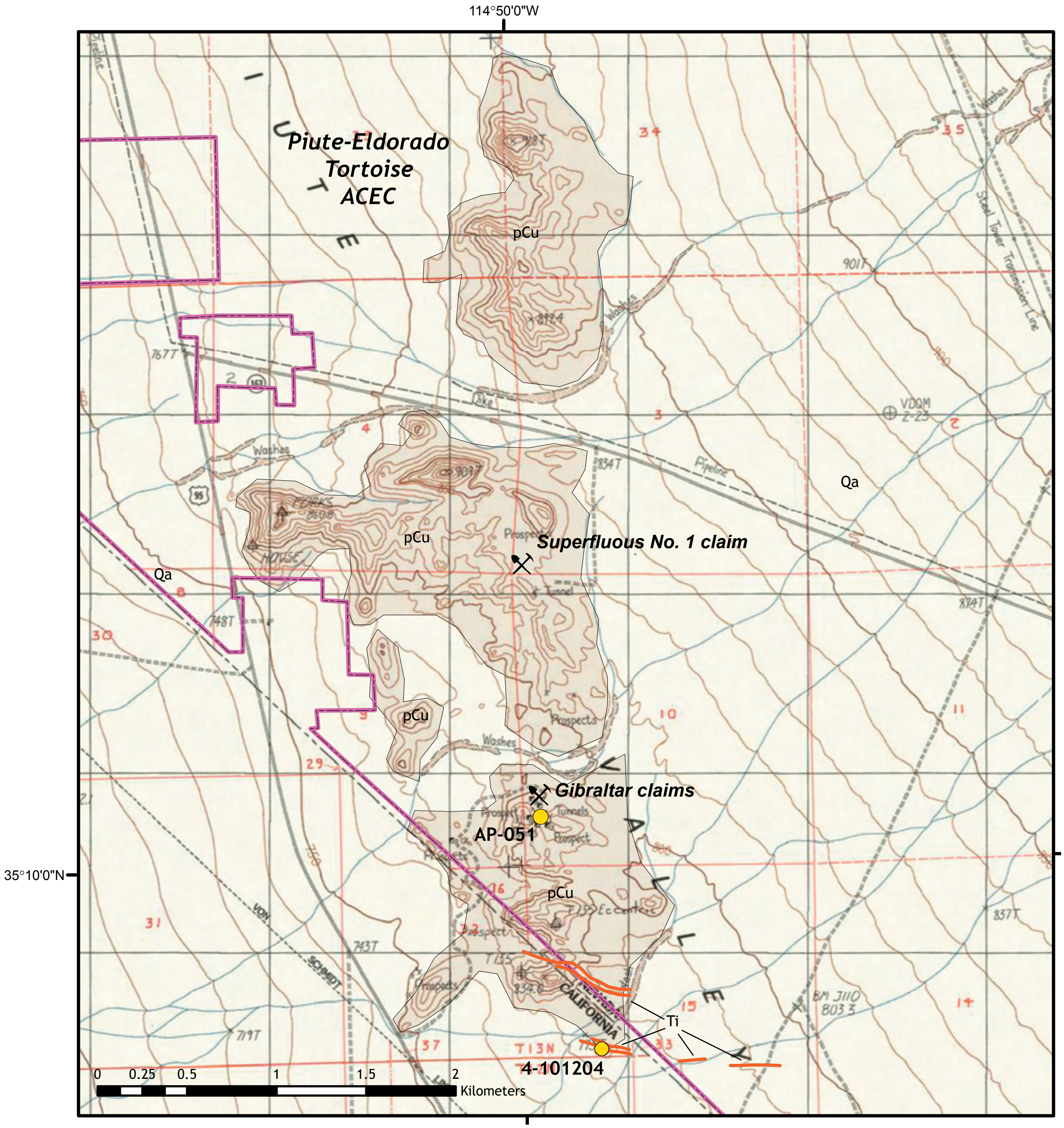


Figure 35. Map showing location of Superfluous and Gibraltar claims in the Chiquita Hills. Analyzed samples shown by yellow circles. Geology compiled and mapped for this study: pCu—undifferentiated Proterozoic metamorphic and igneous rocks; Ti—porphyritic granite dikes; Qa—Quaternary alluvium.

The Superfluous claims may have been originally prospected for uranium (Garside, 1973), but Smith and Tingley (1983) reported a sample with 10 ppm gold and moderately elevated silver and lead (sample 1334, table 4) from a steeply northeast-dipping, quartz-cemented shear zone with calcite, sulfides, and hematite.

The Gibraltar claims were staked just inside California, but workings extend into Nevada. In Nevada, the property is marked by several closely spaced shafts according to the 1:24,000-scale topographic map. Our examination disclosed an open pit about 20 m long that exposes old adits along a fault in Proterozoic gneiss and granite that strikes N70E. In the pit, the fault dips to the north about 45 to 75 degrees (fig. 36), but about 50 m to the west, the fault dips only 25 degrees to the north. The granite is cut by a fine-grained rhyolite dike that dips gently to the north, and both the granite and rhyolite contain abundant hematite adjacent to the fault. Sample AP-051, a 1-m chip across the sheared and altered rock along the fault, contains about 1 ppm each of gold and silver, along with slightly elevated molybdenum, lead, and zinc (sample AP-051, table 4; Ludington and others, 2005). A sample reported in Smith and Tingley (1983) from the same area has 6.6 ppm gold, along with high lead, zinc, and molybdenum (table 4). In addition to the workings, the Gibraltar site has the remains of a small but fairly modern mill in a vigorous state of disrepair (fig. 37).

To the north, the Superfluous area exposes mineralized rock of similar appearance but containing carbonate, specular hematite, and drusy quartz. We took no samples here, but Smith and Tingley (1983) reported a sample from this area with 10 ppm gold and moderately high silver and lead (sample 1334, table 4).

Crescent District

The Crescent district was originally exploited for turquoise, but gold was discovered in 1905, and there was considerable activity until 1942. There has been only limited geologic study of the area, and, for many of the deposits that are briefly described in the literature, the locations are uncertain. The country rock in the region is primarily Proterozoic schist, gneiss, and meta-igneous rocks (Longwell and others, 1965; Miller and Wooden, 1993). The east half of the district is dominated by the north end of a large pluton of Proterozoic biotite leucocratic granite with an age of about 1672 Ma (Miller and Wooden, 1993). A few small plutons and dikes of Cretaceous granodiorite occur. One large altered area that encompasses Crescent Peak was explored as a porphyry copper prospect during the 1960s, and it probably is related to the Cretaceous igneous rocks (Archbold and Santos, 1962). Miocene volcanic rocks are found at the southwest end of the district, primarily in California, and at the extreme east end of the district, where the volcanic rocks lie unconformably on the Proterozoic gneisses. Miocene structure, which is probably key to understanding the geology of the mineral deposits, is poorly understood in the Crescent district.

There are many mines in the district, and most of them are outside the Piute-Eldorado Tortoise and Crescent Townsite ACECs. We describe only some of the principal ones and the ones we visited and sampled (see fig. 38, table 5). At least four types of mineral deposit exist in the district: (1) porphyry copper deposit (Crescent Peak), (2) metal-bearing fluorspar veins (Blue Crystal), (3) gold-rich polymetallic veins (Peyton, Sundog, Double Standard, Nippeno, Cumberland), and (4) detachment-fault-related deposits (Silver Bell, Big Tiger-Rest,

Figure 36. Small open-pit mine with old underground working along north-dipping fault. Sample AP-051 was collected from the shattered zone below the hammer.

Figure 37. Remains of a mill near the site of sample AP-051. The small blue shaking table at right suggests that gravity recovery of gold was planned. The mill appears abandoned, but the presence of modern excavation equipment indicates recent activity.

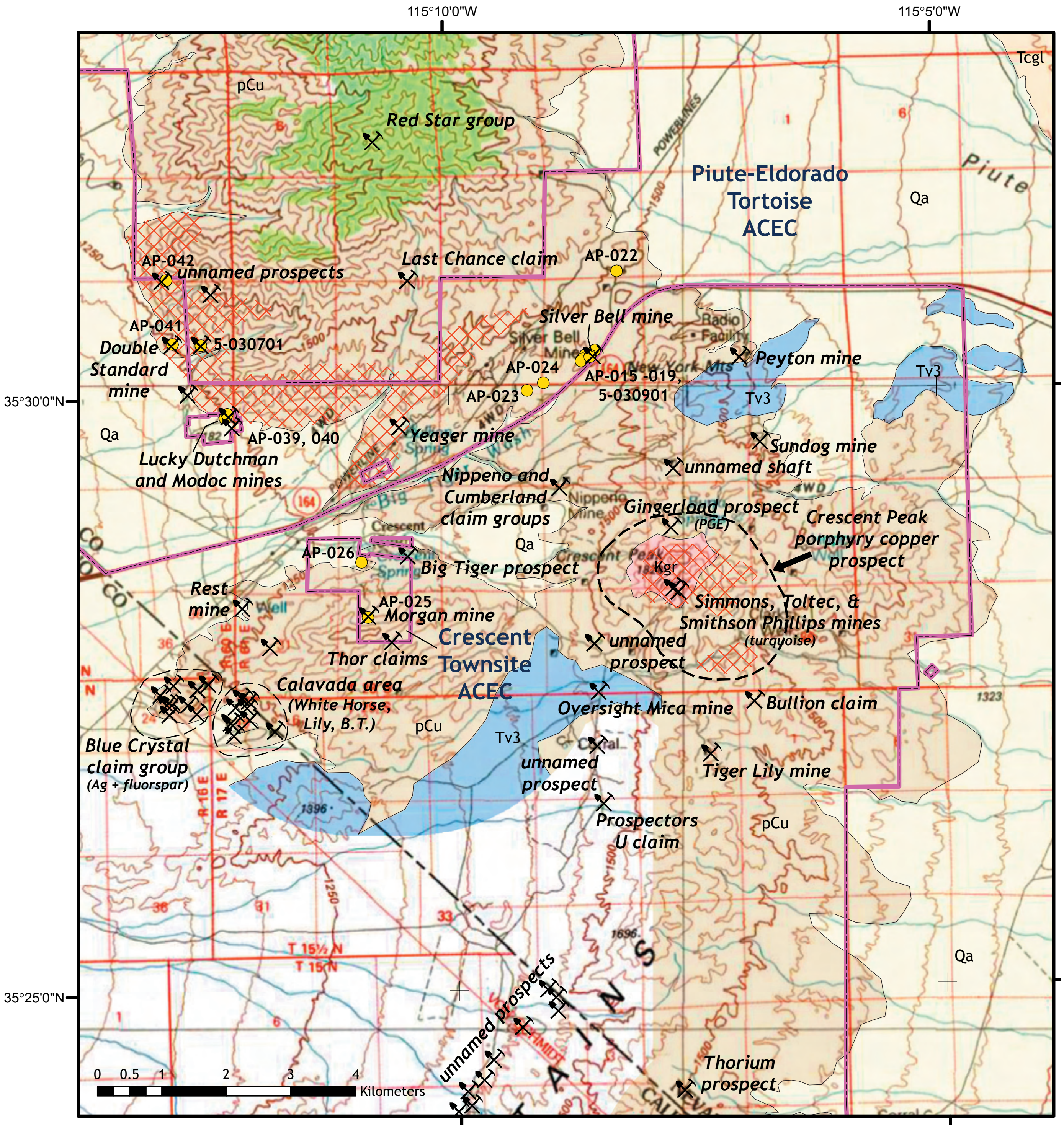


Figure 38. Mines and prospects in the Crescent district. Yellow circles are analyzed samples listed in table 5. Geology is modified from Stewart and Carlson (1978): pCu—Proterozoic metamorphic and igneous rocks; Kgr— Cretaceous granite; Tv—Miocene mafic volcanic rocks; Qa—Quaternary alluvium. Red cross-hatch indicates areas of hydrothermal alteration identified with Advanced Spaceborne Thermal Emission and Reflectance (ASTER) imagery. Boundaries of Areas of Critical Environmental Concern (ACECs) shown in pink.

Calvada, Lucky Dutchman). Several of the deposits are difficult to classify because of the limited information available, and they may be either gold-rich polymetallic veins or detachment-fault-related deposits.

Silver Bell Mine

The Silver Bell Mine is located within the Piute-Eldorado Tortoise ACEC, adjacent to Nevada State Highway 164 (fig. 38). Although it is shown on both 1:24,000 and 1:100,000-scale topographic maps, it is not mentioned in the geologic literature. It is possible that this is because it was discovered and developed subsequent to 1937, when the last primary geologic investigations in the area were carried out (Vanderburg, 1937).

The mine workings at the Silver Bell expose northeast-striking veins and shear zones with shallow northwest dips that consist mainly of bleached and silicified rock. Abundant quartz and manganese oxide were identified in hand specimen, along with local galena and secondary copper minerals. The samples have high gold (as much as 18 ppm), silver (as much as 12 ppm), copper, lead, and zinc along with moderately high molybdenum and antimony (table 5). This mineralized rock occurs along a N30E- to N65E-striking structure that is nearly horizontal in places and dips as much as 35 degrees northwest elsewhere (figs. 39, 40). The mineralized structure cuts Proterozoic gneiss and barren quartz veins (for example, sample AP-015Q, table 5). To the southwest and northeast, and approximately along strike with the Silver Bell structure, are occurrences of similar rock along structures that are horizontal or dip 40 degrees to the northwest. Some samples of this material (AP-022 through AP-024C, table 5) have elevated metal values similar to those of the Silver Bell samples. Sample AP-024C is of interest because it is an ore grade chip sample (with about 4 ppm Au, or 0.1 troy ounce per ton) across 1.2 m of sheared and altered rock from a near-horizontal zone adjacent to an old open stope (fig. 40).

On the basis of petrographic and SEM/EDX studies, samples from the Silver Bell Mine contain several manganese oxide phases, including an iron and manganese mineral (fig. 41), a manganese and lead mineral (coronadite?) (fig. 42), an unknown phase containing manganese, potassium, and lead, and a rare mineral that contains manganese, lead, and antimony. Other secondary phases include an iron oxide mineral and hemimorphite ($Zn_4[(OH)_2|Si_2O_7] \cdot H_2O$) (figs. 43, 44). Primary sulfides include galena, pyrite, sphalerite, and chalcopyrite, along with rare acanthite and imiterite (Ag_2HgS_2). Although galena is present in some samples, late vein- and breccia-filling manganese-oxide phases may be the only lead-bearing minerals in others (fig. 45). Barite is present in minor amounts. Electrum was found as grains as much as 60 μ across in one sample (fig. 44).

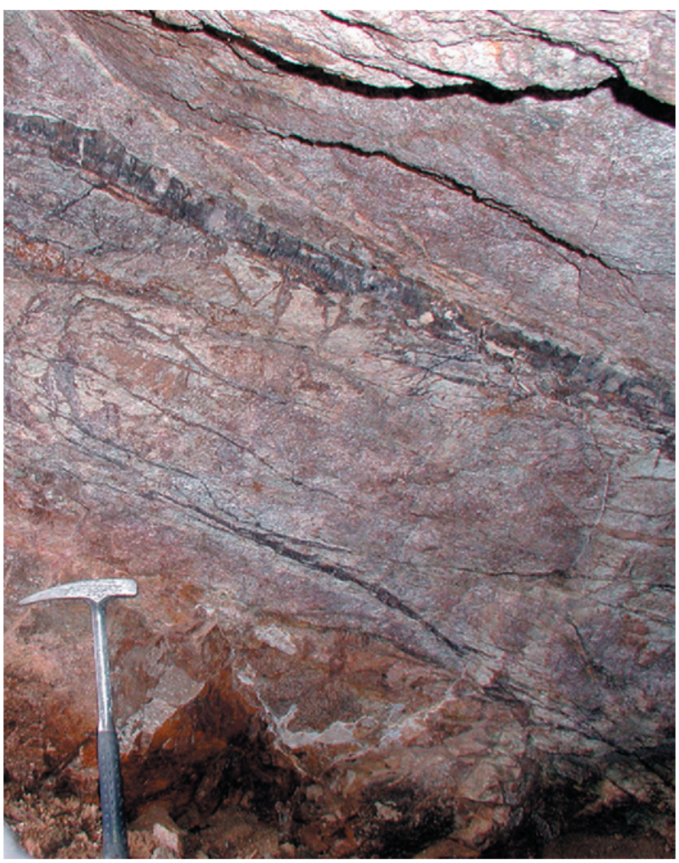


Figure 39. Shallowly northwest-dipping sheared, altered, and silicified gold-bearing zone (behind hammer) in an adit at the Silver Bell Mine. Site of samples AP-015 and AP-015C.

Peyton and Sundog Mines

The Peyton and Sundog Mines are in the northeast end of the Crescent district, about 3 km east of the Silver Bell and about 1 and 2 km respectively south of the Piute-Eldorado

Figure 40. Shallowly-dipping sheared, altered, and mineralized zone southwest of the Silver Bell Mine. AP-024C is a chip sample taken from the hammer (right of opening) downward 1.2 m across the sheared and limonitic rock to the top of unoxidized greenish gneiss below.

Table 5. Samples from vein and shear zone deposits and occurrences in the Crescent district.

[All values in ppm, rounded to 2 or 3 significant figures.]

SAMPLE	LOCATION	Au	Ag	Mo	Cu	Pb	Zn	As	Sb
AP-015	Silver Bell Mine	6.0	4.2	13	133	2,500	570	34	3.2
AP-015C	Silver Bell Mine	0.20	1.0	10.8	35	1,430	480	7	0.6
AP-015Q	Silver Bell Mine	0.01	0.1	0.5	2.3	14.9	12	0.6	0.2
AP-019	Silver Bell Mine	18.1	12.7	28.2	1,150	>10,000	7,800	8.9	34
5-030901	Silver Bell Mine	0.002	<0.5	2.5	19	16	49	2	0.6
AP-022	unnamed adit	0.26	14.8	28.7	>10,000	580	149	126	52
AP-022B	unnamed adit	0.00	<0.1	3	23	16.7	70	<0.5	0.1
AP-023	unnamed adit	1.52	2.9	74.3	89	3745.9	1830	4.1	2.4
AP-024	unnamed stope	4.1	6.5	17.6	200	>10,000	5300	21	7.0
AP-024C	unnamed stope	1.25	7.5	29	370	8,100	>10,000	22	4.1
AP-039	Lucky Dutchman Mine	0.04	0.1	0.5	48	34	17	1.2	0.5
AP-040	Lucky Dutchman Mine	0.00	0.1	0.4	95	14.7	13	2.8	0.4
AP-041	Double Standard Mine	11.6	154	219	1,780	>10,000	5,700	1,300	43
5-030701	Dump east of Double Standard Mine	0.26	<0.5	3.7	10	9	7	9	0.7
AP-042	unnamed shaft	4.8	64	11.3	30	500	180	194	4.1

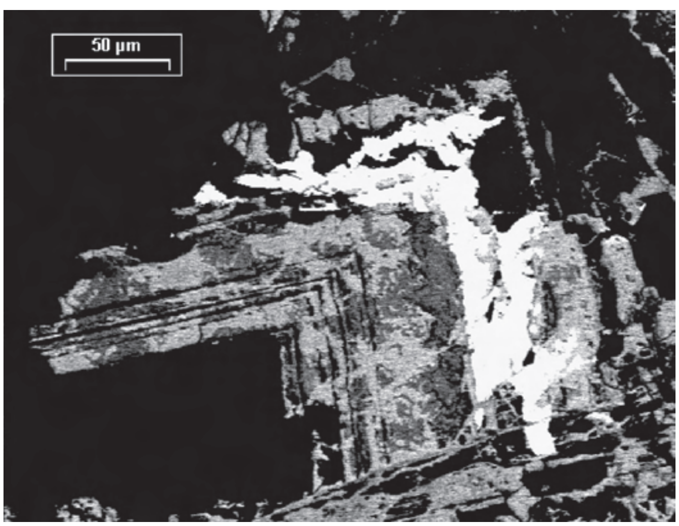


Figure 41. Back-scattered electron image of barite (bright) interlayered with a manganese-oxide mineral (dark gray) that is intergrown with an iron and manganese oxide mineral (light gray) that replaced an unknown crystalline phase. Dark background is mostly quartz. Sample AP-015, Silver Bell Mine.

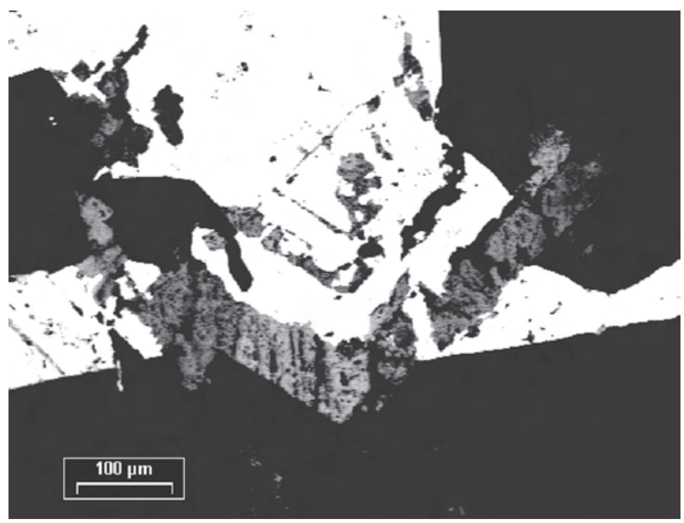


Figure 42. Back-scattered electron image of galena (bright) partially replaced by lead-bearing manganese-oxide mineral, possibly coronadite (gray). Dark background is mostly quartz. Sample AP-019, Silver Bell Mine.

Tortoise ACEC (fig. 38). The Peyton Mine explores a quartz-galena-chalcopyrite vein that strikes north and dips 45 degrees to the west (Hewett, 1956). It has no recorded production. The Sundog Mine exploited quartz veins that contain bornite, chalcopyrite, and copper-oxide minerals, and it probably had a small amount of production, though none was recorded (Longwell and others, 1965).

Big Tiger Prospect and Rest Mine

A linear band of enigmatic hydrothermal quartz-flooded rock extends from the Big Tiger prospect just east of the Crescent Townsite ACEC, slightly south of west a total of nearly 4 km to just west of the Nipton Red decorative stone quarry (fig. 46). This quarry occupies the site of a small gold opera-

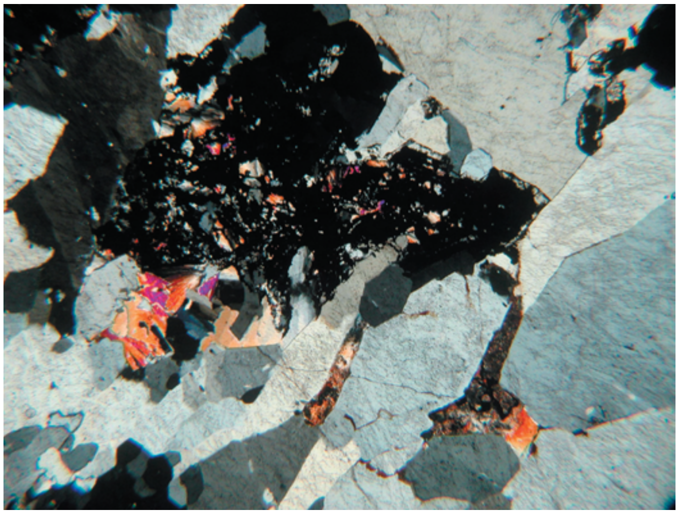


Figure 43. Cross-polarized photomicrograph of hemimorphite (mostly birefringent in orange and red colors) with opaque manganese oxide minerals in comb quartz, sample AP-019, Silver Bell Mine. Horizontal field of view is about 3 mm.

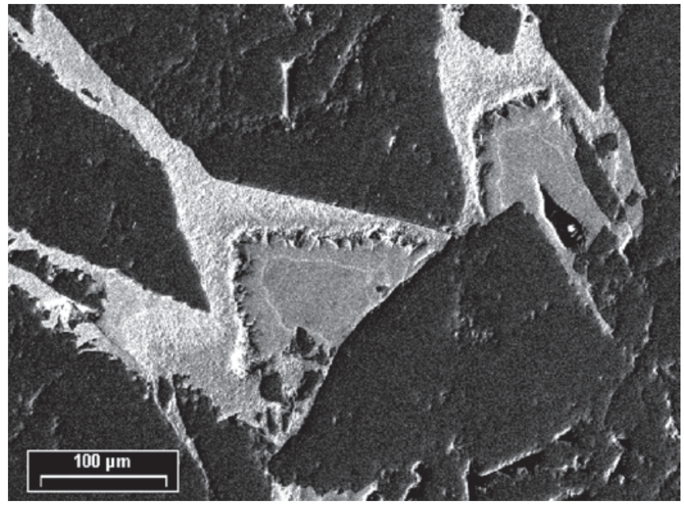


Figure 45. Secondary electron image of manganese-oxide minerals in sample AP-024. Dark gray area is mostly quartz, the late medium gray mineral is an unknown manganese-oxide phase with lead and potassium, and the bright mineral is a lead-bearing manganese-oxide phase, possibly coronadite.

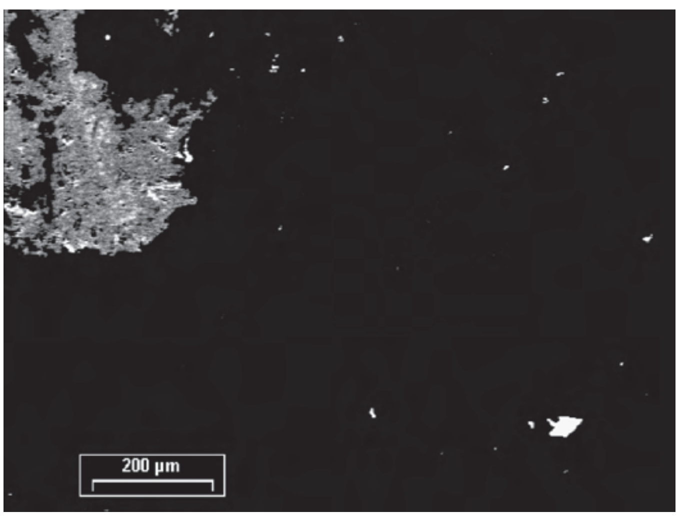


Figure 44. Backscattered electron image showing electrum grains in lower right and a gray mass of hemimorphite with bright inclusions of acanthite and silver and mercury sulfide (imiterite?) in upper left. Quartz (black) contains some tiny bright grains of Fe-bearing sphalerite near the hemimorphite mass. Sample AP-019, Silver Bell Mine.

Figure 46. The Nipton Red decorative stone quarry, the apparent site of the Rest Mine in 1979. This is the west end of the band of silica-rich alteration that extends eastward to the Big Tiger prospect. Note abundant red hematite alteration.

tion that was apparently active in the late 1970s, the Rest Mine (Nevada Division of Mine Inspection, 1977). In 1982, Crescent Mining Ltd. was conducting a small cyanide heap leach operation less than a kilometer away (Gese, 1984), but we have no direct information that it was treating material from the Rest Mine.

The Big Tiger prospect was the chief area of interest in 1905-6, when Crescent was visited by Ransome (1907). He interpreted the mineralized rocks to be a "mass of shattered quartzite that has been recemented by quartz and carries more or less gold and silver." He reported that assays indicated values as high as $12 per short ton (corresponding to about 0.6 opt or 20.5 ppm gold at the 1907 price). There is abundant hematite and rare malachite in the matrix of this breccia. Ransome also reported similar material at the Calavada property, which is described as being "3 miles southwest of Crescent, on the other side of a gneiss ridge." This description would put the location well into California, in an area where only Tertiary mafic volcanic rocks crop out. If he meant road miles, the location is likely the same as what is now known as the Lily Mine, the White Horse Mine, and the B.T. prospect (U.S. Bureau of Mines, 1990). Rocks at these deposits were described as silicified breccias by Gese (1984) and U.S. Bureau of Mines (1990) and yielded gold values as high as 0.48 opt (about 16 ppm) gold in select samples. This area was probably the focus of the large exploration program by Newmont Exploration, Inc., in the early 1990s, in sections 31 and 32 of T28S, R61E and section 6 of T29S, R61E.

Lucky Dutchman Mine

Today the Lucky Dutchman Mine is being exploited for decorative stone, but it was exploited prior to 1927 for gold (Hewett, 1956). It is about 3 km northwest of Crescent (fig. 38), and it exposes altered and silicified gneiss with abundant hematite that contains moderately southward-dipping calcite-, barite-, and fluorite-bearing veins. Two samples analyzed by Tingley (1998) contain about 11 and 5 ppm gold, with relatively low silver and base metal contents. Our samples (table 5) of barite-quartz and barite-fluorite veins have low precious- and base-metal contents.

Double Standard Mine

The Double Standard Mine is about 1.5 km northwest of the Lucky Dutchman (fig. 38) and within the Piute-Eldorado Tortoise ACEC. A sample there (AP-041, table 5) from a steeply north-dipping bleached and limonite-stained structure cutting gneiss contains 11.5 ppm gold, 154 ppm silver, and nearly 1,300 ppm arsenic. An unnamed small dump about 400 m east of the Double Standard yielded a sample (5-030701, table 5) that contains 1.6 ppm gold but low silver and arsenic. About a kilometer north of the Double Standard, an unnamed prospect yielded a sample (AP-042, table 5) that contains 4.8 ppm gold, 150 ppm silver, 500 ppm lead, 194 ppm arsenic, and 14 ppm antimony.

Red Star Group and Last Chance Claim

These two prospects are located about 4 km east of the Double Standard, within the Piute-Eldorado Tortoise ACEC (fig. 38). The Red Star is described by Longwell and others (1965) as a quartz vein in Proterozoic rocks. We did not visit either of these areas.

Nippeno and Cumberland Claim Groups

These two vein deposits are in close proximity about a kilometer southeast of the Piute-Eldorado Tortoise ACEC boundary and about 2 km east of the Crescent Townsite ACEC, between Nevada State Highway 164 and Crescent Peak (fig. 38). The Nippeno was a small producer in the 1930s, with a total production for that period of 538 oz of gold and 294 oz of silver (Longwell and others, 1965; Hewett, 1956). The Cumberland had a very small production of about $1,000 (Vanderburg, 1937). Both deposits are gold-rich quartz veins with moderate amounts of base-metal sulfides.

Crescent Peak Porphyry Copper Prospect

During both the 1950s and 1960s, the area centered on Crescent Peak was explored as a porphyry copper prospect (fig. 38). Most of our information about this prospect is from Archbold and Santos (1962). A large area about a kilometer in diameter is characterized by coarse sericitic hydrothermal alteration in a medium- to coarse-grained granite that is probably Proterozoic in age. In the center of the altered area is a zone of argillic alteration where clay minerals occur along with fine-grained sericite. Milky quartz veins 5 to 30 cm thick occur throughout the area as well. Boxwork casts of former sulfides are found throughout this altered area, and traces of copper-oxide minerals are found in a few places. Surface sampling yielded scattered values of copper in the hundreds of parts per million and molybdenum in the tens of parts per million. The age of this mineralized system has not been directly determined, but it is likely that it is related to the Cretaceous granodiorite intrusions dated by Miller and Wooden (1993) at 94.4 Ma using conventional K-Ar methods.

Six diamond drill holes in the system penetrated to depths of as much as 300 m. Individual 10-ft intervals contained as much as 0.11 percent copper, but values of a few hundred parts per million were most common. Similarly molybdenum values as high as 0.12 percent were encountered, but most intervals contained between 50 and 150 ppm.

On the north side of the porphyry system, the Gingerload prospect appears to explore a polymetallic vein rich in gold and platinum-group elements (PGE) that is peripheral to the porphyry system. The determination by Lechler (1988) of values of as much as 650 ppb platinum in samples from the Gingerload resulted in a flurry of interest in the area, but no PGE resources have been discovered.

Fluorspar and Silver Deposits Southwest of Crescent

At the southwest margin of the district, primarily in California, there are a number of small (most less than 3 cm wide) fluorspar veins that cut the Proterozoic gneiss, strike about N80E, and dip nearly vertically (Gese, 1984). Most are unnamed but have been known collectively as the Mc Dermott fluorspar deposit, the Blue Crystal prospect, and the Nipton prospect. The Blue Crystal block of 67 claims was active in 1982, but no mining was underway. The veins contain copper-oxide and carbonate minerals, and some veins contain as much as about 1 ppm gold and 1,000 ppm copper (Gese, 1984). The age of these veins relative to the gold deposits in silicified and brecciated gneiss is not known.

Sunset District

This district contains only one major deposit, the Lucy Gray, which is about 2 km outside the boundary of the Piute-Eldorado Tortoise ACEC. The Lucy Gray is a polymetallic vein deposit of unknown age that has received repeated attention in the second half of the 20th century. Most recently, the Wild Bill Nos. 1, 6, and 7 were located by William Fuller in 1995 and are still active in 2005. These claims are at least partly within the Piute-Eldorado Tortoise ACEC. The Lucy Gray itself, although showing some promise during earlier exploration efforts, is too far from the ACEC boundary to impact potential resources in the ACEC.

Hart District

The Hart district is mostly in California, but several of the deposits are quite near the west boundary of the Piute-Eldorado Tortoise ACEC and the host rocks for the deposits in the district are exposed in the Castle Mountains, immediately adjacent to the ACEC, in the western part of the region. Although there was minor gold mining in the district in the early part of the 20th century, the Viceroy Mine was the most important producer. Mining at the Viceroy Mine from 1992 until 2001 recovered about 1.2 million troy ounces of gold. The deposit can be classified as a low-sulfidation epithermal deposit and consisted of several discrete orebodies, with gold in quartz stockwork veins. The deposit was briefly described by Linder (1989), and the geologic setting of the district was described by Capps and Moore (1997).

Other Deposits of Locatable Minerals

A number of minor metal prospects were described by Close (1987) in the McCullough Range, mostly several kilometers west of the Piute-Eldorado Tortoise ACEC. The War Lord prospect, the nearest one (1 km) to the ACEC boundary, was described as a northeast-striking quartz vein in Proterozoic gneiss containing small amounts of malachite and scheelite. The Hacienda prospect, which is adjacent to the northeastern part of the Piute-Eldorado Tortoise ACEC, appears to be an oxidized gold-rich polymetallic vein that strikes northwest in Proterozoic gneiss and was traceable for about 200 m.

The Mammoth Mine, located about 9 km southeast of the town of Searchlight, is a small shaft located at the contact between Proterozoic gneiss and overlying Peach Springs Tuff. The mine is known only from its presence on the 1:24,000-scale topographic map. We saw no evidence of mineralized rock on the small dump, and a sample of Peach Springs Tuff taken nearby showed no anomalous metals.

Perlite

Nevada has large perlite resources and several deposits that were mined extensively in the past. The Hollinger Mine near Pioche in Lincoln County was the largest producer, with production of as much as 40,000 short tons per year in the 1950s. However, current Nevada perlite production is restricted to relatively small-scale mining of two deposits. In Lincoln County, Wilkin Mining and Trucking, Inc., mines perlite from the Tenacity (Mackie) Mine and has a small plant that produces relatively coarse expanded perlite useful in horticultural applications. It currently produces about 1,500 to 2,000 short tons of expanded perlite per year. Eagle-Picher Minerals, Inc., produces expanded perlite that is marketed as filter aid from perlite mined in northern Nevada. The plant capacity is reportedly about 8,000 tons per year (Castor, 2005a). By contrast, the largest domestic perlite producer is a mine at No Agua Peaks in New Mexico that yields about 200,000 short tons per year. Other mines in New Mexico, Oregon, and Utah produce more than 20,000 short tons per year (Barker and Santini, 2006).

Two perlite deposits are in or near the Piute-Eldorado Tortoise ACEC. Both are in rhyolite flows or domes in Miocene (15 to 16 Ma) volcanic rock sequences. Neither is being mined currently, but each has had production in the past.

The Searchlight Insulation Products (Perlite Ridge) Mine, which is about 5 km north of the town of Searchlight, is in a small inholding of private land within the Piute-Eldorado Tortoise ACEC (fig. 21). It produced 300 to 600 short tons of crude perlite annually in the 1950s, and consists of three small open pits (fig. 47). The largest is the north pit, which is about 30 m long, 10 m wide, and 5 m deep. Most of the perlite here is hard, gray, granular rock that occurs as clasts in friable white perlite. It contains trace amounts of purplish devitrified material in small masses and discontinuous veinlets. The north pit is near the northeast end of a mass of perlite that is bounded on the northwest by a near-vertical fault. About 300 m to the southwest is a 35 m x 10 m x 3 m pit in similar perlite that appears to be part of the same mass. A smaller pit

Figure 47. Aerial photograph of Searchlight Insulation Products property, showing north and south pits.

containing nearly pure granular perlite lies between the two pits. On the basis of our field examination, the perlite mass that contains these pits is about 600 m long and 100 m wide. It extends south-southwest into the ACEC. It is likely a rhyolitic flow that dips steeply to the northwest. We estimate reserves at about 1.2 million short tons to a depth of 10 m with little waste removal. Cochran (1951) estimated indicated reserves of good quality, granular perlite at about 10 million short tons, but reported that the deposit consisted of two masses, one 1,500 ft x 240 ft x 21 ft and a second 2,600 ft x 500 ft x 100 ft.

Perlite that we collected from the Searchlight Insulation Products deposit (AP-301 and AP-302, table 6) is light-gray granular rock with sparse feldspar and biotite phenocrysts, silica contents (72.6 to 74.0 percent) typical of rhyolite, and LOI (loss on ignition) of 3.6 to 5.1 percent. In these samples, LOI values mostly represent combined water contents, and perlite is defined as having 2 to 5 percent combined water (Barker and Santini, 2006). Our samples from the Searchlight deposit have high expanded density when compared with perlite from the large No Agua perlite deposit in New Mexico and with other Nevada perlites (table 6). Sinks (unexpanded material) for Searchlight perlite are moderate to high and coarse expanded perlite sizes are low. Brightness is low relative to the No Agua perlite, but comparable to other Nevada perlites. The results do not show that perlite from the deposit is noncommercial, but they suggest that it would find limited markets. For example, it would likely not be usable in horticultural or loose-fill insulation applications, which require relatively

Table 6. Physical and chemical properties of perlite samples.

[Test data are for perlite expanded at 1300°F without preheat using -50+100 mesh samples. Sieve analyses of expanded perlite are reported as percent of sample retained at each mesh size. Testing by New Mexico Bureau of Geology and Mineral Resources. The testing parameters (for example, temperature, sizing) are optimized for testing perlite from No Agua; somewhat different results might be obtained using a modified methodology.]

Sample	SiO_2	LOI	Furnace Yield	Expanded Density	Avg. Bright	Sinks	Percent Expanded Retained (Tyler Mesh)						
	(%)	(%)	(%)	(lbs/ft^3)	(%)	(%)	+20	+30	+50	+70	+100	+140	-140
AP-10A	73.6	4.0	77	1.94	52.1	22.2	1.0	9.4	30.5	14.2	10.8	11.4	22.7
AP-10B	71.0	5.1	88	2.27	55.5	9.6	1.9	17.9	41.1	10.5	7.4	6.8	12.4
AP-45	73.3	4.3	68	1.97	60.1	8.4	0.6	6.0	29.9	17.2	12.5	13.0	20.8
AP-119	72.3	3.8	92	2.06	52.5	4.8	20.1	34.0	33.7	5.6	2.5	1.3	2.8
AP-120	72.8	3.4	96	2.05	50.8	9.0	1.0	8.4	33.1	16.8	12.0	10.3	18.4
AP-121	74.1	3.8	86	2.04	52.8	12.0	2.4	16.7	34.5	16.1	9.8	2.1	17.4
AP-122	73.1	4.0	85	2.52	57.2	7.0	16.2	27.4	38.7	7.5	35.0	1.9	4.8
AP-124	72.1	4.0	96	3.05	42.4	0.6	8.1	42.1	42.9	3.2	1.1	5.0	2.1
AP-186	70.8	5.1	95	2.26	57.2	10.2	16.8	33.3	36.0	8.4	3.3	2.1	3.1
AP-301	72.6	5.1	84	3.03	56.0	26.2	1.0	12.1	35.9	16.5	11.7	7.7	15.1
AP-302	74.0	3.6	90	2.80	59.2	11.4	2.8	12.5	35.1	16.5	10.3	9.5	13.3
AP-303	73.3	3.7	90	3.79	62.3	14.2	1.6	21.8	52.0	11.4	4.0	3.0	6.2
Std.			99	1.87	72.4	6.8	9.9	41.0	37.4	2.9	2.1	4.0	2.7
Std.			99	1.54	70.6	2.4	19.4	42.5	30.7	3.2	1.9	1.5	0.8

Sample locations and descriptions:

AP-10A—grab sample, friable perlite, Nu-Lite Mine, Clark County, Nevada
AP-10B—5-m chip, friable perlite, Nu-Lite Mine, Clark County, Nevada
AP-45—select grab sample, granular perlite, NW, Searchlight Perlite Mine, Clark County, Nevada
AP-119—grab sample, granular perlite, Tenacity pit, Mackie Mine, Lincoln County, Nevada
AP-120—select grab sample, onionskin perlite, Mackie Mine underground, Lincoln County, Nevada
AP-121—grab sample, granular perlite, main pit, Hollinger Mine, Lincoln County, Nevada
AP-122—grab sample, granular perlite, east pit, Hollinger Mine, Lincoln County, Nevada
AP-124—grab sample, granular perlite with obsidian cores, Lovelock perlite pit, Pershing County, Nevada
AP-186—select grab sample, granular perlite with phenocrysts, River Mountains, Clark County, Nevada
AP-301—grab sample, granular perlite, north pit, Searchlight Perlite Mine, Clark County, Nevada
AP-302—grab sample, granular perlite, south pit, Searchlight Perlite Mine, Clark County, Nevada
AP-303—grab sample, granular perlite, outcrop east of north pit, Searchlight Perlite Mine, Clark County, Nevada
Std.—perlite from two No Agua, New Mexico, deposits

coarse perlite (Barker and Santini, 2006). It would not be useful in most construction applications, which require perlite with expanded densities of less than 2.5 lbs/ft^3 (M. Houseman, oral commun., 2006). Perlite from this deposit could find applications in uses that do not require low expanded density and large particle size, such as in filter aids. It might find markets in uses that require fine perlite, but its low brightness might preclude its use in some products.

Perlite at the Searchlight deposit occurs in a rhyolite flow of the middle rhyolitic unit of the volcanics of the Highland Range (Faulds and others, 2002a). Our reconnaissance of these rocks revealed that perlite is locally abundant, but most of the perlite that we found was moderate to dark-gray rock with relatively high phenocryst contents. A sample from a 30- to 60-m-wide perlite zone about 0.5 km northwest of the Searchlight deposit (AP-45, table 6) had similar brightness and expanded size distribution to perlite from the Searchlight deposit but considerably lower expanded density. However, this sample was selected to represent the purest material available, and much of the perlite in this mass contains variable amounts of non-glassy rock, particularly in the form of spherulites (fig. 48) that would decrease its value as commercial perlite.

The Nu-Lite Perlite Mine is on the east flank of the Castle Mountains about 17 km southwest of Searchlight near the California State line. It is about 200 to 300 m outside the Piute-Eldorado Tortoise ACEC. The deposit was mined between 1948 and 1954 by Nu-Lite Insulated Homes, Inc., and produced as much as 600 short tons of crude perlite annually. The mine consists of a shallow open pit about 20 m in diameter in a west-northwest striking and shallowly north dipping, possibly intrusive mass that is nearly 1 km long and 100 m wide. Other small open cuts occur in this zone. In addition, perlite occurs as a shallowly dipping rhyolite flow as much as 50 m thick that occurs in places atop a thick sequence of light colored bedded tuffs and beneath a sequence of devitrified rhyolite flows and domes. Capps and Moore (1997) reported ages of about 15 Ma for these rhyolites. They have mapped the perlite within a unit of rhyolite autoclastic breccias, block and ash flows, and pumice flows. The perlite-bearing unit has been locally prospected both in Nevada and California, in places by underground workings. Neither our mapping or that of Capps and Moore (1997) shows any nearby exposures within the Piute-Eldorado Tortoise ACEC, although these same rhyolites crop out in the ACEC about 3 km to the northeast.

We collected two samples of perlite from the small Nu-Lite pit. Both are of friable, light-gray to white perlite that ranges from breccia (fig. 49) to nicely flow-banded rock (fig. 50). Testing of these samples yielded expanded density approaching that of the No Agua perlite; but the Nu-Lite perlite has similar expanded size distribution to, and lower brightness than, expanded Searchlight Insulation Products perlite (table 6). These data suggest that it would face some

Figure 48. Spherulites in perlite near the Searchlight perlite deposit.

Figure 49. Perlite breccia, Nu-lite Mine. Fragments of light-gray, moderately resistant perlite in white friable perlite.

Figure 50. Pure, friable, flow-banded perlite, Nu-lite Mine.

of the same marketing challenges faced by the Searchlight perlite, but its low expanded density indicates that it could be used in construction applications.

Stone

Crushed stone is mined from several deposits in private inholdings within and areas adjacent to the Piute-Eldorado ACECs. The stone is used as decorative landscape rock in Las Vegas where the market is relatively large because Clark County imposed a ban on grass front lawns for newly constructed residences in 2003. This has resulted in a substantial market for crushed stone in the Las Vegas metropolitan area. Colored decorative aggregate from quarry locations as distant as Searchlight now commands a price of $8/short ton or more (depending on color) at quarry sites, and selected boulders sell for as much as $30/short ton (Castor, 2005b). Prices are higher for material delivered in Las Vegas where single decorative boulders sell for as much as $400.

The largest decorative crushed stone producers in the Las Vegas region are the El Dorado operation of Rinker Materials at Railroad Pass and the Rainbow Quarries of Las Vegas Rock north of Goodsprings. Exact tonnages of decorative stone produced at these operations are not known, but we estimate them to be on the order of 200,000 short tons per year. In addition to use in residential and commercial landscaping projects, crushed stone from these operations is used along newly constructed highways in the Las Vegas area. The operations are commonly on old patented gold mining claims and thus on lands under private ownership. They include moderate sized operations at the Roman Mine in the Newberry Mountains, which is on unpatented claims about 2 km from the boundary of the Piute-Eldorado Tortoise ACEC (fig. 34), and at the Pompeii Mine directly north of Searchlight, which is about 100 m south of the ACEC boundary (figs. 21, 51). The rock from these operations is of various colors, including gray, light yellowish gray, and pale red. Smaller operations include at least three producers in the Crescent district—the John Yeager operation; the Lucky Dutchman Mine (figs. 38, 52); and the Modoc Mine (fig. 38). These operations are apparently all within the boundaries of old mining claims that were patented as gold claims. In addition, there is an inactive operation on private land just south of the Crescent townsite. Most of the rock from these producers is pale red, light pink, and purplish gray, colors that apparently bring premium prices in Las Vegas and are due to the presence of hematite in altered Proterozoic rocks.

Turquoise

Turquoise was mined extensively from the Simmons (Toltec) Mine on the south side of Crescent Peak about 3 km outside the Piute-Eldorado ACEC beginning in the late 1890s (fig. 38). According to Morrissey (1968), the total value of turquoise taken from this mine may have exceeded $1 million, and the deposit showed evidence of prehistoric Native American mining.

A less-productive turquoise mine, the Morgan (Iron Door) Mine is within the Crescent Townsite ACEC (fig. 38). Our examination disclosed a small open pit and an adit (fig. 53). The turquoise, which is light blue to greenish blue, occurs as irregular veins as much as 5 mm thick in white to brown altered and limonitized granitic rock (fig. 54). Several hundred pounds of gem-quality turquoise were produced from the mine in 1906 (Morissey, 1968). Turquoise such as that shown in figure 54 can still be found on the dumps at this site.

Figure 51. Quarries and access roads at a decorative stone operation north of Searchlight. The Piute-Eldorado Tortoise Area of Critical Environmental Concern lies just to the north of the northern pit.

Figure 52. Crushing and screening equipment with light pink to purplish-gray decorative stone stockpiled at the Lucky Dutchman Mine, Crescent district.

Figure 53. Portal of the Iron Door (Morgan) Turquoise Mine in the Crescent Townsite ACEC. A small open pit is out of the picture on the upper right.

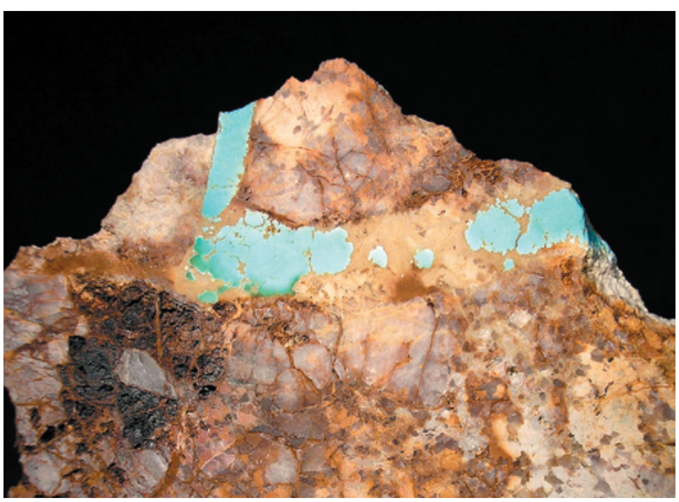


Figure 54. Turquoise vein in altered and limonitized granitic rock, Iron Door Mine, Crescent Townsite ACEC. Horizontal field of view about 5 cm.

Mineral Exploration and Development

Although most metal mining activity has been greatly reduced since World War II, the Piute-Eldorado ACECs have been the site of a number of mineral exploration programs since that time, and they are still the focus of some mineral exploration today. There are a number of current and recently current mining claims in the area. Our information was gathered in the Spring of 2006.

Crescent District

Most of the mineral exploration and development in this area appears to have taken place since the visit of Vanderburg (1937), as he did not mention most of the patented claims now present in the district.

A prominent area of hydrothermally altered rocks centered on Crescent Peak was explored during the 1950s and early 1960s as a porphyry copper prospect. Drilling of at least seven holes to depths of more than 300 m was conducted at that time by Bear Creek Mining Company and Homestake Mining Company. No ore-grade material was found, but sporadic occurrences of copper values >1,000 ppm and molybdenum values >300 ppm in the analyzed drill core seems to confirm the existence of a large mineralized body that can be characterized as a porphyry copper deposit. Although analyses for precious metals were made only on 50-foot composite samples, the precious-metal content of the rock appears to be low. Widespread phyllic alteration and some anomalous copper concentrations in surface samples were the basis for the exploration effort. Curiously, the age of this mineralization is still completely unknown. No radiometric age determinations have been made, and the geologists working in the area at that time were unable to map a post-Proterozoic intrusion within the altered area. Miller and Wooden (1993) mapped and dated a Cretaceous granodiorite about 4 km to the west, and they tentatively suggested that this rock may be present within the mineralized area at Crescent Peak.

Most of this area is about 3 km outside the boundaries of the Piute-Eldorado Tortoise and Crescent Townsite ACECs. Subsequently, Houston International Minerals held claims in this area from 1983 to 1993, but we have found no documentation of their exploration activity or findings. A small company proposed mining gold ore from the surface just north of Crescent Peak in the early 1980s, but they apparently never conducted the operation. The 1988 publication that platinum-group elements were present in mineralized rock from the Gingerload Mine (Lechler, 1988), on the north flank of Crescent Peak, sparked renewed activity. In section 23 of T28S, R61E, near the Sundog Mine on the northeast flank of Crescent Peak, about 2 km outside the Piute-Eldorado Tortoise ACEC, drilling was conducted in 1989 by Francis Friestad and Mark Davis, with unknown results. In 1991, Westland Mineral Exploration Company drilled two holes just west of Crescent Peak, between the Gingerload and Nippeno Mines, with unknown results. Subsequent attempts to organize mining and exploration ventures at Crescent Peak have been unsuccessful.

In the early 1990s, Newmont Exploration Ltd., in conjunction with Westland Minerals Exploration Co. and Stena Resources, conducted exploration on a large claim block about 4 km southwest of Crescent townsite, near the California border. The results of the work are unknown, but the exploration was probably for gold in the area described by Ransome (1907) as the Calavada claims. In 1992, a resource of 390,000 short tons at 0.05 opt gold, or 3.3 million short tons at 0.022 opt gold was reported by Westland Minerals Exploration Co. for their Crescent properties, but we do not know exactly to what deposit(s) they referred (Nevada Bureau of Mines and Geology, 1994).

At about the same time, a company called Nevada Noble Metals explored the Susie Q claim block that is partly within the Piute-Eldorado Tortoise ACEC, about 2 km north of the Silver Bell Mine in sections 9 and 10 of T28S, R61E. Immediately to the west, Eldorado Mining Co. explored the Silver Lady claims, as well as an area between the Silver Bell and Nippeno Mines. Also within the Piute-Eldorado Tortoise ACEC, Houston International Minerals conducted exploration on the alluvium-covered area between the Lucky Dutchman Mine and the Crescent townsite in 1983. We have no information on the nature of the target or of the results for any of these exploration programs.

In 2005, there were 43 current lode claims and 3 current millsite claims along the corridor where Nevada State Highway 164 crosses the south end of the McCullough Range. Many of these are at least partially within the Piute-Eldorado Tortoise and Crescent Townsite ACECs. At the east end of the district, in sections 10, 15, 16, and 21 of T28S, R61E, the Rainbow's End group of 31 claims is owned by Stanley Pierce, Michael Sean, Katherine Pierce Denos, and Diana Kirtley; these have been maintained for nearly 15 years, and we presume their target is gold. In addition, in section 25 of T28S, R60E, the Silver Crescent millsite claim has been maintained since 1994 by Norma Pierce Oppenheimer. In section 20 of T28S, R62E, two millsite claims have been maintained by James Skidmore since 1983. A single claim in section 10 of T28S, R61E has been maintained by Saylor Dean since 2001. Two claims in section 21 of T28S, R61E have been maintained by Fuller Gulliosa since 2001. The Gold Nos.11, 14, and 15 have been maintained in section 30 of T28S, R61E by John and Sally Denton since 1984. At the west end of the district, at the south end of the Lucy Gray Mountains in sections 10 and 16 of T28S, R60E, 3 claims (the Wild Bill group) have been maintained by William Fuller since 1995.

Searchlight District

Interest in the Searchlight district has never totally disappeared, and there are a number of active mining claims in the area, some of them reflecting the interests of mining and exploration companies, and others the interests of individual prospectors. Two areas on the margins of the Searchlight district within the Piute-Eldorado Tortoise ACEC are the objects of active exploration programs by mining companies.

A large block of more than 100 claims (45 in our database) was located in 2003–2005 by Desert Pacific Resources, Inc., in sections 15, 16, 17, 20, and 29 of T28S, R63E. This claim block (the 'VES' group) is partly within the Piute-Eldorado Tortoise ACEC, immediately north and west of the Searchlight district, and it is known as the Copper Hill project. The claims are presently (spring, 2006) under option to Great Western Minerals Group Ltd., and are being actively explored.

A group of 20 claims were located in 2004 by William R. Stanley, within the Piute-Eldorado Tortoise ACEC, directly north of the Searchlight district, in sections 14 and 15 of T28S, R63E. This claim block (the Searchlight Bonanza group) is being explored by Atna Resources Ltd. In addition, Coyote Mines, Inc., has held 1 claim nearby in sections 14 and 15 of T28S, R63E since 1994.

A major exploration program was mounted by Southwestern Exploration Associates, Inc., on behalf of the Felmont Oil Corporation in 1979–81. Homestake Mining Company acquired Felmont Oil during this effort. A large area west of the historic part of the Searchlight district was mapped at 1:6,000 scale, several hundred surface geochemical samples were collected and analyzed, and a total of 29 holes were drilled using reverse circulation methods. Only sporadic gold anomalies were encountered in these holes, which were designed specifically to test the possibility for disseminated low-grade precious-metal ore. A more surprising result was elevated levels of copper in several of the holes, at depths of about 100 m. Intervals containing in excess of 200 ppm copper were encountered in 6 of the holes, compared to background values of less than 50 ppm.

Areas North of Searchlight

Two claims (Canaan), located by Pete Baldonado and Richard H. Culmer, near the north end of the Highland Range, in sections 26 and 27 of T26S, R62E, have been current since 1985. A claim located by Joan Sullivan in the Eldorado Mountains near the Rockefeller Mine and Cobalt claims, in section 25 of T27S, R64E, has been current since 2003. A placer claim, located by Robert Anderson and Douglas E. Noland, near Nevada State Highway 164 west of the Searchlight district, in section 29 of T28S, R63E, has been current since 1994. Doris Atchison and a group of four other individuals hold a placer claim in section 7 of T28S, R 64E that was newly located in 2005. The claim is within the Piute-Eldorado Tortoise ACEC, about 10 km northeast of the town of Searchlight.

Areas South of Searchlight

Three placer claims located by James E. Tinnell are near the Roman Mine in the Newberry Mountains, in section 21 of T30S, R65E. They have been current since 2003. A placer claim and a millsite claim, located by Thomas E. Smigel, near Hiko Spring, in the southeasternmost part of the Piute-Eldorado Tortoise ACEC, have been current since 1997. The claims are in section 12 of T32S, R65 SE.

A group of 10 claims (the Big John group), located by Misra Shruti, along the west flank of the Newberry Mountains about 2 km north of the Juniper Mine, has been current since 1999. The claims are in section 24 of T31S, R64E. We took a single sample here of quartz-veined Proterozoic gneiss (5-050703) that did not contain anomalous metals (Ludington and others, 2005).

Four claims (the Search group) were located by four individuals in 1980 and were still current in 2005. These claims are in section 6 of T31S, R65E, on the pediment along the front of the Newberry Mountains about 2 km northwest of Christmas Tree Pass. We noticed some small pits in the areas but saw no evidence of hydrothermal mineralization. Two claims (the Blue Cloud group) were located in 2001 by Leslie W. Hopper, in section 32 of T31S, R65E. These claims are in granite of the Spirit Mountain batholith about 2 km southeast of the Juniper Mine.

A group of 9 claims (the Treasure Trove group) were located by Michael Steven and Stanley Pierce in 1981 and 1998, in sections 9, 10, and 16 of T32S, R64E. These claims are 2 to 3 km southeast of the junction of U.S. Highway 95 and Nevada State Highway 163 in the Chiquita Hills. They are, at least in part, within the Piute-Eldorado Tortoise ACEC and remained current in 2005.

Placer Claims in Piute and Eldorado Valleys

In addition, most of the surface of Piute and Eldorado Valleys in the Piute-Eldorado Tortoise ACEC is covered by a group of hundreds of association placer claims staked in 1986, 1989, 1990, 1993, 1994, 1996, 1997, 1999, and 2000 under a variety of names. The claims appear to be all controlled by a group known as Cactus Gold Corp., of Surrey, British Columbia. The intention of this group is to recover precious metals that might occur in late Tertiary and Quaternary sediments. Their activities and exploration model came to our attention after field and laboratory studies for this assessment were complete.

Mineral Resource Potential

Locatable minerals in Piute-Eldorado Tortoise ACEC

The complex structural environment of the Piute-Eldorado Tortoise ACEC means that relating inferences about the size and shape of the original preextension mineral deposits is difficult and subject to different interpretations. The mineral resource potential tracts described in this section are subject to this caveat. Furthermore, because of suspected low-angle faults with large displacements in the subsurface, these tracts are valid to depths of no more than a few hundred meters. As structural interpretations improve, it may become possible to identify tracts at greater depths. The tracts were delineated in the context of the entire mineralized system; those that are not within the ACECs are identified as such.

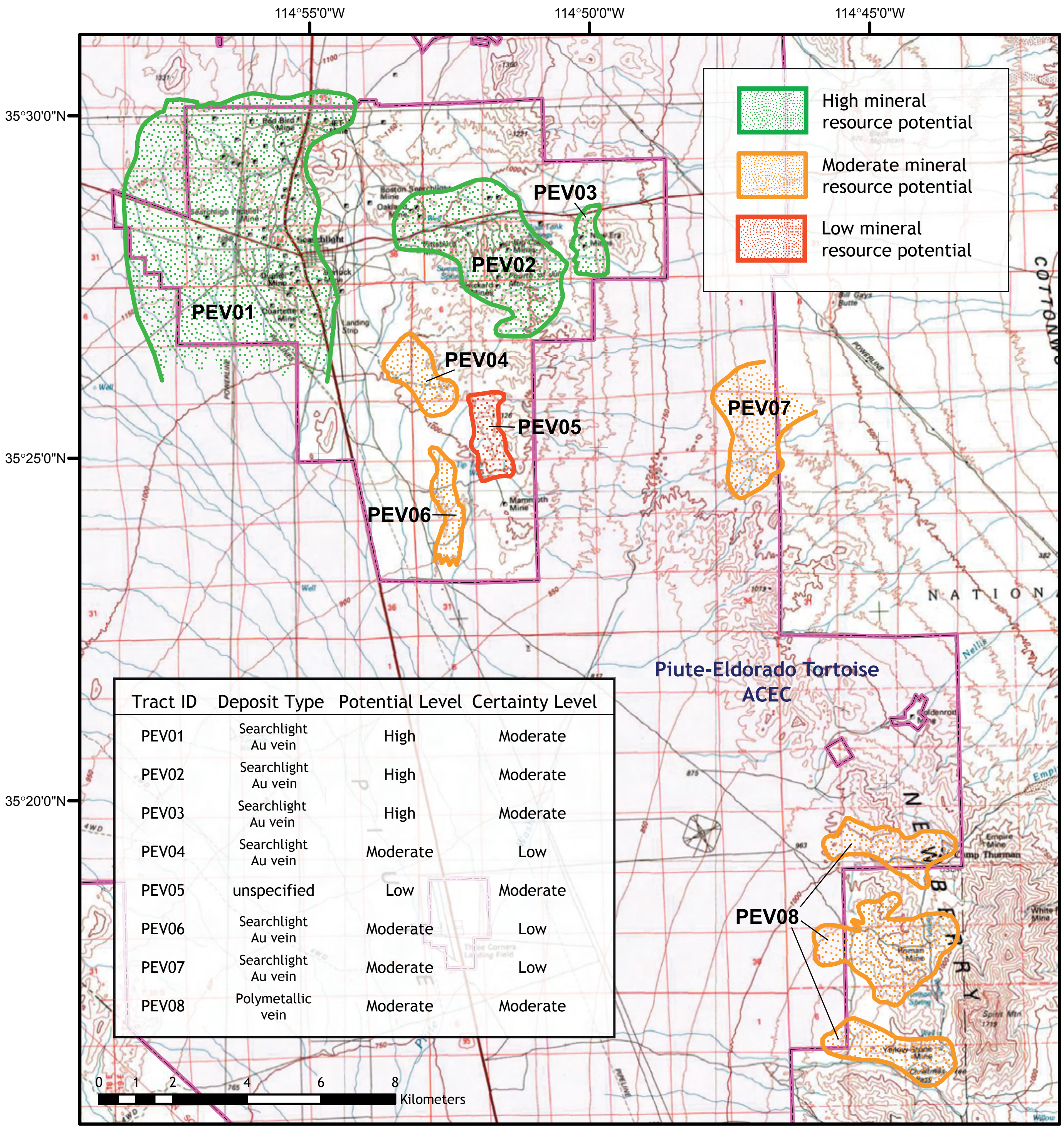
Searchlight-Type Gold-Bearing Vein Deposits (Searchlight Area)

Many of the mines in the Searchlight District were abandoned because of changing economic conditions, and it is likely that modern exploration methods could find significant quantities of additional ore in the known part of the district. However, reassessment of the district in the light of our present understanding of the structural context for these veins, combined with the geochemical sampling we conducted, leads to the identification of additional areas that have the potential for the discovery of gold ore. Figure 55 shows areas that have potential for Searchlight-type gold-bearing vein deposits, as well as some other types of deposits.

Tract PEV01 includes the mines that were productive in the 20th century, but it also includes areas to the west, originally above the roof of the Searchlight pluton. The tract has high potential for undiscovered Searchlight-type gold-bearing vein deposits, with a moderate level of certainty, and it includes all the environments where gold might have been deposited, based on studies of hydrothermal alteration (fig. 29) and geochemistry (fig. 31). Most of the area is outside the Piute-Eldorado Tortoise ACEC, but much of the outer parts of the tract are within the ACEC. The tract includes the hills underlain by alunite-bearing rhyolite west of the main part of the Searchlight district, and, although we found no significant amounts of precious metals in this altered rock, the rocks of the lower intermediate-composition unit of the volcanics of the Highland Range, which commonly host gold veins in the district, may underlie these hills at shallow depths. The position of the western limit of the tract is guided by the hydrothermal alteration west of the rhyolite hills and by the presence of >0.2 ppm gold in sample 5-110201 (Ludington and others, 2005). To the south, the identified rocks pass under Quaternary alluvium, and we lack any subsurface information that would allow the delineation of the southern limits of the tract. Further geochemical sampling near the margins of this tract would be required to raise the certainty level.

Tract PEV02 (fig. 55), which is centered on the Fourth of July Mountain area, is our interpretation of where this same environment is located in the Fourth of July structural block. It has high potential for undiscovered Searchlight-type gold-bearing vein deposits, with a moderate level of certainty. The samples taken at the Chief of the Hills Mine (5-031702 and 5-031703; Ludington and others, 2005) contain some of the highest gold values we obtained in this study, >15 ppm and 6.5 ppm, respectively. The area to the west of this mine is characterized by intense hydrothermal alteration, both illite and quartz-alunite (fig. 29), and the limits of the tract are delineated primarily on the basis of this alteration, the high gold values obtained, and the structural setting just above the contact with the Searchlight Pluton. This tract is entirely outside the Piute-Eldorado Tortoise ACEC, but the south end is within 150 m of the ACEC boundary. Further geochemical sampling could help modify the boundaries and increase the certainty level of this tract.

Tract PEV03 (fig. 55), about 2 km east of Fourth of July Mountain, includes the New Era Mines, delimits the analogous environment in the Pinto structural block, and has high potential for undiscovered Searchlight-type gold-bearing vein



Tract ID	Deposit Type	Potential Level	Certainty Level
PEV01	Searchlight Au vein	High	Moderate
PEV02	Searchlight Au vein	High	Moderate
PEV03	Searchlight Au vein	High	Moderate
PEV04	Searchlight Au vein	Moderate	Low
PEV05	unspecified	Low	Moderate
PEV06	Searchlight Au vein	Moderate	Low
PEV07	Searchlight Au vein	Moderate	Low
PEV08	Polymetallic vein	Moderate	Moderate

Figure 55. Mineral resource potential tracts for gold-bearing deposits in the Searchlight area (Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC)).

deposits, with a moderate level of certainty. The volcanic rocks just above the quartz monzonite in the upper member of the Searchlight Pluton are altered to smectite clays, and the tract is delineated primarily on the basis of this alteration and the structural setting just above the contact with the Searchlight Pluton. None of the samples we took contained substantial amounts of precious or base metals, but they are variously anomalous in arsenic, antimony, and tellurium (Ludington and others, 2005). Interestingly enough, all the samples in this tract contained detectable platinum or palladium, although at levels less than 2 ppb. This tract is entirely outside the Piute-Eldorado Tortoise ACEC, but the south end is within 100 m of the ACEC boundary. Sampling in this area was sparse, and further geochemical samples could change the boundaries and certainty level for this tract.

Two areas in the Fourth of July structural block have moderate potential for undiscovered Searchlight-type gold-bearing vein deposits, with a low level of certainty (tracts PEV04 and PEV06, fig. 55). The northern one, PEV04, is about 2 km east of the Searchlight airport, and its boundaries are delineated primarily on the basis of inferred hydrothermal alteration, based on ASTER imagery (fig. 29). We did not sample this area. The other one (PEV06) is about 3 km further south, just to the south of Tip Top Well. The boundaries of this tract are similarly delineated using inferred hydrothermal alteration based on ASTER imagery, and passes to the south under the sediment that fills Piute Valley. Neither of these tracts is within the Piute-Eldorado Tortoise ACEC. These areas have been little studied, and field visits and geochemical sampling could help modify the tract boundaries and raise the certainty level.

Tract PEV05 (fig. 55) is also delineated on the basis of ASTER imagery, as well as petrographic studies. Rocks in this area seem to have abundant, but very fine-grained drusy quartz filling myriad internal fractures, but are otherwise little altered. One sample, 5-061103 contains only mildly anomalous precious-metal values (1 ppm silver and 0.01 ppm gold; Ludington and others, 2005). We designate the tract based on the coherent area of silica addition but have difficulty assigning a mineral deposit model. The tract has low potential with a moderate level of certainty; it is also not within the Piute-Eldorado Tortoise ACEC.

Tract PEV07 (fig. 55) also has moderate potential for undiscovered Searchlight-type gold-bearing vein deposits, but with a low level of certainty. It lies partially within the Pinto structural block and partially within the Bill Gays structural block. It is delineated on the basis of inferred hydrothermal alteration based on ASTER imagery, on the structural setting, and on some curious geochemistry in the only sample we took from the area (5-060702, Ludington and others, 2005). This sample is a brecciated rhyolite that has been subjected to strong argillic alteration. Kaolinite is the chief alteration mineral. The sample contains 0.68 percent sulfur and 24 ppm tungsten. The area is mostly within the Piute-Eldorado Tortoise ACEC and partly within the Lake Mead National Recreation Area and Nellis Wash Wilderness. Further study of this remote area is necessary to refine the assessment.

Gold-Bearing Vein Deposits North and South of Searchlight

Tract PEV08 (fig. 55) also has moderate potential for undiscovered gold-rich polymetallic vein deposits with a moderate level of certainty. This tract is well to the southeast (20 km) of Searchlight, and it is entirely in Proterozoic granitic and metamorphic rocks. It contains the area surrounding Camp Thurman, where the mines are known variously as the Potential Mine, the Yarmouth Mine, and the New Deal Mine. A sample from the dumps in this area contained 9 ppm gold and 3 ppm silver (4-050304; table 4 and Ludington and others, 2005). ASTER imagery shows a linear band of hydrothermal alteration extending from Camp Thurman west to the range front, an area about 3.5 km long and about 800 m wide. Two areas farther south, near the Roman Mine, show similar ASTER signatures. Our field examination and PIMA studies of these areas confirmed that the rocks are altered to clays and illite and stained with iron oxide. Chemical analyses of rocks from these areas show only weakly anomalous Ba, Li, Mo, Zn, P, Sn, and Y. None of the samples (aside from one from the Potential dump) showed elevated precious metals. Many areas within the tract show scattered quartz veining. Parts of all three areas delineated as tract PEV08 extend into the Piute-Eldorado Tortoise ACEC. The parts within the ACEC were not sampled, and further study could help refine the tract boundaries and raise the certainty level.

Although the area has been prospected to a moderate degree in the past, the deposits at the Sazarac patented claim group (Rockefeller Mine) and the Cobalt claims (figs. 19, 56) have yielded gold values that merit the designation of mineral resource potential for the area. Tract PEV19 (fig. 56) has moderate potential for detachment-fault-related gold deposits, with a moderate level of certainty. The tract is partially within the Piute-Eldorado Tortoise ACEC and partly within the Lake Mead National Recreation Area. More detailed geochemical sampling could help refine the boundaries of this tract and increase the certainty level.

Significant gold values are also present in samples from the Juniper Mine (fig. 33), and from the Superfluous and Gibraltar claims (fig. 35), and these areas definitely have potential for the development of additional resources. Tract PEV18 (fig. 57) has moderate potential for gold-bearing polymetallic vein deposits, with a low level of certainty. The low level of certainty applies to the spatial accuracy of the delineation; this is because no large area of hydrothermally altered rock is associated with these deposits, and we can identify no other features to guide the delineation of tracts.

Porphyry Copper Deposits (Searchlight Area)

Evaluation of the possibility for existence of a porphyry copper deposit beneath the Searchlight mining district is based primarily on results of the exploration program carried out by Felmont Oil Corporation and Homestake Mining Company in 1979–81. They conducted an extensive surface sampling program to complement the 41 shallow drill holes. The surface sampling and the drill holes yielded disappointing results for gold and silver, as no indications of low-grade disseminated deposits were found. However, several of the drill holes intersected zones of copper mineralization, and one in particular revealed more than 30 m with greater than 1,000 ppm copper and a corresponding increase in sodium and decrease in potassium. Drill logs suggest that the copper-rich zone is in a rhyolite breccia altered to a quartz-alunite-topaz assemblage. Pyrite is found in this lower zone, instead of hematite. Although it is critical to the structural interpretation, it is not clear whether this breccia is intrusive and post-tilting or not. We interpret the mineralization to be pre-tilting like the gold mineralization, and therefore, any porphyry deposit would be rotated 90 degrees and lying on its side.

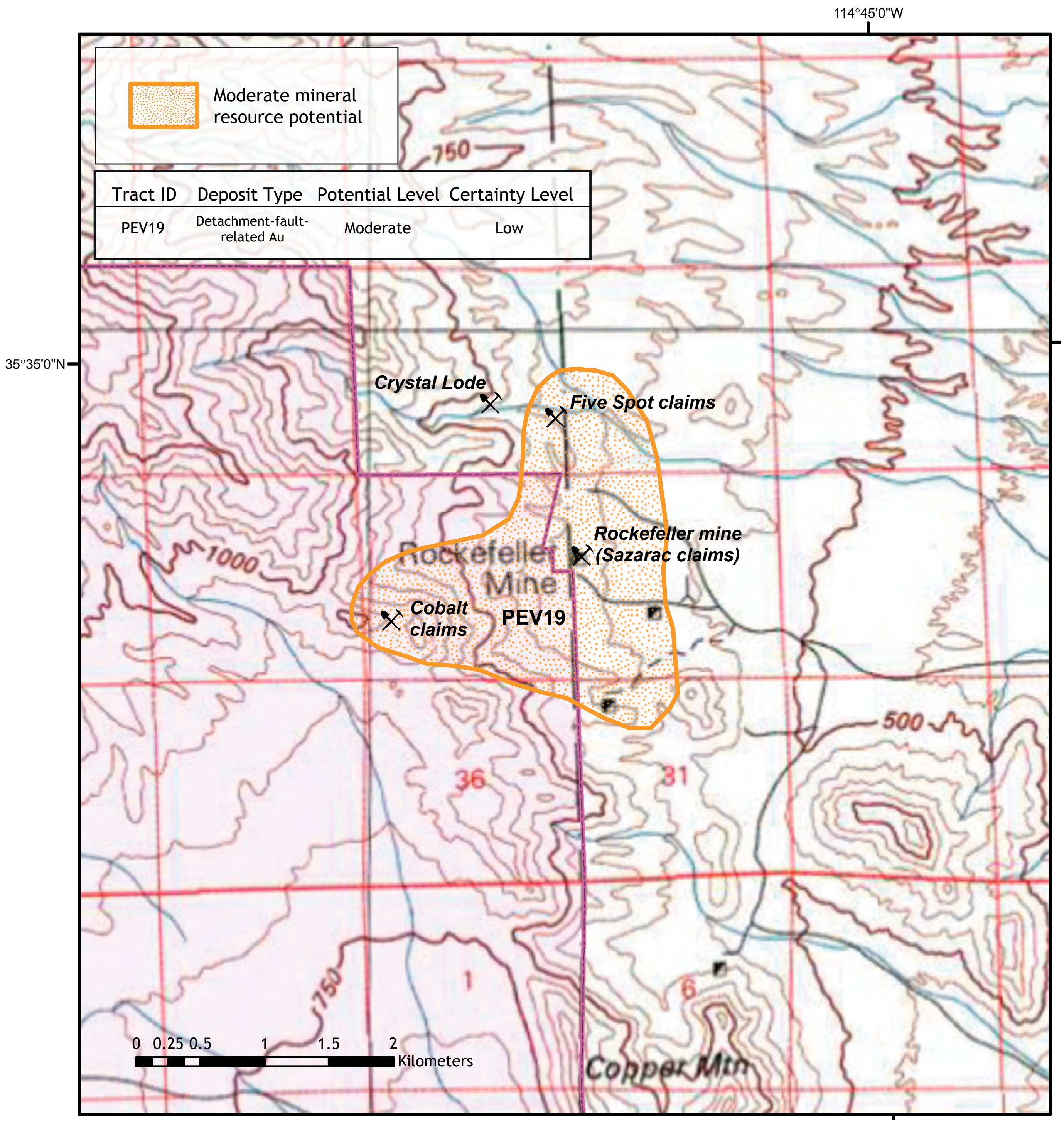
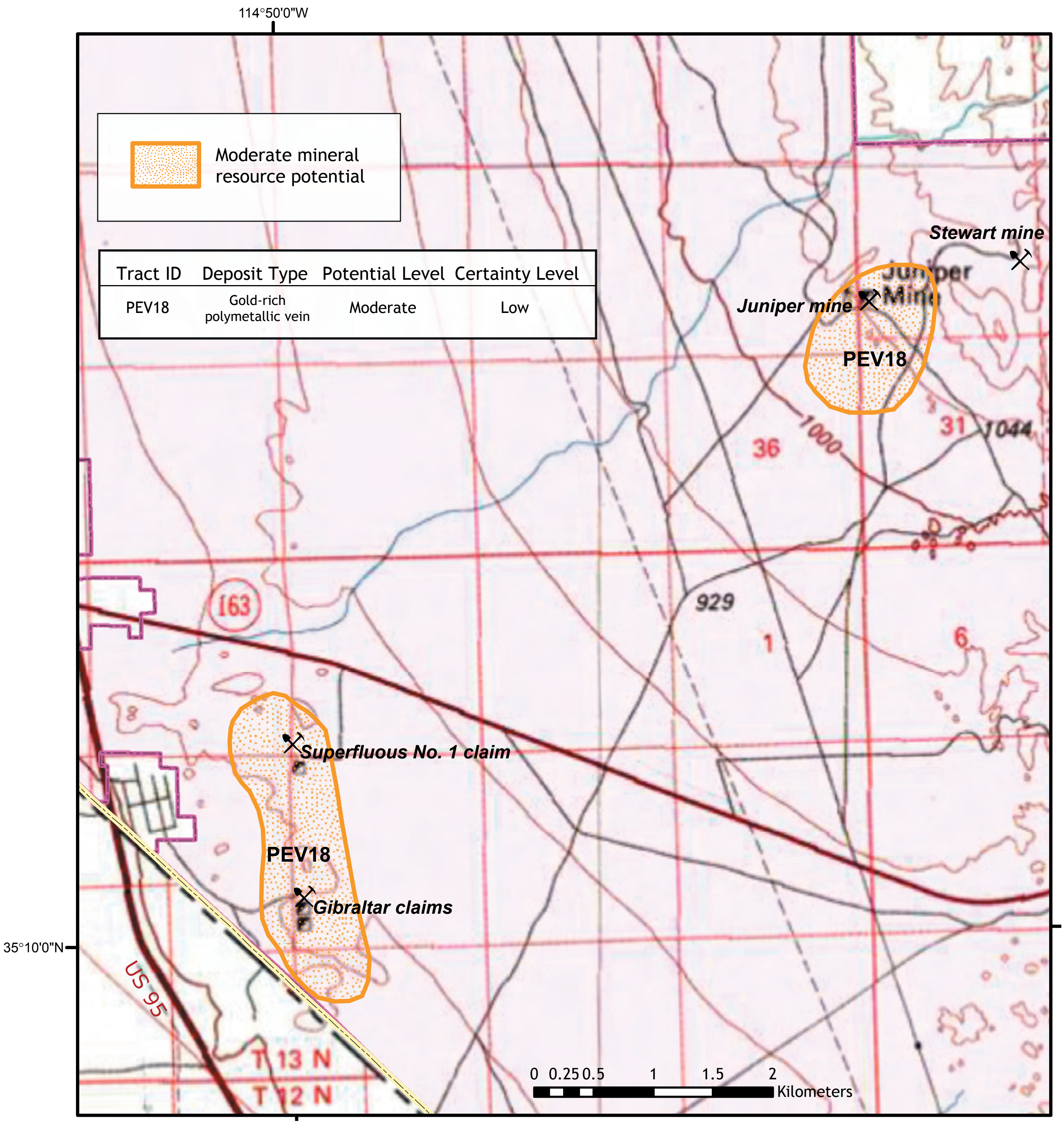


Figure 56. Mineral resource potential tract for detachment-fault-related gold deposits near the Rockefeller Mine, in the northern part of the Piute-Eldorado Tortoise Area of Critical Environmental Concern ACEC). Boundary of ACEC is in pink.

The copper mineralization encountered in these drill holes leads us to designate three tracts in the area with potential for porphyry copper deposits, albeit with a low level of certainty. Tract PEV10 (fig. 58) has moderate potential with a low degree of certainty and represents our interpretation of where porphyry copper mineralization may be found in the subsurface in the main part of the Searchlight district, in the Searchlight structural block. It includes a small area within the Piute-Eldorado Tortoise ACEC west of the rhyolite hills on the north side of Nevada State Highway 164. Additional drilling and petrographic study of subsurface rocks, more radiometric dating, and detailed structural studies would be necessary to further refine this assessment.



Tract ID	Deposit Type	Potential Level	Certainty Level
PEV18	Gold-rich polymetallic vein	Moderate	Low

Figure 57. Mineral resource potential tract for gold-bearing polymetallic vein deposits in the southern part of the Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC). Boundary of ACEC is in pink.

Tracts PEV11 and PEV12 (fig. 58) have low potential with low certainty. They represent where the analogous porphyry environment may occur in the Fourth of July and Pinto structural blocks. PEV12 includes a small part of the Piute-Eldorado Tortoise ACEC south of Nevada State Highway 164, east of the town of Searchlight. In addition, we designate a more generalized tract, PEV13 (fig. 58), also with low potential and low certainty, to reflect the uncertainty in the structural interpretation of the area; it simply encloses all areas where a possible porphyry copper deposit might underlie the area. Tracts PEV11, 12, and 13 lack any direct evidence for copper mineralization and are based on extrapolation from porphyry copper deposit models.

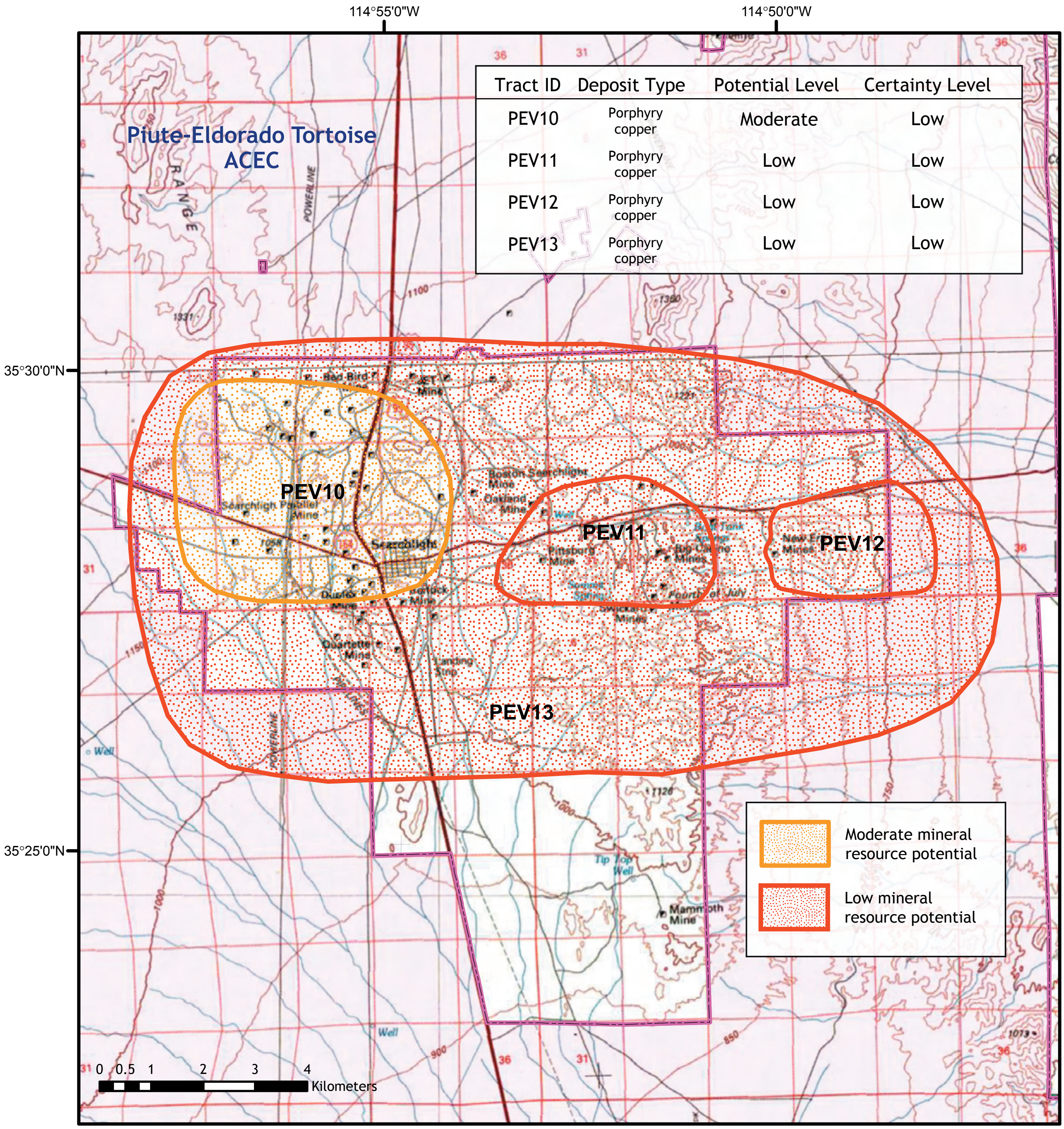
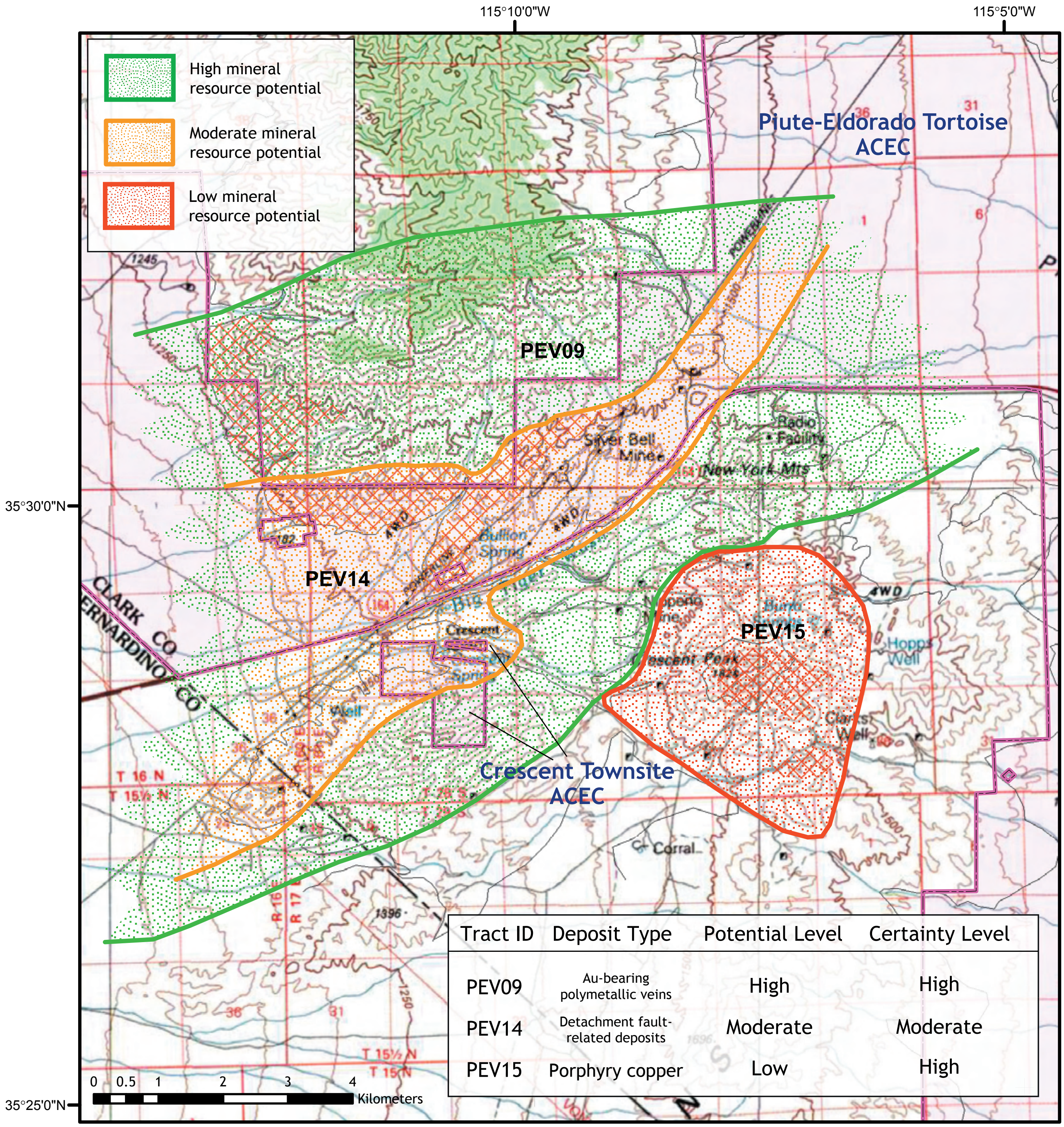


Figure 58. Mineral resource potential tracts for porphyry copper deposits in Searchlight area (Piute-Eldorado Tortoise Area of Critical Environmental Concern(ACEC)).

Gold-Bearing Polymetallic Vein Deposits (Crescent Area)

A number of deposits that contain significant amounts of gold in both veins and shear zones are found in the Crescent district. Because we are uncertain of the classification of many of these deposits, we designate two tracts to represent the mineral potential of these deposits, one (PEV09) for gold-bearing polymetallic veins and one (PEV14) for detachment-fault-related gold deposits (fig. 59).



Tract ID	Deposit Type	Potential Level	Certainty Level
PEV09	Au-bearing polymetallic veins	High	High
PEV14	Detachment fault-related deposits	Moderate	Moderate
PEV15	Porphyry copper	Low	High

Figure 59. Map showing mineral resource potential tracts for gold-bearing polymetallic veins, detachment-fault-related gold deposits, and porphyry copper deposits in the Crescent area of the Piute-Eldorado Tortoise and Crescent Townsite Areas of Critical Environmental Concern (ACECs). Red cross hatch indicates areas of hydrothermal alteration identified with Advanced Spaceborne Thermal Emission and Reflectance (ASTER) imagery. Boundaries of ACECs are in pink.

Tract PEV09 includes all the gold-bearing deposits in the Crescent area, so we designate it as high potential, with a high level of certainty for gold-bearing polymetallic veins. A remarkable proportion of the samples we took in this area contained significant gold values. The tract includes a large area on both sides of Nevada State Highway 164, and it also extends both eastward and westward under cover of Quaternary alluvium; we do not have information to delimit the western and eastern limits of this tract. Large areas of the tract are within the Piute-Eldorado Tortoise ACEC, and the Crescent Townsite ACEC is entirely within the tract. More exhaustive geochemical sampling of rocks within the ACEC could help refine the boundaries of the tract; petrographic studies of these samples could help refine the deposit classification.

Detachment-Fault-Related Gold Deposits (Crescent Area)

Tract PEV14 (fig. 59) is designed to represent the potential area for deposits we interpret to be detachment-fault-related gold deposits. It is entirely enclosed within tract PEV09, and has moderate potential with moderate certainty. Note that this is not meant to represent an area with lower potential within tract PEV09. Deposits within this tract could also be gold-bearing polymetallic veins; the designation of this tract reflects our lower confidence in the classification of some of the deposits, not overall lower mineral potential. The boundaries of this tract are guided by the distribution of silicified rocks related to low-angle faulting and by the mapping of Miller and Wooden (1993). Most of this tract is not within either the Piute-Eldorado Tortoise or Crescent Townsite ACEC. Detailed structural mapping of this area could help raise the level of certainty for application of the detachment-fault-related model.

Porphyry Copper Deposits (Crescent Area)

Tract PEV15 (fig. 59) has low potential with a high degree of certainty for porphyry copper deposits. The exploration of the deposit at Crescent Peak was done nearly 50 years ago. However, the drilling showed that some areas do not contain significant mineralization, and, unless there are important structural complications related to low-angle faulting, there is little room left in the prospective area to contain a porphyry copper deposit. The tract does not impinge on the Piute-Eldorado Tortoise or Crescent Townsite ACECs.

Perlite

Two tracts in the Piute-Eldorado Tortoise ACEC have potential for perlite deposits. A small area (Tract PEV16, fig. 60) that includes the Searchlight Insulation Products perlite mine has high potential, with a moderate level of certainty. Perlite was produced in small amounts from this area in the 1950s, and significant reserves remain. However, it is not clear that perlite from this property would be competitive in current markets. Part of the high potential area is in a private inholding, but the perlite mass that was mined and the tract we designated both extend into the ACEC.

A much larger tract (PEV17, fig. 60) has moderate potential for perlite deposits, with a moderate level of certainty. This tract includes areas mapped as middle Miocene rhyolite lavas (Faulds and others, 2002), which is the same rock unit that contains perlite in the high potential perlite area. On the basis of our field examination, this unit contains local exposures of perlite that might have commercial potential. None of the perlite occurrences that we examined outside Tract PEV16 were as large or as pure as the perlite in the Searchlight Insulation Products deposit, but undiscovered deposits may exist.

Perlite deposits that had past production, including the Nu-Lite Mine, are in the Castle Mountains just west of the Piute-Eldorado Tortoise ACEC. However, no perlite occurs within the Piute-Eldorado Tortoise ACEC, and we do not designate any potential tracts in this area.

Leasable Minerals in Piute-Eldorado Tortoise ACEC

None of the Piute-Eldorado Tortoise 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 Piute-Eldorado Tortoise ACEC contains no known deposits of other leasable minerals, and the potential for their occurrence is low.

Salable Minerals in Piute-Eldorado Tortoise ACEC

Crushed Stone.—High quality crushed stone resources occur mostly in the northern and eastern parts of the ACEC in parts of the Highland Range, Eldorado Mountains, and Newberry Mountains. Tract APET01 (fig. 61) has high potential for crushed rock aggregate resources, with a moderate level of certainty. Isolated areas of high potential resources are also scattered along the northeast flank of the New York Mountains on the southwest side of Piute Valley. The rock types that were used to define high potential areas include Miocene basaltic andesite and basalt in the Highland Range, northern McCullough Range, northeastern New York Mountains, and parts of the Newberry Mountains, as well as Miocene and Cretaceous granites within the Searchlight and Ireteba plutons.

Most of the rock outcrops in the ACEC were designated to have moderate potential for crushed-stone aggregate deposits, with a moderate level of certainty (Tract APET02, fig. 61). Volcanic rocks with moderate potential are so designated primarily based on the occurrence of volcanic glass. Although the glassy intervals may be interbedded with higher-quality volcanics, selective mining in such a case would probably not be feasible. Other volcanic units, particularly hydrothermally altered, intermediate-composition units of volcanics of the Highland Range are also considered to have moderate potential. Plutonic rocks classified as moderate aggregate potential include most of the Newberry Mountains, along with parts of the Eldorado Mountains and McCullough Range. Many of these granitic rocks commonly weather to gruss, and the porphyritic nature of these granitic rocks can result in rapid mechanical breakdown of the aggregate, which would be considered deleterious for many aggregate applications.

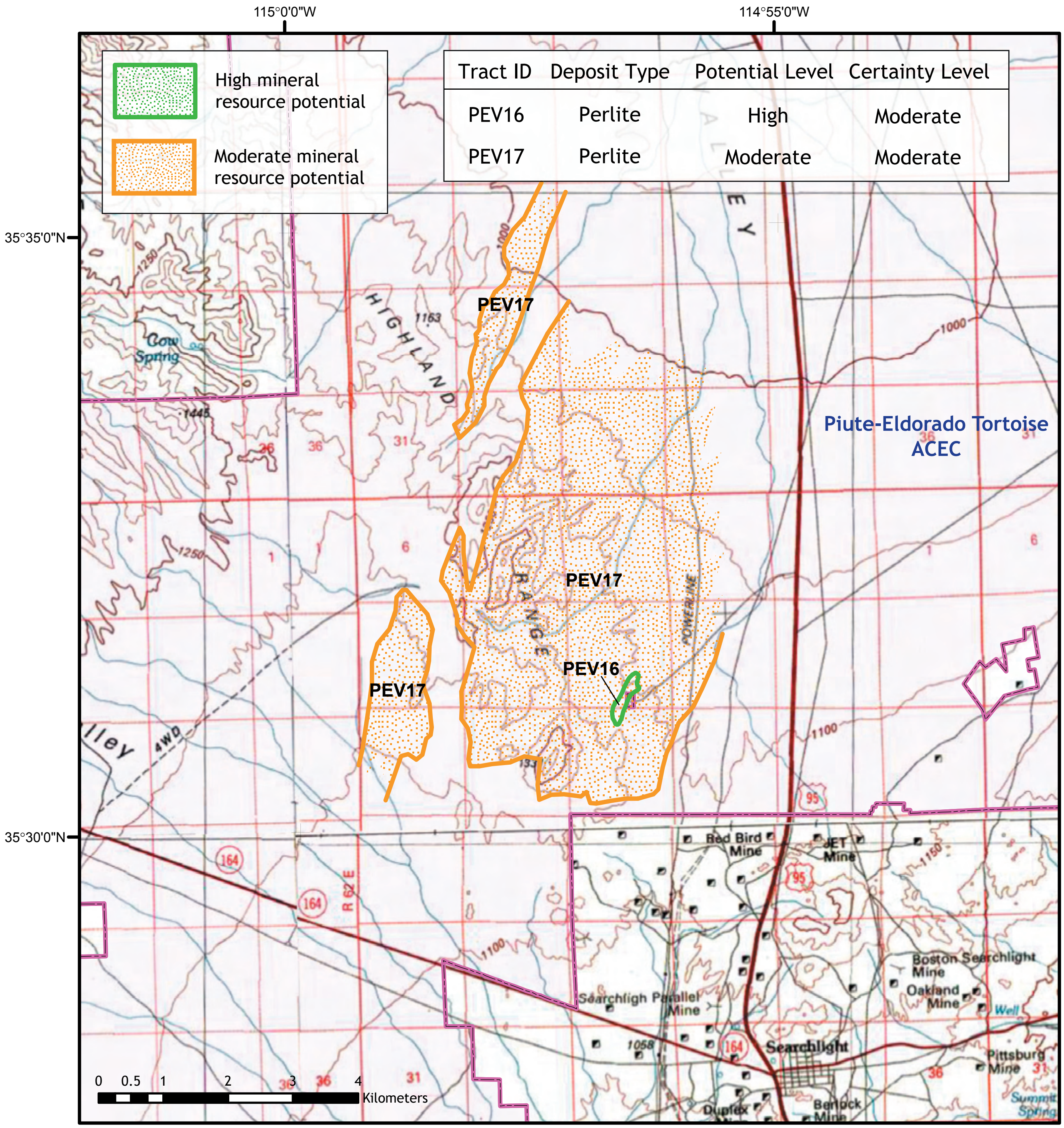
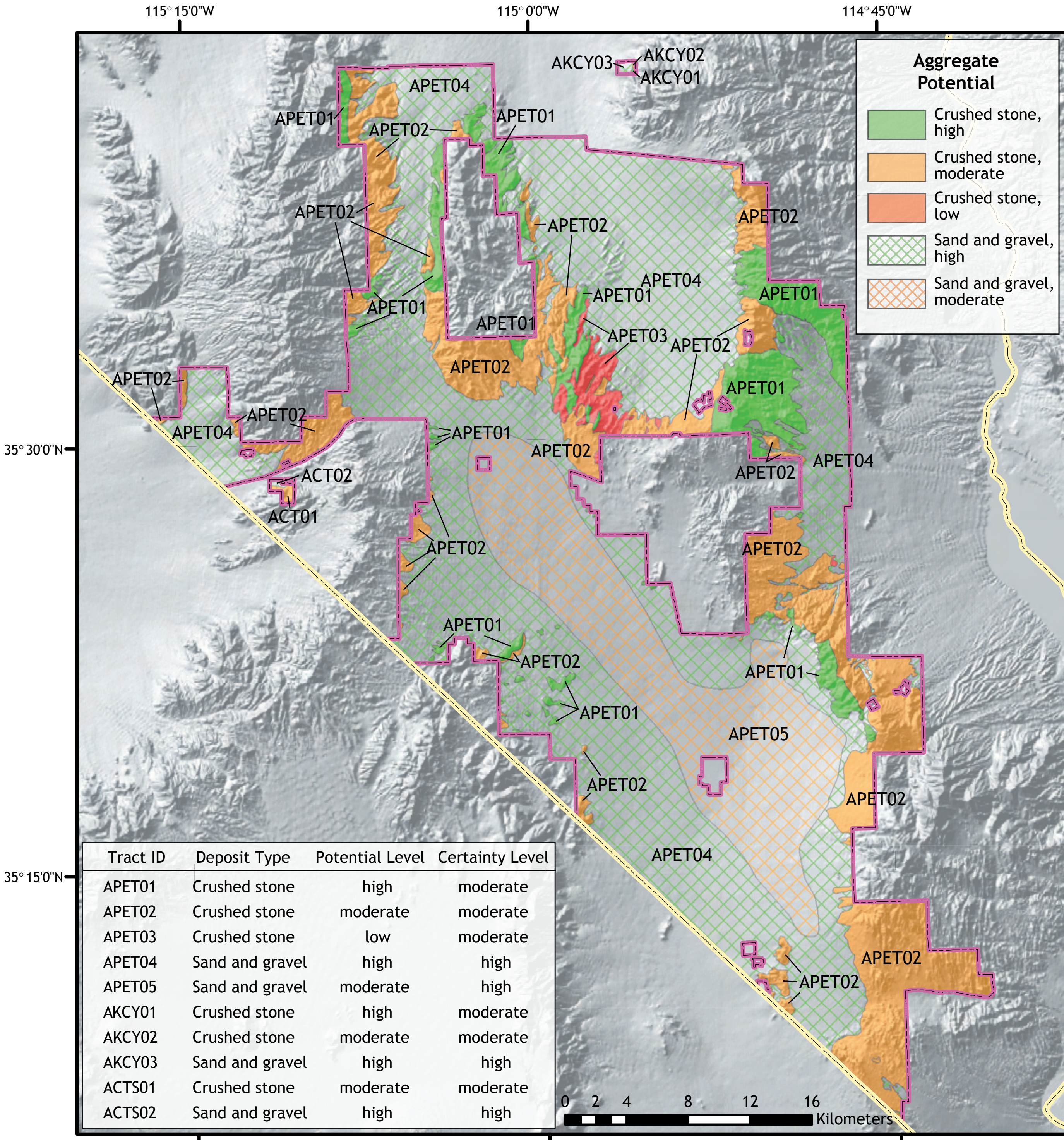


Figure 60. Mineral resource potential tracts for perlite deposits in the Piute-Eldorado Tortoise Area of Critical Environmental Concern (ACEC). ACEC boundary is in pink.

The lowest quality rocks in the area occur in the southern Highland Range to the northwest of Searchlight (Tract APET03, fig. 61). These rocks are felsic volcanics that are both unsound and commonly contain abundant glass, which would severely limit their use in aggregate applications. Tract APET03 has low potential for crushed-stone aggregate deposits, with a moderate level of certainty.

Sand and Gravel.—High quality sand and gravel deposits occur on the alluvial fans and washes along the margins of both Eldorado and Piute Valleys. Farther down slope, rock



Tract ID	Deposit Type	Potential Level	Certainty Level
APET01	Crushed stone	high	moderate
APET02	Crushed stone	moderate	moderate
APET03	Crushed stone	low	moderate
APET04	Sand and gravel	high	high
APET05	Sand and gravel	moderate	high
AKCY01	Crushed stone	high	moderate
AKCY02	Crushed stone	moderate	moderate
AKCY03	Sand and gravel	high	high
ACTS01	Crushed stone	moderate	moderate
ACTS02	Sand and gravel	high	high

Figure 61. Mineral resource potential tracts for crushed-stone and sand and gravel aggregate in the Piute-Eldorado Tortoise, Keyhole Canyon, and Crescent Townsite Areas of Critical Environmental Concern (ACECs). ACEC boundaries are in pink.

materials are commonly broken into smaller and smaller fragments, eventually to mostly coarse sand with only minor amounts of material coarser than 4.75 mm, which is the necessary size for most aggregate applications. The width of the zone of high quality deposits is controlled by composition and mechanical properties of the source rock. Coarse, porphyritic-type granites and granite gneisses are distinctly more rapidly affected by mechanical breakdown than basalts, thus the transition from coarse- to fine-grained deposits is closer to the mountain front for the porphyritic and micaceous rocks, whereas large basalt clasts can be found many kilometers from their source. Tract APET04 (fig. 61) has high potential for sand and gravel aggregate deposits with a high level of certainty. Tract APET05 (fig. 61), which occupies the central parts of Piute Valley, has moderate potential for sand and gravel aggregate deposits, with a high certainty level.

Decorative Stone.—Decorative stone is generally considered a saleable commodity and is a subset of the crushed-stone category. The Las Vegas metropolitan area is an excellent decorative stone market. Decorative stone, which is mostly used for landscaping, does not need to meet standards for high-quality construction aggregate, such as concrete or asphalt aggregate. Therefore, almost any rock type has potential as decorative stone, and it is difficult to assess its suitability on the basis of physical properties. However, it should be relatively sound and resistant to weathering, and it is generally sold on the basis of appearance. Pink or pale red stone seems to be the most marketable material in Las Vegas, but yellow, gray, white, brown, and black stone are also used. Therefore, marketability of decorative stone is based on the customer's personal taste. Sandstone, granitic rock, volcanic rock, carbonate rock, and metamorphic rock are all utilized. Hydrothermally altered rock that contains hematite and (or) limonite is also suitable, providing that it is relatively sound.

With the exception of the Roman Mine, which is on unpatented mining claims directly east of the ACEC, decorative stone mines active in the vicinity of the Piute-Eldorado Tortoise ACEC are on patented mining claims. Mining on fee land obviates the necessity for BLM contracting and oversight, and reduces cost to the producer. Because it is difficult to assess the suitability of any rock unit or rock type for decorative stone, we have not delineated potential areas for these deposits.

Locatable Minerals in Crescent Townsite ACEC

All of the Crescent Townsite ACEC is within tract PEV09 (fig. 59), which has high potential, with a high level of certainty for gold-bearing polymetallic veins. A remarkable proportion of the samples we took in this area contained significant gold values. The northern part of the ACEC is also within tract PEV14 (fig. 59), which has additional moderate potential with moderate certainty for detachment-fault-related gold deposits.

Leasable Minerals in Crescent Townsite ACEC

None of the Crescent Townsite 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 Crescent Townsite ACEC contains no known deposits of other leasable minerals, and the potential for their occurrence is low.

Salable Minerals in Crescent Townsite ACEC

Crushed Stone.—Bedrock areas within this ACEC have moderate potential for crushed-stone aggregate deposits, with a moderate certainty level (tract ACTS01, fig. 61). Although much of the southern part of the ACEC is granodiorite, there are zones of hydrothermal alteration and shearing, both of which reduce the quality of any potential crushed-stone deposits.

Sand and Gravel.—The northern part of the ACEC has high potential for sand and gravel aggregate deposits with high certainty in Big Tiger Wash (tract ACTS02, fig. 61). Although relatively thin, the sand and gravel deposits contain abundant coarse clasts of resistant metamorphic and igneous rocks.

Decorative Stone.—Decorative stone is generally considered a saleable commodity and is a subset of the crushed-stone category. The Las Vegas metropolitan area is an excellent decorative stone market. Decorative stone, which is mostly used for landscaping, does not need to meet quality standards for high-quality construction aggregate, such as concrete or asphalt aggregate. Therefore, almost any rock type has potential as decorative stone, and it is difficult to assess its suitability on the basis of physical properties. However, it should be relatively sound and resistant to weathering, and it is generally sold on the basis of appearance. Pink or pale red stone seems to be the most marketable material in Las Vegas, but yellow, gray, white, brown, and black stone are also used. Therefore, marketability of decorative stone is based on the customer's personal taste. Sandstone, granitic rock, volcanic rock, carbonate rock, and metamorphic rock are all utilized. Hydrothermally altered rock that contains hematite and (or) limonite is also suitable, providing that it is relatively sound.

Decorative stone mines active in the vicinity of the Crescent Townsite ACEC are on patented mining claims. Mining on fee land obviates the necessity for BLM contracting and oversight, and reduces cost to the producer. Because it is difficult to assess the suitability of any rock unit or rock type for decorative stone, we have not delineated potential areas for these deposits.

Locatable Minerals in Keyhole Canyon ACEC

Although it is relatively close to the Eldorado mining district, the Keyhole Canyon ACEC has no areas with high or moderate potential for metallic mineral deposits or any other locatable minerals.

Leasable Minerals in Keyhole Canyon ACEC

None of the Keyhole Canyon 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 Keyhole Canyon ACEC contains no known deposits of other leasable minerals, and the potential for their occurrence is low.

Salable Minerals in Keyhole Canyon ACEC

Crushed Stone.—The granite in the north end of the Keyhole Canyon pluton is quite competent and has high potential for crushed-stone aggregate deposits, with a moderate level of certainty (tract AKCY01, fig. 61). The Proterozoic gneiss and schist north of the granite has moderate potential for crushed-stone aggregate deposits with a moderate level of certainty (tract AKCY01, fig. 61).

Sand and Gravel.—Deposits of high quality sand and gravel aggregate in the alluvial fan that empties Keyhole Canyon constitute tract AKCY03 (fig. 61), which has high potential for sand and gravel aggregate, with a high certainty level. These deposits are a mixture of Keyhole Canyon granite and Proterozoic metamorphic rocks.

*Decorative Stone.—*Decorative stone is generally considered a saleable commodity, and is a subset of the crushed-stone category. The Las Vegas metropolitan area is an excellent decorative stone market. Decorative stone, which is mostly used for landscaping, does not need to meet quality standards for high-quality construction aggregate, such as concrete or asphalt aggregate. Therefore, almost any rock type has potential as decorative stone, and it is difficult to assess its suitability on the basis of physical properties. However, it should be relatively sound and resistant to weathering, and it is generally sold on the basis of appearance. Pink or pale red stone seems to be the most marketable material in Las Vegas, but yellow, gray, white, brown, and black stone area also used. Therefore, marketability of decorative stone is based on the customer's personal taste. Sandstone, granitic rock, volcanic rock, carbonate rock, and metamorphic rock are all utilized. Hydrothermally altered rock that contains hematite and (or) limonite is also suitable, providing that it is relatively sound.

Decorative stone mines active in the vicinity of the Keyhole Canyon ACEC are on patented mining claims. Mining on fee land obviates the necessity for BLM contracting and oversight, and reduces cost to the producer. Because it is difficult to assess the suitability of any rock unit or rock type for decorative stone, we have not delineated potential areas for these deposits.

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