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GEOLOGICAL SURVEY

# MINERAL DEPOSITS OF THE RENO 1° x 2° QUADRANGLE, NEVADA, with a comprehensive bibliography

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey standards and stratigraphic nomenclature.

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## INTRODUCTION

The Reno CUSMAP (Conterminous United States Mineral Assessment Program) project is a mineral assessment of known and possible future mineral resources in the Reno 1° by 2° quadrangle (lat. 39°00' N to 40°00' N by long. 118°00' W to 120°00' W), Nevada. The project was initiated in fiscal year 1986 (October 1, 1985), and it will run for 4 years. This report is a review of the known mining districts within the Reno quadrangle, as well as a guide for field assessments of known and potential deposits. In addition, a comprehensive albeit incomplete bibliography is included.

This report should be considered preliminary in nature. It is a compilation of previously published papers and maps available prior to the first field season. These sources include maps of metal deposits and occurrences published by the Nevada Bureau of Mines and Geology (NBMG), and compilations of metal production and occurrences such as those by Elevatorski (1982), Mosier et al. (1985), and Cox and Singer (1986). As field work progresses and areas are ground-checked, these data will be revised and updated. However, this report should prove useful as a starting point for those interested in previous mining and research efforts within the Reno quadrangle.

## KNOWN PRODUCTION

More than 14 metals and 10 industrial minerals have been produced from several hundred mines in about 48 mining districts within the Reno quadrangle (Fig. 1). Gold and silver, followed by lead and copper, dominate the production totals, as shown in Table 1. The Comstock Lode district in Storey and Lyon Counties is by far the largest producer of precious metals with about 8,500,000 oz gold and 200,000,000 oz silver recovered from about 75 mines (Tables 1 and 3). Other districts with notable production include: Chalk Mountain (Pb, Ag), Fairview (Ag, Au, Pb, Cu), Sand Springs (Ag, Au), Toy (W), Wonder (Ag, Au, Cu, Pb), and Mineral Basin (Fe) in Churchill County; Buckskin (Fe, Cu, Au, Ag) in Douglas County; Como (Ag, Au, Cu) and Yerington (Cu, Ag, Au) in Lyon County; Broken Hills (Ag, Pb, Cu, Au, Zn), Nevada Scheelite (W, Pb, Ag, Au), and Rawhide (Ag, Au, Pb, Cu) in Mineral County; Quartz Mountain (Ag, Pb, Au, W) in Nye County; Ragged Top (W) and Nightingale (W) in Pershing County; Gooseberry (Ag, Au) in Storey County; and Galena (Zn, Pb, Ag, Cu), Olinghouse (Au, Ag), and Peavine (Ag, Cu, Pb) in Washoe County. Several of the districts, such as Yerington, Mineral Basin, Quartz Mountain, and Ragged Top, are located on the periphery of the quadrangle, and some or most of their mines are actually out of the quadrangle. However, they are included here for completeness in describing known deposits of the region.

The data in Table 1 are accurate inasmuch as most of the districts have not produced any metals in many years, and references as old as 10 or 15 years have not been updated. Thus, approximate production values are used where available, and maximum cutoffs (eg., <1000) are used where data were estimated or incomplete. For example, records of production from the Broken Hills district are not currently available, though the district is identified as having produced Au, Ag, Sb, Mo, Cu, Pb, Zn, and fluorspar on NBMG metal maps and in county reports. Production of each metal is listed as a maximum possible amount (<1000 oz Au, <1,000,000 oz Ag) based on information from NBMG metal maps. The industrial mineral with production in each district is listed, rather than its total amount of production. Question marks (?) in a column indicate ambiguous or conflicting data for a district.

Comments on the geologic environment of ore deposition in each district, grade of metals produced (eg., 0.18 oz Au and 16 oz Ag/ton), ore reserves, and the type of deposit are tabulated in Table 2. The age and composition of host rocks are noted for those districts where such information is available. Metals such as cobalt, nickel, titanium, manganese, and uranium which have limited production or occurrence are also identified. For example, <1000 tons of cobalt and nickel were produced from the Table Mountain district, and placer or lode titanium occurrences are present in the Sand Springs, Table Mountain, and Peavine districts. The types of deposits identified in Table 2 are broad classifications. Different varieties of skarn (Fe, Cu, Pb-Zn, or W) and epithermal gold (quartz-alunite, Comstock vein, or hot spring type) deposits are not indicated here. These distinctions are the subject of the next section.

The names of mines, prospects, and claims in each district are listed in Table 3. District names in capital letters appear at the top of each column. Synonyms for some districts are the first (and second where needed) names in capital letters above the list of mine names. For example, the Rawhide and Wonder districts are also known as the Regent and Hercules, respectively. Also, Rawhide, Table Mountain, Holy Cross, IXL, and Comstock Lode contain data for areas previously considered separate districts. These subdistricts (as used here) are denoted by capital letters, and along with their mines are listed below the names of the major district. Therefore, the production totals for some of the districts listed in Table 1 include that from subdistricts as well (eg., the Table Mountain district includes production from Dixie Valley and Corral Canyon). It should be noted that a few individual mines or prospects which are not in close enough proximity to be included within a district are not identified in this overview. However, none of these deposits have significant, if any, production, and the types of mineralization are similar to those already identified and which will be discussed in the next section.

## TYPES OF KNOWN DEPOSITS

A variety of metallic deposits is present among all the mining districts in the Reno quadrangle. The classification of deposit types used in this report is that of Cox and Singer (1986) for mineral deposit models. Additional references are incorporated, as indicated, in the discussion of each type of deposit. Most, if not all, of the deposits appear to be related to hydrothermal activity, with a direct association to volcanic or plutonic rocks. These include epithermal gold, skarn, porphyry copper (±molybdenum), volcanogenic uranium, hot spring mercury and gold, and simple antimony deposits. Other types of deposits that may be located during field examinations include porphyry molybdenum, epithermal or replacement Mn, volcanic-hosted Cu-As-Sb, sandstone U, and several associated with the Humboldt lopolith such as Noril'sk or Duluth Cu-Ni-PGE, basaltic Cu, and sediment-hosted Cu; however, most of the lopolith is exposed outside of the Reno quadrangle. Deposits in clastic sedimentary or carbonate rocks such as sandstone-hosted, sedimentary-exhalative, or Southeast Missouri (Mississippi Valley-type) Pb-Zn, carbonate-hosted (Carlin-type) Au, and sediment-hosted Cu, as well as chemical sedimentary deposits such as sedimentary Mn or Superior Fe and those associated with marine felsic to mafic extrusive rocks such as massive sulfides and Algoma Fe, are not present in the quadrangle. Placer gold and industrial mineral deposits, which are known to occur in the Reno quadrangle, are not discussed in this report.

## Epithermal Gold Deposits

Epithermal deposits are classified as such on the basis of host rock, mineralogy, and elemental associations, according to Lindgren (1933). These hydrothermal deposits generally formed at temperatures between 50° and 300°C and depths from the surface to 1000 m. The deposits occur as thin to large veins, stockworks, disseminations, and replacements, and the vein textures include open-space filling, colloform banding, vein breccias, drusy cavities, and comb structure. Alteration is characterized by silicification, argillization, and propylitization, with quartz, sericite, illite, and adularia commonly present. Quartz may be in the form of fine-grained chalcedony or coarser pseudomorphs after calcite (Berger, 1982). Strong, persistent fractures related to calderas, domed areas, or basin-and-range-type normal faults are ubiquitous. Some faults show evidence of movement during mineralization, and episodic vein emplacement (through cross-cutting relationships) is characteristic (Berger and Eimon, 1983).

At least two types of epithermal gold deposits are represented in the Reno quadrangle. The Comstock epithermal vein type (also known as the quartz-adularia or alkali-chloride type) accounts for a large percentage of the precious metal production in the area. Districts included in this type are the Comstock Lode, Fairview, Holy Cross, Olinghouse, Rawhide, Sand Springs, Wonder, Como, Ramsey, Talapoosa, and Gooseberry. Epithermal quartz-alunite Au (or enargite gold) deposits are represented by the Pyramid, Peavine, and Wedekind districts. Steamboat Springs is characteristic of hot spring mercury and gold deposits.

### Comstock epithermal vein type

The Comstock Lode district is the type example of the Comstock epithermal vein model (Mosier, Singer, and Berger, in Cox and Singer, 1986). These deposits are characterized by quartz-adularia veins that cut across Tertiary silicic to intermediate volcanic rocks. Stockworks and banded veins that infill fault and breccia zones are common. Orebodies are present as stacked or vertically separated deposits, with subeconomic vein filling and stringers of quartz and calcite in between. Disseminated and replacement ore may be found in the more permeable horizons (Berger and Eimon, 1983). Fractures form anastomosing, through-going systems in the host rocks, and they may be related to intrusive domes or ring fracture zones. The host-rock types are Miocene (in the Reno quadrangle), porphyritic rhyolitic to andesitic tuffs, flows, breccias, dikes, and pyroclastic rocks. They are calc-alkalic in composition and generally oxidized and hydrous (Keith, 1984). These rocks overlie basement composed of Mesozoic (Tr to J) metasedimentary and metavolcanic rocks such as slate, phyllite, hornfels, quartzite, and marble, and Mesozoic (J or K) granitic rocks. Propylitic alteration is pervasive, with potassic (quartz, adularia, calcite, dolomite, Mn carbonate and silicates, fluorite, and barite) and phyllic-argillic (kaolinite, sericite, illite, smectite, zeolites, albite, and calcite) alteration typically restricted to narrow envelopes around the veins (Bonham and Giles, 1983). A vertical zonation of alteration and metallization is also common. Surface rocks may be bleached by alunite and kaolinite and stained with iron oxide minerals such as limonite, hematite, goethite, and jarosite. The assemblage quartz + kaolinite + montmorillonite ± zeolite ± barite ± calcite is present in the top of the system. It grades downward to the assemblages quartz + illite; quartz + adularia ± illite; and quartz + chlorite. The ore contains Au and Ag with Sb, Hg, and As higher in the system, and it grades downward into Pb-Zn-Cu-Ag veins. Ore minerals include native gold, electrum, argentite ($Ag_2S$), cerargyrite ($AgCl$), various sulfosalts such as pyrargyrite ($Ag_3SbS_3$), stephanite ($Ag_5SbS_4$), and polybasite ($Ag_{16}Sb_2S_{11}$), and arsenic, mercury, and antimony sulfides. Pyrite, galena, sphalerite, and chalcopyrite are commonly present. Iron and manganese oxides are moderate to sparse. Gangue minerals in the veins include quartz, adularia, calcite, sericite, fluorite, manganese carbonate and silicates, barite, and chlorite.

The Comstock epithermal vein deposits differ from those of the Creede epithermal vein type (Mosier, Sato, Page, Singer, and Berger, in Cox and Singer, 1986) primarily in geochemical associations and fluid compositions (William Bagby, personal communication, 1986). For example, the Comstock-type deposits have a lower Ag/Au ratio, less base metals, and are formed from less saline fluids (3 wt % NaCl at Comstock vs. 5 to 14 wt % NaCl equivalent at Creede, according to Hayba, 1983).

## Epithermal quartz-alunite Au

Epithermal quartz-alunite Au or enargite gold deposits such as Goldfield, NV, Summitville, CO, and El Indio, Chile, are characterized by quartz-pyrite-gold-enargite veins and breccias in zones of high-alumina, acid-sulfate hydrothermal alteration (Berger, in Cox and Singer, 1986). The Pyramid, Peavine, and Wedekind districts in the Reno quadrangle are examples of this occurrence model. High-grade siliceous veins (about 30 cm wide at Pyramid) fill breccias or fractures in intermediate to silicic calc-alkalic volcanic rocks (the Hartford Hill Rhyolite sequence in the Reno quadrangle). Through-going faults are present in all districts, and the fracture system is commonly associated with graben or collapse structures, ring fracture zones, normal faults, and domes. In particular, these deposits are localized above and peripheral to porphyry copper-type systems. Host rocks are usually Tertiary (Oligocene to Miocene in the Reno quadrangle) rhyodacites, dacites, andesites, quartz latites, rhyolites, and trachyandesites that form tuffs, flows, and intrusive domes. At least one unit of intermediate volcanic rocks in proximity to these deposits is porphyritic and is both spatially and temporally associated with hydrothermal alteration and ore deposition (Ashley, 1982). Alteration is widespread, extending far beyond economic concentrations, and predominantly argillic with an inner zone of advanced argillic (Bonham and Giles, 1983). Assemblages include an inner vein envelope of quartz + alunite + pyrophyllite + pyrite ± corundum ± diaspore ± andalusite ± zunyite, surrounded by quartz + alunite + kaolinite + montmorillonite (argillic), quartz + sericite + pyrite (sericitization), and a varied propylitic assemblage commonly with chlorite + calcite in outer parts of the district (Wallace, 1979). Oxidation of pyrite at the surface results in yellow, brown, orange, or red limonite stains, jarosite, goethite, and hematite. The predominant ore minerals are native gold and copper sulfosalts such as the enargite-luzonite series ($Cu_3AsS_4$), tetrahedrite-tennantite ($Cu_{12}Sb_4S_{13}$-$Cu_{12}As_4S_{13}$), and silver sulfosalts such as pyrargyrite-proustite ($Ag_3SbS_3$-$Ag_3AsS_3$). Pyrite is ubiquitous, and other sulfides such as bismuthinite ($Bi_2S_3$), chalcopyrite, bornite, galena, sphalerite, marcasite, and wurtzite become more abundant at the outer edges of the ore zone. At Pyramid, the veins are zoned from pyrite + galena in the outer part of the district to pyrite + tetrahedrite + sphalerite + galena + chalcopyrite + bornite to enargite + pyrite ± chalcopyrite in the central area (Wallace, 1979). Precious-metal tellurides, huebnerite, mercury and antimony sulfides, and hypogene oxidation phases such as chalcocite and covellite are moderate to sparse. Quartz is the most abundant gangue mineral, and it forms comb structures in breccia fillings. Barite, alunite, or kaolinite may also be important gangue minerals. Moreover, the contact between ore-filled breccias or fractures and advanced argillic alteration of wall rocks is commonly obscured, and the entire alteration assemblage could be considered gangue (Ashley, 1982). The quartz-alunite Au deposits differ from those of the Comstock epithermal vein type by their high total sulfur content in both sulfides and sulfates, gold associated with enargite-group minerals, advanced argillic alteration, widespread argillic alteration, and more common multiple event hydrothermal brecciation.

### Hot spring Hg and hot spring Au-Ag

Hot spring deposits of mercury and gold-silver, such as Sulfur Bank, CA, and Round Mountain, NV, McLaughlin, CA, and Delamar, Idaho, respectively, formed in the shallow parts of fossil geothermal (or hot spring) systems (Rytuba, in Cox and Singer, 1986; Berger, in Cox and Singer, 1986). Steamboat Springs in the Reno quadrangle is a present-day equivalent of these Tertiary geothermal systems (White, 1985). Ore is contained in silicified explosion breccias, hydrofractured vein stockworks, and occurs as disseminations in Tertiary and Quaternary silicified volcanic rocks (Bonham and Giles, 1983). Host rocks generally form part of a large silicic volcanic system, particularly characterized by rhyolite domes. At Steamboat Springs, sinter deposits, chemical sediments formed in hot-spring vents, and veins (all <3 m. y. old) host anomalous metal concentrations (White, 1985). Alteration is dominantly silicification and K-Na metasomatism, with chalcedonic or opaline sinter, stockworks and veins of quartz + adularia, and breccias cemented with quartz ± chlorite. At the surface, rocks are bleached yellow by limonite, jarosite, fine-grained alunite, hematite, and goethite. Above the paleo-groundwater table, kaolinite, alunite, iron oxides, and native sulfur are common, whereas below the paleo-groundwater table pyrite, zeolites, adularia, calcite, chlorite, and quartz are present. Cinnabar, native mercury, and stibnite are zoned toward the surface, and base metal sulfides are enriched at depth (Bonham and Giles, 1983). White (1985) has noted that all cinnabar in the Steamboat Springs area occurs within 15 m of the present surface, mercury is not detectable from samples collected at depths below 26 m, and stibnite is present in veinlets and cavities in drill core to a maximum depth of 45 m. Gangue minerals include microcrystalline silica, chalcedony, quartz, calcite, and adularia. Native gold and electrum with associated fine-grained pyrite-marcasite and a variety of silver sulfosalts characterize the precious metal ores. Alunite, kaolinite, and montmorillonite are common gangue minerals in sulfide ore (Bonham and Giles, 1983).

Other hot springs and sinter deposits in the Reno quadrangle include: Brady's Hot Springs, Eagle Salt Works Spring, Borax Spring, and Lee Hot Springs in Churchill County; Wabuska Spring in Lyon County; Carson Hot Springs in the Delaware district, Carson City County; the Hobo and Walley's Hot

Springs in Douglas County; and Anaho Island Spring, Bowers Mansion Hot Springs, Cottonwood Spring in the Donatelli district, and Lawton Hot Springs, Moana Hot Springs, and Reno Hot Springs in the Steamboat Springs area of Washoe County. The Erway mercury prospect in the Truckee district is about 0.5 mi east of Brady's Hot Springs. Cinnabar, sulfur, gypsum, and other minerals are present in a silicified and argillized rhyolite tuff (Willden and Speed, 1974). However, neither mercury nor gold production is known from this area. The other hot springs in the Reno quadrangle also do not have production or reported metal occurrences.

## Skarn deposits

Skarn consists of Ca-Fe-Mg-Mn silicates that formed by replacement during contact or regional metamorphism and metasomatism. Skarn-type deposits contain various metals and skarn as gangue (Einaudi, Meinert, and Newberry, 1981). The major types of skarn deposits are those of Fe, W, Cu, Zn-Pb, Mo, and Sn. In the Reno quadrangle, Fe, W, Cu, and Zn-Pb skarn deposits are present. These include mines and prospects in the districts of Red Mountain (Fe), Buckskin (Fe), Delaware (Fe, W), Ragged Top (Fe, W), Nevada Scheelite (W), Nightingale (W), Churchill (W), Toy (W), Wild Horse (W, Fe), Truckee (W?), Quartz Mountain (W, Zn-Pb), Galena (Zn-Pb), Chalk Mountain (Zn-Pb), Broken Hills (Zn-Pb), Yerington (Cu), IXL (Cu, Zn-Pb), Copper Kettle (Cu, Fe), White Cloud (Cu, Zn-Pb), Westgate (Cu, Zn-Pb), Carson City (Cu, Zn-Pb), and Jessup (Cu?).

Voluminous descriptions and discussions of skarn and skarn deposits are available in the literature. Good review articles of skarn deposits may be found in Einaudi and Burt (1982, part of a special issue in Economic Geology devoted to skarn deposits), Einaudi, Meinert, and Newberry (1981), Einaudi (1982), and Meinert, Newberry, and Einaudi (1980), among others. Many of the distinctions between the various types of skarn deposits are based on geochemical features such as the composition of garnet and pyroxene in skarn (Meinert, 1983). For example, andraditic garnet is typical of Cu skarns, whereas grossular-spessartine garnet is more characteristic of tungsten skarns. Also, diopsidic to salitic clinopyroxene is more common in Cu skarns, and hedenbergitic and manganohedenbergitic pyroxene are present in W and Zn-Pb skarn deposits, respectively (Einaudi, 1982). In this review, I will try to summarize the more pertinent field criteria and identify distinguishing features between the various skarn deposits.

### Tungsten skarns

The most production from skarn deposits in the Reno quadrangle has come from those of W skarns. The Nevada Scheelite and Nightingale mines are the largest producers. Tungsten skarns are characterized by scheelite in hedenbergite, grandite, and wollastonite skarn (Cox, in Cox and Singer, 1986). These skarns form at deeper levels of the crust than other types. Hence, the intrusive rocks typically form large plutons and batholiths that are medium to coarsely crystalline, hypidiomorphic granular to slightly porphyritic (Meinert et al., 1980). These calc-alkalic intrusions are generally mid-Paleozoic to Late Cretaceous in age, and they intrude Precambrian to Triassic carbonate rocks. The intrusives range from quartz diorite and tonalite to quartz monzonite in composition. Pegmatite, aplite, and dikes are common, but cogenetic volcanic rocks are absent. Endoskarn, or skarn formed in the intrusive rocks, is developed only locally and consists of clinopyroxene-plagioclase-epidote. Minor potassic alteration with quartz-biotite-muscovite-calcite-pyrite may also be present adjacent to zones of retrograde alteration in skarn (Einaudi et al., 1981). Wall rocks in tungsten skarns are typically argillaceous carbonate rocks and intercalated carbonate-pelite or carbonate-volcanic sequences. These are converted to hornfels in a large metamorphic aureole of several kilometers prior to skarn formation. Contacts with the intrusion are sharp to migmatitic, and dikes rarely penetrate into the wall rocks. Skarn itself is localized along hornfels and intrusive contacts, and it is generally long (100s of meters) and narrow (0.5 to 15 m) with some zones only 1 to 5 cm wide. The skarns form small stratiform bodies on the order of 0.1 to 2 million tons (m. t.); the largest known deposit is MacMillan Pass, Yukon-Northwest Territories, Canada, at 63 m. t. (Einaudi et al., 1981). The mineralogy and composition of the skarn is dependent on host rock composition and the oxidation state imposed by both the intrusive and wall rocks. Skarns formed from impure marble tend to be coarsely crystalline and vuggy with irregular tungsten grades, whereas those in pure marble are medium crystalline, dense, and have uniform grades of tungsten (Einaudi et al., 1981). Reduced skarns, generally formed in carbonate-rich units at great depth, contain abundant ferrous iron assemblages such as hedenbergitic pyroxene, almandine-rich garnet, biotite, and hornblende. Oxidized skarns, formed in noncarbonaceous or hematitic host rocks at lesser depths, contain ferric iron assemblages such as andraditic garnet and epidote. The pyroxene:garnet ratio varies from 10:1 to 2:1 in reduced skarns to 1:1 to 1:10 in oxidized skarns (Einaudi et al., 1981). Prograde alteration produces pyroxene, garnet, idocrase, and wollastonite in reduced skarns with retrograde biotite, hornblende, plagioclase, quartz, calcite, and opaques such as pyrrhotite and magnetite with minor pyrite and native bismuth. Hematite and high-S sulfides such as bornite are absent. In oxidized skarns, the prograde minerals are similar, although with different compositions as noted previously, and the retrograde assemblage includes epidote, chlorite, aluminous ferroactinolite, quartz, calcite, and pyrite with minor magnetite, pyrrhotite, and bismuthinite. Ore-grade concentrations of scheelite are generally restricted to metasomatized marble, even though a variety of rock types may be affected by metasomatism. Sulfides, especially chalcopyrite, pyrrhotite, and pyrite, are commonly present with retrograde alteration in proximity to intrusive contacts (Einaudi et al., 1981). Other metals associated with tungsten skarns include Mo (as molybdenite), Cu (as chalcopyrite), Zn (as sphalerite), and Sn (as cassiterite). These features indicate that: (1) the magma cooled slowly at depth without explosive release of volatiles; (2) small amounts of hydrothermal fluids evolved at high temperatures in equilibrium with the primary igneous minerals; (3) wall rocks were at high temperatures prior to and during skarn formation; (4) the massive carbonate units were too plastic at high temperature and pressure to deform brittlely; and (5) skarn formation took place under relatively reducing conditions, in a low sulfur and oxygen environment at high temperatures (prograde about $400^{o}$ to $650^{o}$C, retrograde about $300^{o}$ to $450^{o}$C) and pressures (about 1 to 2 kb).

## Zinc-lead skarns

Mines in the Chalk Mountain and Galena districts of the Reno quadrangle are typical of Zn-Pb skarn deposits. In contrast to tungsten skarns, zinc-lead skarn deposits (1) are commonly located along structural or lithologic contacts distal from intrusive contacts; (2) do not have a significant, if any, metamorphic aureole centered on the skarn; (3) have iron and manganese-rich pyroxene as the dominant calc-silicate with associated sulfide minerals, as opposed to sulfides associated with garnet (in Cu skarns) or other silicate minerals (in W skarns); and (4) have a retrograde assemblage of Mn-rich ilvaite, pyroxenoids, subcalcic cummingtonite, and chlorite (Einaudi et al., 1981; Cox, in Cox and Singer, 1986; Meinert et al., 1980). Zinc-lead skarns are not always directly associated with igneous rocks. In fact, in some districts such as Linchburg, New Mexico, and Paymaster, Nevada, skarn may be several kilometers from any known or hypothetical intrusive rocks. Moreover, those igneous rocks that are associated with zinc-lead skarns are highly diverse. They range from deep-seated equicrystalline batholithic intrusives to porphyritic hypabyssal stocks and dikes. Their composition ranges from diorite and granodiorite to syenite and granite. Skarn itself tends to be small (typically 0.2 to 3 m. t.) and elongate along structural pathways. The length:width ratio is commonly >10:1. Prograde alteration is characterized by coarse, bladed johannsenitic-hedenbergitic pyroxene, coarse, granular andraditic garnet, bustamite, and rhodonite. Minor retrograde alteration consists of rhodochrosite, manganoan ilvaite, chlorite, subcalcic cummingtonite, and dannemorite. Endoskarn, which may be locally intense, contains epidote, amphibole, chlorite, garnet, pyroxene, idocrase, and sericite. Sphalerite is the dominant sulfide mineral. Minor galena, chalcopyrite, pyrrhotite, magnetite, and pyrite are also present. The bulk of the sulfide minerals may be in proximal skarns formed near contacts with batholiths and stocks, in distal skarns away from dikes and some stocks, or in limestone beyond skarn. Typical ore grades are 6 to 12% Zn, 6% Pb, negligible Cu, and 1 to 9 oz Ag per ton (Einaudi et al., 1981). These features of Zn-Pb skarn deposits indicate that the travel distance of hydrothermal fluids between source and reactive rocks operates as a control on the composition of skarn formed. Those further from the source are depleted in Mg, Al, W, and Cu, and may be relatively enriched in Mn, Fe, Zn, and Pb. Moreover, zinc-lead skarn formation is generally at depths, pressures, and temperatures less than those of tungsten skarns (about 0.5 kb, <500°C).

## Copper skarns

Copper skarn deposits are typically associated with Mesozoic, hypabyssal, calc-alkalic porphyritic stocks that intrude carbonate, calcareous clastic, or carbonate-volcanic sequences of rocks (Cox, porphyry Cu, skarn-related, in Cox and Singer, 1986; Cox and Theodore, in Cox and Singer, 1986). These deposits have high garnet:pyroxene ratios, relatively high oxidation and sulfidation states, and are in close proximity to intrusive contacts (Einaudi et al., 1981). Some of the world's largest skarn deposits are related to porphyry copper deposits such as those at Ely and Copper Canyon, Nevada; however, some are associated with barren stocks such as at San Pedro, New Mexico. The latter types of skarn deposits are similar to calcic iron skarns and Mo-bearing, polymetallic skarns, and their features will be emphasized in those sections. Porphyry-related skarns may be up to 600 m. t. in size and are generally 1 to 100 m. t. with <1 to 2% Cu, whereas barren stocks form copper skarns that are <50 m. t. with 1 to 3% Cu (Einaudi et al., 1981).

Yerington, on the southern border of the Reno quadrangle, is the largest skarn deposit in the area (Table 1). Other possible small copper skarns, perhaps related to barren stocks, include occurrences in the Copper Kettle, IXL, White Cloud, Westgate, Carson City, and Jessup districts. Yerington has been described by many geologists over the years. It is also, perhaps, an unusual type of copper skarn deposit. As Einaudi (1982) has noted, the skarn deposits at Yerington are 3 to 4 km from the porphyry copper deposits, and the characteristics of skarn formation are similar to many nonporphyry, barren-stock skarns. Thus, they may illustrate the link between porphyry and nonporphyry copper skarn deposits (Einaudi, 1982). For details of Yerington, readers are referred to Einaudi (1982, 1977), Dilles (1983), Proffett (1977), Knopf (1918), and references contained therein. It might also be noted here that the recent discovery of gold-bearing quartz-tourmaline veins at Jessup (California Mining Journal, 1986) indicates that this possible skarn deposit may be porphyry-related.

Copper-bearing skarns are in proximity to highly fractured, hypabyssal, silicic porphyry stock and dike complexes and associated breccia pipes. The stocks are typically granodiorite and quartz monzonite in composition, but less commonly include tonalite to monzogranite. Alteration in the stocks includes potassic and sericitic assemblages associated with disseminated and veinlet copper-iron sulfide minerals. Locally, epidote-pyroxene-garnet endoskarn may be developed. Skarn in limestone wall rocks of the intrusion is zoned relative to the intrusive contact. The innermost zone is characterized by finely crystalline to massive aggregates of andraditic garnet and diopsidic pyroxene. The garnet:pyroxene ratio decreases away from the stock, and the color of garnet changes from reddish brown to greenish. The outer zone, closest to marble, contains wollastonite with minor idocrase, garnet, and clinopyroxene. Sulfide minerals also show a zonal distribution from pyrite-chalcopyrite-magnetite with garnet to bornite-chalcopyrite±sphalerite±tennantite in the wollastonite zone. They occur as disseminations, massive streaks, and as veins in skarn, and as massive replacements of marble at the skarn front (Einaudi et al., 1981). The opaques may form up to 25 per cent of the skarn with 15 per cent sulfide and 10 per cent magnetite, and pyrite:chalcopyrite ratios range from 1:2 to >5:1 in the garnet zone. Skarn formed in dolomite differs from that in limestone. These magnesian skarns develop forsterite, serpentine, talc, and tremolite with high magnetite contents, sulfides less than 6 per cent, and pyrite:chalcopyrite ratios of <1:2. Retrograde alteration may destroy the simple zonal pattern of prograde alteration, especially in porphyry-related copper skarns. Tremolite-actinolite after diopside and smectite clay after diopside or garnet are the most abundant retrograde minerals. Calcite, siderite, quartz, chalcedony, opal, iron oxides and sulfides, talc, epidote, and chlorite are also common. Quartz-sulfide veinlets with actinolite alteration envelopes in diopside skarn or hornfels are characteristic of porphyry-related copper skarn deposits. In addition, a high density of veins developed from the repetitive fracturing of sedimentary rocks, hornfels, and earlier skarn is typical, and large-scale silica-pyrite replacement of carbonate rocks that forms massive irregular bodies and mantos (as at the Ludwig deposit in the Yerington district) may accompany sulfide deposition. Copper skarn formation takes place at temperatures of $550^{\circ}$ to $<300^{\circ}C$ (Johnson and Norton, 1985) and depths of 1 to 5 km. Equivalent lithostatic pressures range from 220 to 1,100 bars and hydrostatic pressures of 100 to 500 bars (Einaudi et al., 1981).

## Iron skarns and volcanic-hosted magnetite

Iron deposits exhibit perhaps the most widely diversified geologic settings of all the skarn deposits. They are found in Mesozoic and Tertiary oceanic island-arc, continental arc, postorogenic, and rifted continental margin terrains (Einaudi et al., 1981). Compositions of igneous rocks range from diorite, gabbro, and diabase to quartz monzonite, granite, and syenite, with their volcanic equivalents commonly present. Host rocks include carbonate, calcareous clastic, and continental volcanic-clastic sediment sequences. Endoskarn varies from extensive to minor and may also contain ore. Furthermore, economic deposits of magnetite may be mined solely for iron as well as for other metals. For example, some calcic iron skarns contain anomalous recoverable concentrations of cobalt, nickel, copper, and gold (Meinert, 1984). In addition, the inner garnet zone of some Zn-bearing skarns such as Hanover, New Mexico, tin-bearing skarn at granite contacts in West Malaysia, and some magnesian skarns of porphyry-related copper skarns such as Christmas and Morenci, Arizona, contain massive magnetite bodies (Einaudi et al., 1981). Iron skarn deposits range in size from 2 to 10 m. t. Fe for small deposits and 40 to 300 m. t. Fe for large deposits, with average grades >40% Fe. In the Reno quadrangle, iron skarn deposits include Dayton, Easter, and Iron Blossom in the Red Mountain district, the Minnesota mine in the Buckskin district, the Bessemer and Capitol prospects in the Delaware district, the Basalt prospect in the Ragged Top district, those in the Mineral Basin district, and possibly Pumpkin Hollow near Yerington (Reeves and Kral, 1955; Reeves et al., 1958; Shawe et al., 1962; and Schrader, 1930).

The highly variable nature of iron skarn and volcanic-hosted magnetite deposits makes it difficult to generalize their characteristic features. However, a few distinctions may be made. For example, calcic iron skarns are commonly associated with oceanic island-arc and Andean continental arc terrains, and less commonly with rifted continental margins. As noted previously, some skarns mined for copper that are associated with barren stocks have many features similar to calcic iron skarns. Skarn may form in limestone at intrusive contacts, as conformable lenses at a distance from any pluton, or within the intrusive. The intrusions range in composition from gabbro to granodiorite, and cogenetic basalt and andesite flows and tuffs may be present (Cox, Fe skarn and volcanic-hosted magnetite, in Cox and Singer, 1986; Einaudi et al., 1981). Thus, the intrusions have a wide range of silica contents and similar total alkali concentrations as other skarn types, but they are generally more mafic and their $Na_2O/K_2O$ ratios are higher (Meinert, 1984). Their textures are characteristically medium-grained equicrystalline to slightly porphyritic. Also, the iron content of intrusions is inversely proportional to the iron content of associated skarn minerals. Endoskarn may be extensive, and it is characterized by epidote-pyroxene±garnet and sodium metasomatism represented by albite and marialitic scapolite. Zones of calc-silicate minerals are poorly developed in both endoskarn and exoskarn. In general, epidote, diopsidic-salitic pyroxene, sphene, and apatite are more typical in altered igneous rocks, and grandite garnet associated with magnetite is most common in replaced limestone. Retrograde alteration minerals include actinolite, chlorite, calcite, quartz, ilvaite, and less commonly biotite, tourmaline, potassium feldspar, sericite, and kaolinite. Magnetite may occur as disseminations, massive replacement bodies, or in veins and breccias within the intrusive rocks as well as in the garnet zone or in limestone beyond skarn. Pyrite and chalcopyrite are the dominant sulfide minerals, and cobaltite, cubanite, pyrrhotite, arsenopyrite, molybdenite, and sphalerite may be present. The total of sulfide minerals is generally less than 3 to 5 per cent. Gangue minerals include apatite, scapolite, actinolite, and quartz.

Magnesian iron skarn deposits form magnetite skarns only in dolomite at the contacts with hypabyssal stocks and dikes of granodiorite, quartz monzonite, and rarely granite (Einaudi et al., 1981). Endoskarn is not developed extensively and, where present, consists of secondary feldspars, chlorite, and epidote. Prograde skarn formation results in a diopside-spinel assemblage near the intrusion and forsterite-calcite skarn near dolomite. This may be overprinted by garnet-pyroxene calcic skarn or retrograde alteration that forms magnetite with humite group minerals, phlogopite, serpentine, and ludwigite (Einaudi et al., 1981). Minor sulfide minerals such as pyrite and pyrrhotite with traces of chalcopyrite and sphalerite are paragenetically later than magnetite.

The conditions of formation for iron skarn deposits have not been quantified as systematically as those for other types of skarn. However, Meinert (1984) and others have determined that skarn formation and ore deposition in some calcic iron skarns took place at temperatures of about 700$^{o}$ to 350$^{o}$C and pressures of 0.5 to 1 kb or more.

Polymetallic skarns

The polymetallic skarn classification is used for those deposits that contain a variety of metals such as copper, lead, zinc, silver, molybdenum, tungsten, bismuth, manganese, and others. Districts such as IXL, White Cloud, Westgate, and Carson City in the Reno quadrangle may fall in this category. The mineralogy of the polymetallic skarns is less well known than that of other types, and deposition of different metals may be related to different episodes of mineralization. In general, they are located in areas of porphyritic calc-alkalic intrusions that cut sequences of limestone, dolomite, and shale overlain by volcanic rocks, such as epicratonic miogeosynclines (Morris, in Cox and Singer, 1986). Alteration of the wall rocks varies with composition. For example, limestone is commonly dolomitized and silicified to form jasperoid, whereas shales and volcanic rocks are chloritized and argillized. Minor skarn with prograde hedenbergitic pyroxene, grandite garnet, and wollastonite, and retrograde hornblende, actinolite, epidote, chlorite, and fluorite may also be present (Einaudi et al., 1981). Orebodies form massive lenses, pipes, veins, and ribbons or blankets (mantos) in country rocks both near to and far from intrusions, and they are commonly localized by faults and breccias. A zonal sequence from a copper-rich core with enargite + sphalerite + argentite + tetrahedrite ± chalcopyrite ± molybdenite ± scheelite to a wide lead-silver zone with galena + argentite ± tetrahedrite ± silver sulfosalts to a fringe zone of zinc and manganese with sphalerite and rhodochrosite may be present. Pyrite, marcasite, and barite may be widespread throughout (Morris, in Cox and Singer, 1986).

<u>Porphyry copper (± molybdenum) deposits</u>

Porphyry copper deposits form some of the largest concentrations of metals in the world. Yerington, on the southern border of the Reno quadrangle, is a major deposit with 162 m. t. of 0.55% Cu production, and

>1,008 m. t. of about 0.4% Cu resources (Einaudi, 1982). There has been minor production from other possible porphyry copper deposits in the quadrangle, such as Buckskin. North Carson in the Carson City district has characteristics representative of the upper parts of porphyry copper systems (Hudson, 1983). As discussed in previous sections, some quartz-alunite gold and copper skarn deposits may be associated with porphyry copper systems. For example, the Guanomi quartz monzonite stock in the Pyramid epithermal quartz-alunite gold district hosts low-grade disseminated chalcopyrite and molybdenite (Wallace, 1979). Porphyry copper deposits have received extensive scientific and engineering investigations. Among the many reviews of these deposits are those by Titley and Beane (1981), Beane and Titley (1981), Titley (1982a), and Sutherland Brown (1976). Of course, articles related to specific deposits or certain aspects of some deposits appear in many different journals and special volumes.

The characteristic feature of porphyry copper deposits is stockwork veinlets of quartz and chalcopyrite (± pyrite ± molybdenite) in hydrothermally altered porphyritic intrusions and adjacent country rocks (Cox, porphyry Cu and porphyry Cu-Mo, in Cox and Singer, 1986). These intrusions are emplaced into high levels of the crust, sometimes as cupolas of batholiths, and they may have consanguineous volcanic rocks. Porphyritic textures with closely spaced phenocrysts and microaplitic quartz-feldspar groundmass are typical. The composition of the intrusions is characteristically quartz monzonite and diorite in continental arc and island arc settings, respectively. The Yerington batholith, for example, consists of granodiorite and quartz monzonite with later quartz monzonite porphyry dike swarms associated with mineralization (Einaudi, 1982). Compositions that range from quartz diorite and tonalite to quartz monzonite and monzogranite are commonly associated spatially and temporally with porphyry copper deposits in southwestern North America (Beane, 1982). The age of porphyry copper deposits is mainly Mesozoic and Cenozoic. In particular, the Laramide (about 75 to 55 m. y. ago) was a major period of porphyry copper formation in the western United States. Yerington, 150 m. y. old, and Bisbee, Arizona, about 170 m. y. old, are the oldest known deposits in the western U. S. (Titley, 1982b).

Hydrothermal alteration of the intrusive rocks is represented by pervasive, characteristic assemblages of secondary minerals that exhibit systematic spatial and temporal zonations with respect to one another (Titley and Beane, 1981). Alteration includes the innermost potassic, sodic-calcic, phyllic, argillic, and outermost propylitic assemblages. The lower and innermost potassic or K-silicate zone is characterized by K-feldspar replacement of plagioclase and fine-grained, shreddy blue-green biotite + rutile + pyrite or magnetite after hornblende (Cox, porphyry Cu, in Cox and Singer, 1986). Muscovite (or sericite), quartz, anhydrite, apatite, siderite, and chlorite may also be present (Creasey, 1966; Lowell and Guilbert, 1970; Rose, 1970; Meyer and Hemley, 1967). Rocks in the potassic zone look fresh; however, K-feldspar veinlets and black biotite veinlets cut the rocks and clusters of fine-grained biotite replace mafic phenocrysts. The hypogene, ore-forming minerals chalcopyrite and pyrite form in veins as stockworks and in the mafic silicates altered to biotite. Chalcopyrite and pyrite are in subequal abundance (chalcopyrite ±> pyrite), and total sulfides are in low concentrations of about 1 per cent (Beane, 1982).

A sodic-calcic or albitic zone has recently been recognized as a deep zone in the Yerington deposits (Dilles, 1983; Carten, 1981). There, oligoclase-albite replaces K-feldspar and actinolite + sphene replaces biotite. These rocks are hard and dull white in color, and biotite is generally absent. Veinlets of actinolite, epidote, and hematite in this zone have bleached white alteration haloes (Dilles, 1983; Cox, porphyry Cu, in Cox and Singer, 1986).

The phyllic (also known as the quartz-sericite) zone contains sericite after plagioclase and sericite + chlorite + rutile + pyrite after hornblende and biotite. Tourmaline rosettes may be present, and pyrite veinlets have distinct, soft gray sericitic haloes. Pyrite may be present in amounts of 15 to 20 per cent and form a shell around the ore shell of the potassic zone. Pyrite is in much greater abundance than chalcopyrite, and the total of sulfide minerals is high. These rocks are soft and dull to lustrous white in color (Beane, 1982; Cox, porphyry Cu, in Cox and Singer, 1986).

The argillic alteration assemblage consists predominantly of clay-group minerals. Kaolinite, montmorillonite, sericite, chlorite, and pyrite replace plagioclase and the mafic minerals. These altered rocks are soft, white in color, and are usually located in the upper portions of the system in the supergene zone. Intense acidic, high alumina alteration that converts all earlier minerals to pyrophyllite, alunite, andalusite, corundum, and diaspore with variable amounts of clay and sericite is recognized as advanced argillic alteration (Beane, 1982; Cox, porphyry Cu, in Cox and Singer, 1986). As noted earlier, this type of alteration is also associated with epithermal quartz-alunite Au deposits.

The outermost zone of propylitic alteration contains a greenschist-like assemblage of epidote-zoisite, chlorite or septachlorite, albite-oligoclase, calcite, rutile, magnetite or pyrite, and less commonly actinolite. Veinlets of sulfide or epidote and chlorite do not have significant alteration haloes (Beane, 1982; Cox, porphyry Cu, in Cox and Singer, 1986).

Supergene alteration and weathering of porphyry copper deposits produce covellite, chalcocite, green and blue copper oxides, and yellowish to reddish iron oxides and hydroxides (Anderson, 1982). The grade of hypogene ore may be significantly enhanced in the supergene zone.

Ore generally occurs as massive open-space fillings of sulfide minerals in stockwork veins and veinlets and in breccia pipes, as finely disseminated sulfides, and as peripheral veins and replacement bodies in the intrusive and in country rocks (Einaudi, 1982). Chalcopyrite, bornite, and enargite are the major hypogene ore minerals with abundant pyrite, and minor molybdenite, sphalerite, galena, and tetrahedrite. The grade of copper varies from about 1.2 to 2% Cu in lode (vein or breccia) deposits to about 0.5% Cu in disseminated deposits (Einaudi, 1982).

## Simple antimony deposits

Antimony is associated with a variety of metals in different deposits such as epithermal gold, hot-spring mercury and gold, skarns, and pegmatites (Lawrence, 1963). Simple antimony deposits are those mined exclusively for antimony. Known mines in the Reno quadrangle include the Choates and

Donatelli mines, the Hazel mine and Green prospect in the Lake district, the Green Antimony mine in the Wild Horse district, the St. Anthony mine in the Toy district, and the Happy Return mine in the Rawhide district. Other minor occurrences of antimony are found in the Shady Run, Westgate, Broken Hills, Benway (Holy Cross), Ramsey, and Steamboat Springs districts. These deposits occur most commonly as quartz-stibnite veins, pods, and disseminations in or adjacent to brecciated or sheared fault zones (Bliss and Orris, in Cox and Singer, 1986). Stibnite may be massive in form or as streaks, grains, and bladed aggregates. Structure is the most important ore control, although wall rocks may influence where antimony is deposited (Lawrence, 1963). As a consequence, a wide variety of rock types host these deposits. Limestone, shale (±calcareous), sandstone, and quartzite are common hosts, but igneous rocks that range in composition from gabbro to granite and their volcanic equivalents as well as diabasic dikes may also contain ore. Wall-rock alteration varies according to lithology. For example, limestone is commonly silicified, and argillization and sericitization may also be present. However, the degree of alteration is not consistent. In some deposits, alteration extends only a few inches from the vein, whereas in others it is extensive. Those with greater intensity of alteration also generally contain other sulfides such as pyrite, galena, sphalerite, chalcopyrite, argentite, arsenopyrite, and cinnabar, as well as scheelite, gold, and barite. Quartz is the principal gangue mineral, and calcite and barite are sparse (Lawrence, 1963; Bliss and Orris, in Cox and Singer, 1986).

## Volcanogenic uranium deposits

The National Uranium Resource Evaluation of the Reno quadrangle (Hurley et al., 1982) determined several areas as favorable for volcanogenic uranium deposits. These include ash-flow tuffs in the Stateline Peak, Pyramid, and Nightingale districts. Mines and prospects such as Buckhorn and Bastain in Stateline Peak and Lowary, Red Bluff, Hopeless, Lost Pardner, Garrett, and Armstrong in Pyramid are examples of this type of mineralization. Tuffs in the Stateline Peak and Pyramid districts belong to the Hartford Hill Rhyolite sequence of late Oligocene to Miocene age, whereas middle Tertiary quartz latitic tuffs host occurrences in the Nightingale district (Hurley et al., 1982). These deposits are typical of other volcanogenic uranium deposits such as Marysvale, Utah, and Aurora, Oregon (Bagby, in Cox and Singer, 1986). Uranium is localized in veins that fill fault and breccia zones along the margins of shallow intrusive or volcano-plutonic complexes such as calderas. Less commonly, in the Reno quadrangle, mineralization may be associated with unconformities above, below, and within the Hartford Hill Rhyolite or with altered zones around faults that are intruded by a basaltic dike (Hurley et al., 1982). Host rocks are typically porphyritic to aphyric vesicular flows and shallow intrusions that are high-silica alkali rhyolites and potassium-rich trachytes in composition. The intensity of alteration in the host rocks varies from weak to intense with original textures obscured. Alteration consists of argillization, zeolitization, and silicification. Kaolinite, montmorillonite, alunite, adularia, and limonite are commonly present. Devitrification is widespread, although welding may be minor (Hurley et al., 1982). Uraninite, autunite, carnotite, coffinite, and brannerite are the dominant uranium-bearing minerals. Other minor minerals include pyrite, realgar, orpiment, fluorite, quartz, and barite as well as trace occurrences of other uranium minerals (Bagby, in Cox and Singer, 1986).

## TYPES OF POTENTIAL NEW DEPOSITS

Several types of deposits that have not yet been discovered in the Reno quadrangle are hosted elsewhere in Nevada and the western United States by rocks similar to some in the Reno area. Some deposits are commonly associated with one of the known types discussed above. For example, epithermal manganese occurrences may be present with epithermal gold-silver deposits. The following are brief descriptions of several types of mineral occurrences that may be identified during this CUSMAP project. Those possibly associated with the Humboldt lopolith such as Nor'ilsk or Duluth Cu-Ni-PGE and basaltic or sediment-hosted Cu are not discussed here because they are the subject of a separate investigation by M. L. Zientek and G. B. Sidder.

### Porphyry molybdenum deposits

Both Climax-type (Ludington, in Cox and Singer, 1986) and low-F type (Theodore, in Cox and Singer, 1986) porphyry molybdenum deposits are present in Nevada. Low-fluorine stockwork molybdenum deposits are genetically related to Mesozoic and Tertiary stocks and plutons of calc-alkalic and high K calc-alkalic magma series (Westra and Keith, 1981). Granodiorite and quartz monzonite are the most common compositions of the host rocks, but rocks of quartz diorite to granite compositions also host these deposits (Theodore, in Cox and Singer, 1986; Mutschler et al., 1981). Some high-grade deposits are also associated with late-stage differentiates such as leucocratic granites, alaskites, and aplites. Textures of the intrusions are generally porphyritic with a finely crystalline groundmass. Some plutons (as opposed to stocks) associated with these deposits may be equicrystalline (Westra and Keith, 1981). Disseminated ore and stockwork veinlets of quartz and molybdenite are characteristically within or at the top of an intrusion or in surrounding country rocks (Theodore, in Cox and Singer, 1986). Breccia pipes, faults, and plutonic contacts may localize ore distribution. Alteration in the intrusive rocks consists of a potassic core with outer phyllic, argillic, and propylitic assemblages (see descriptions for each in the section on porphyry copper deposits). Potassic selvages around veins are common, and plagioclase may be altered over a distance of 1000 m or more. Ore is localized at the outer edge of the potassic zone and within the inner part of the quartz-sericite-pyrite (phyllic) zone. Molybdenite and pyrite are the dominant sulfide minerals, with minor chalcopyrite, scheelite, and argentian tetrahedrite (Theodore, in Cox and Singer, 1986; Westra and Keith, 1981). Yellow ferrimolybdite is a characteristic weathering product after molybdenite. The Hall and UV Industries deposits in the Tonopah $1^{o} \times 2^{o}$ quadrangle, Buckingham in the Winnemucca $1^{o} \times 2^{o}$ quadrangle, and Pine Nut in the Walker Lake $1^{o} \times 2^{o}$ quadrangle, Nevada, are examples of the low-fluorine porphyry molybdenum model.

Climax-type stockwork molybdenum deposits are genetically associated with middle Tertiary, porphyritic, hypabyssal intrusive suites of quartz monzonite to high silica, alkali-rich rhyolite and granite porphyry (Ludington, in Cox and Singer, 1986; White et al., 1981). These rocks represent extreme differentiates of mafic to intermediate parent magmas. The host stocks are commonly warped, domed, and fractured. Ring dikes, cone sheets, and radial dikes may also be present (Westra and Keith, 1981). Molybdenum occurs in quartz-molybdenite veinlets that form a stockwork centered on an intrusive cupola. Thus, the orebodies are generally dome-shaped as well. Alteration includes the potassic core, the phyllic zone, an outer and upper argillic zone, and the propylitic halo. Other smaller zones of alteration overprinted on the potassic to propylitic pattern in some deposits are the vein silica zone, pervasive (>90%) silica zone, magnetite and topaz zone, greisen zone, and the garnet zone (White et al., 1981). The presence of abundant fluorite and some topaz in addition to more intense K-feldspar alteration distinguishes these deposits from the low-fluorine type. The Climax-type stockwork orebodies contain complex networks of diverse-trending veinlets. The ore veinlets predominantly consist of quartz + molybdenite with fluorite and traces of K-feldspar, pyrite, biotite, and sericite. Other veinlets within the deposits include barren quartz, quartz-pyrite±huebnerite±topaz, and veins with variable amounts of fluorite, rhodochrosite, sphalerite, galena, and traces of chalcopyrite. Multiple pulses of intrusion and mineralization may be represented by stacked orebodies associated spatially and temporally with distinct but similar intrusions (White et al., 1981). Examples of Climax-type deposits include Climax, Mount Emmons, Redwell Basin, and Red Mountain (Urad and Henderson), Colorado, and Mount Hope in east-central Nevada (Ludington, in Cox and Singer, 1986).

## Epithermal manganese deposits

Epithermal veins of rhodochrosite, manganocalcite, and other minerals fill fault and breccia zones in subaerial volcanic rocks (Mosier, in Cox and Singer, 1986). These manganese deposits are commonly associated with epithermal gold-silver deposits. The volcanic rocks vary from rhyolitic to basaltic flows, tuffs, breccias, and agglomerates and are Tertiary in age. Alteration is limited to kaolinization and weathering which results in manganese and iron oxides and hydroxides such as pyrolusite, psilomelane, wad, manganite, and hematite or limonite. Ore forms veins as well as stringers, nodules, and disseminations in through-going faults and brecciated volcanic rocks. Gangue minerals include calcite, quartz, chalcedony, barite, and zeolites. Known deposits in the United States are restricted to Arizona and New Mexico, such as at Gloryana, New Mexico (Mosier, in Cox and Singer, 1986).

## Replacement manganese deposits

Epigenetic manganese minerals fill fractures and cavities in carbonate sequences intruded by small plutons (Mosier, in Cox and Singer, 1986). The plutons are commonly granite to granodiorite in composition, but they do not host ore. The veins are tabular to irregular in shape, and cavity fillings may form pods, pipes, and chimneys. Rhodochrosite, rhodonite, and manganocalcite, along with Mn oxide and hydroxide minerals in the weathered zone, are the dominant ore minerals. Calcite, quartz, barite, fluorite, jasper, and some sulfide minerals such as pyrite, chalcopyrite, galena, and sphalerite may be present. These deposits are represented by Philipsburg, Montana, and Lake Valley, New Mexico, and they may be associated with some skarn or replacement Pb-Zn deposits (Mosier, in Cox and Singer, 1986).

## Volcanic-hosted Cu-As-Sb deposits

Deposits of copper, arsenic, and antimony sulfide and sulfosalt minerals are hosted by Tertiary andesitic to dacitic flows, tuffs, and breccias associated with porphyry copper (±molybdenum) or low-fluorine porphyry molybdenum systems (Cox, in Cox and Singer, 1986). The host rocks are generally porphyritic with an aphanitic groundmass and are locally brecciated. Silicification (with chalcedony) and high-alumina acidic alteration assemblages that contain alunite, pyrophyllite, diaspore, dickite, and andalusite are common. Tuff breccias and breccia pipes act as channelways for ore fluids. Stratabound to pipe-like massive ore fills breccias and replaces clasts. Ore minerals include enargite-luzonite, tennantite-tetrahedrite, covellite, chalcocite, bornite, chalcopyrite, and arsenopyrite (Cox, in Cox and Singer, 1986). The deposits are typically located 500 to 700 m from known porphyry-type mineralization. Lepanto, Philippines, and Sam Goosly, B. C., Canada, are examples of this mineral deposit model.

### Sandstone uranium deposits

The National Uranium Resource Evaluation identified the Stateline Peak district to be favorable for sandstone or Wyoming roll-type uranium deposits (Hurley et al., 1982). Late Tertiary arkosic sandstones, siltstones, and mudstones of fluvio-lacustrine origin may host stratabound or disseminated deposits. These rocks are derived from granitoid plutons and felsic tuffs and locally are intercalated with diatomites, conglomerates, and andesitic to basaltic flows and tuffs. Alteration within the sediments consists of argillization and limonitization with feldspars replaced by kaolinite and felsic tuff fragments altered to montmorillonite. Both reduced (grayish green to white) and oxidized (red, yellow, brown stains) facies are present (Hurley et al., 1982). Ore forms typically at the interface between these two facies (Hodges, in Cox and Singer, 1986). Reductants of the uranium are lignitic plant debris and pyrite, and adsorbents include clay, iron oxide, and zeolite minerals. Pitchblende or uraninite, coffinite, carnotite, and pyrite are the characteristic ore minerals; however, pyrite, uraninite, and coffinite have not been identified in surface outcrops in the Stateline Peak area (Hurley et al., 1982). Copper, molybdenum, vanadium, arsenic, iron, and nickel are present in anomalous quantities compared to other Cenozoic sediments of the Reno quadrangle. These occurrences are most similar to deposits in the Shirley Basin of Wyoming (Hurley et al., 1982).

Otton et al. (1985) and Otton and Culbert (1984) have identified the west side of Carson Valley and parts of the Carson Range as possible hosts for uranium deposits. These areas contain anomalous concentrations of uranium in Holocene and older fluvial and paludal sediments that overlie and were perhaps derived from the granodiorite of Daggett Pass in the Sierra Nevada.

## SUMMARY

More than 400 mines and prospects are in the Reno $1^{o} \times 2^{o}$ quadrangle, Nevada, and a wide variety of metals and industrial minerals have been produced. This report has tried to locate and detail the geologic setting for known deposits and to classify occurrences by mineral deposit models. Continuing work will provide further data and refine occurrence models for deposits in the quadrangle. An understanding of the occurrence of these economic commodities will ultimately allow us to better evaluate the potential for additional resources within the quadrangle.

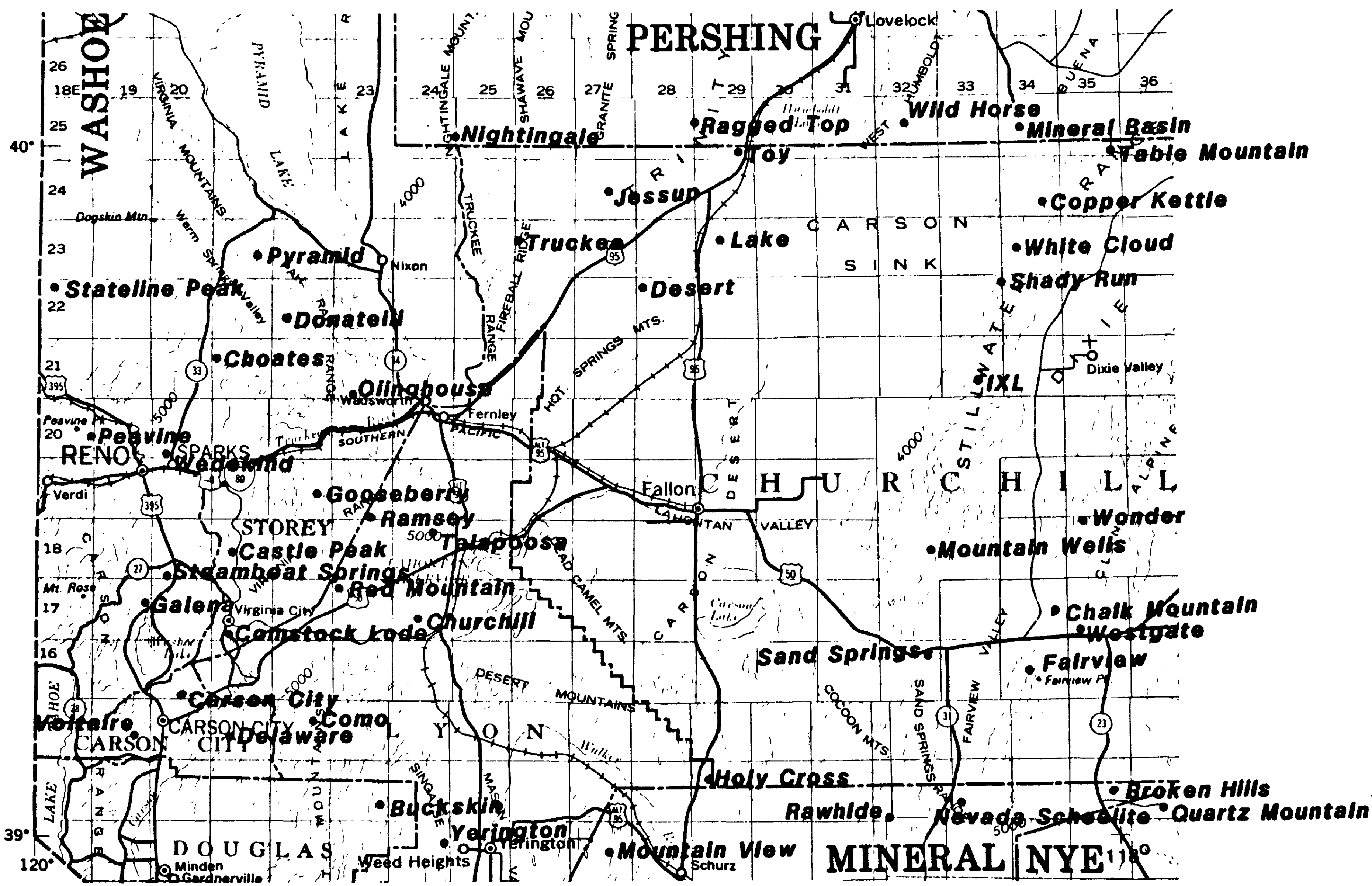


Figure 1. Location map of mining districts in the Reno 1° x 2° quadrangle, Nevada

Table 1. Known production from mining districts in the Reno 1° x 2° quadrangle, Nevada

| MINERAL DISTRICT | COUNTY | Au (oz) | Ag (oz) | Hg (flasks) | Sb (tons) | W (units $WO_3$) | Mo (lbs) |
|---|---|---|---|---|---|---|---|
| Carson City | Carson City | <1000 | <10,000 | | | prospect | |
| Voltaire (Eagle Valley, Washoe) | Carson City | <1000 | <10,000 | | | | |
| Delaware (Brunswick Canyon, Sullivan) | Carson City/Douglas | <1000 | <10,000 | | | 20 | |
| Chalk Mountain | Churchill | >150 | >91,200 | | | | <100 |
| Copper Kettle | Churchill | <1000 | <10,000 | | | | <100 |
| Desert (White Plain) | Churchill | <1000 | <10,000 | prospect | | | |
| Fairview (Bell Mt., Au Basin) | Churchill | 53,000 | 5,125,000 | | | | |
| IXL | Churchill | <1000 | <10,000 | | | | |
| Jessup | Churchill | <1000 | <10,000 | | | | |
| Lake (Mopung Hills) | Churchill | | ? | | 15 | | |
| Mountain Wells (La Plata) | Churchill | <1000 | <10,000 | | | | |
| Sand Springs | Churchill | 21,350 | 1,300,000 | | | prospect | <100 |
| Shady Run (Fondaway) | Churchill | <1000 | <10,000 | | prospect | 10,000 | |
| Table Mountain | Churchill | 4200 | 6800 | | | | |
| Toy (Browns, St. Anthony) | Churchill | | | | <1 | 19,200 | |
| Truckee (Fireball, Leete) | Churchill | <1000 | <10,000 | prospect | | | |
| Westgate | Churchill | <1000 | <10,000 | | prospect | | |
| White Cloud (Coppereid) | Churchill | <1000 | <10,000 | | | | |
| Wonder (Hercules) | Churchill | 74,000 | 6,900,000 | | | | <100 |
| Holy Cross (Terrell, Wild Horse) | Churchill/Lyon | 300 | 75,000 | | | | <100 |
| Mineral Basin | Churchill/Pershing | | | | | | |
| Buckskin (Minnesota, Smith Valley) | Douglas | <10,000 | <10,000 | | | | |
| Churchill | Lyon | | | | | 80 | <100 |
| Como (Palmyra, Indian Springs) | Lyon | 11,500 | 267,000 | | | | |
| Ramsey | Lyon | 3,000 | 1100 | <1 | 44 | | |
| Red Mountain | Lyon | | | | | 215 | |
| Talapoosa | Lyon | 13,300 | 105,000 | | | | |
| Yerington (Ludwig, Mason) | Lyon | 100+ | 49,000+ | | | | <100 |
| Broken Hills | Mineral | <1000 | <1,000,000 | | <1 | | <100 |
| Mountain View (Granite, Reservation) | Mineral | <1000 | ? | | prospect | | |
| Nevada Scheelite (Leonard) | Mineral | <1000 | <10,000 | | | 277,000+ | <1000 |
| Rawhide (Regent) | Mineral | 51,000 | 758,000 | | <100 | <1000 | <100 |
| Quartz Mountain (Lodi) | Nye | <1000 | <10,000 | | | <?/>?100,000 | prospect |
| Ragged Top (Copper Valley) | Pershing | | | | | 12,000-20,000 | |
| Wild Horse (Green Antimony) | Pershing | | ? | | 155 | <10,000 | |
| Nightingale | Pershing/Washoe | | | | | 100,000 | <100 |
| Castle Peak | Storey | | | 2600 | | | |
| Gooseberry | Storey | 60,000 | >700,000 | | | | |
| Comstock Lode | Storey/Lyon | 8,500,000 | 200,000,000 | | | | <100 |
| Choates | Washoe | | | | 57 | | |
| Donatelli | Washoe | | | | 2 | prospect | |
| Galena (Washoe Valley) | Washoe | 265 | 52,500 | | | | |
| Olinghouse (White Horse) | Washoe | 45,000 | 30,000 | <1 | | 200 | |
| Peavine (Granite Mt.) | Washoe | 1300 | 77,000 | <1 | | <1000 | <100 |
| Pyramid | Washoe | 50 | 2800+ | | | | prospect |
| Stateline Peak | Washoe | 20 | 100 | | | | |
| Steamboat Springs | Washoe | | | 25 | <1 | | <100 |
| Wedekind (Glendale) | Washoe | 500 | 124,000 | | | | |

Table 1 (cont.). Known production from mining districts in the Reno 1° x 2° quadrangle, Nevada

| MINERAL DISTRICT | COUNTY | Fe (tons) | Cu (lbs) | Pb (lbs) | Zn (lbs) | Industrial |
|---|---|---|---|---|---|---|
| Carson City | Carson City | | | <1000 | | |
| Voltaire (Eagle Valley, Washoe) | Carson City | | <10,000 | <100,000 | <1000 | |
| Delaware (Brunswick Canyon, Sullivan) | Carson City/Douglas | <1000 | <1000 | <100,000 | | barite |
| Chalk Mountain | Churchill | | | >1,320,000 | <1000 | |
| Copper Kettle | Churchill | prospect | <10,000 | | | |
| Desert (White Plain) | Churchill | | | | | salt, limestone, pumice |
| Fairview (Bell Mt., Au Basin) | Churchill | | 28,500 | 2,700,000 | <1000 | |
| IXL | Churchill | | | <1000 | <1000 | fluorspar |
| Jessup | Churchill | | | | | diatomite |
| Lake (Mopung Hills) | Churchill | | | <1000 | | gypsum |
| Mountain Wells (La Plata) | Churchill | | | <1000 | | fluorspar |
| Sand Springs | Churchill | | | | | borate, salt |
| Shady Run (Fondaway) | Churchill | | | <1000 | | |
| Table Mountain | Churchill | <1000 | 83 | 1250 | <1000 | gypsum, salt |
| Toy (Browns, St. Anthony) | Churchill | | | | | |
| Truckee (Fireball, Leete) | Churchill | | | <1000 | | salt, borate, diatomite |
| Westgate | Churchill | | | <1000 | | |
| White Cloud (Coppereid) | Churchill | | <10,000 | <1000 | <1000 | fluorspar |
| Wonder (Hercules) | Churchill | | 7100 | 4320 | <1000 | fluorspar |
| Holy Cross (Terrell, Wild Horse) | Churchill/Lyon | | 650 | 34,000 | 300 | diatomite |
| Mineral Basin | Churchill/Pershing | 4,000,000 | | | | |
| Buckskin (Minnesota, Smith Valley) | Douglas | 4,200,000 | <1,000,000 | | | |
| Churchill | Lyon | | | | | |
| Como (Palmyra, Indian Springs) | Lyon | | <10,000 | | <1000 | |
| Ramsey | Lyon | | | | | cinder, diatomite |
| Red Mountain | Lyon | prospect | | | | |
| Talapoosa | Lyon | | <1000 | 3350 | | |
| Yerington (Ludwig, Mason) | Lyon | | 804,000,000 | <100,000 | <100,000 | gypsum |
| Broken Hills | Mineral | | <100,000 | <10,000,000 | <1000 | fluorspar |
| Mountain View (Granite, Reservation) | Mineral | | ? | <1000 | ? | |
| Nevada Scheelite (Leonard) | Mineral | | | <100,000 | | |
| Rawhide (Regent) | Mineral | | 27,000 | 30,000 | <1000 | barite |
| Quartz Mountain (Lodi) | Nye | | <1000 | <10,000,000 | <1000 | talc |
| Ragged Top (Copper Valley) | Pershing | | | | | |
| Wild Horse (Green Antimony) | Pershing | prospect | | <100,000 | | fluorite |
| Nightingale | Pershing/Washoe | | | <1000 | <1000 | diatomite, silica, limestone |
| Castle Peak | Storey | | | | | |
| Gooseberry | Storey | | | | | |
| Comstock Lode | Storey/Lyon | | 77,000 | 56,000 | <100,000 | |
| Choates | Washoe | | | | | |
| Donatelli | Washoe | | | | | |
| Galena (Washoe Valley) | Washoe | | 66,700 | 794,250 | 2,560,000 | |
| Olinghouse (White Horse) | Washoe | | 4000 | 1200 | | |
| Peavine (Granite Mt.) | Washoe | prospect | 187,000 | 43,000 | <1000 | |
| Pyramid | Washoe | | <100,000 | <1000 | <1000 | |
| Stateline Peak | Washoe | | <1000 | | | |
| Steamboat Springs | Washoe | | | | | clay, S, silica |
| Wedekind (Glendale) | Washoe | | | <1000 | <1000 | |

Table 2. Occurrences of mineral deposits in mining districts of the Reno 1° x 2° quadrangle, Nevada

| MINERAL DISTRICT | COMMENTS |
|---|---|
| Carson City | Replacement of pre-Tertiary metased and sed rxs adjacent to granodiorite intrusion; skarn |
| Voltaire (Eagle Valley, Washoe) | Veins, pods, stockworks, breccia zones in Tertiary silicic/intmd igneous or pre-Tertiary met rxs; epithermal gold (?) |
| Delaware (Brunswick Canyon, Sullivan) | Veins and replacement in pre-Tertiary calcareous sed rxs and Tertiary silicic/intmd volc rxs near granitoid intrusions; skarn |
| Chalk Mountain | Replacement of pre-Tertiary sed rxs, dominantly limestone, adjacent to granodiorite; skarn |
| Copper Kettle | Veins, breccias in J gabbro, basalt, and Lower Mesozoic sed and volc rxs (Leach Fm); skarn-like |
| Desert (White Plain) | Quartz veins in strongly jointed J diorite |
| Fairview (Bell Mt., Au Basin) | Veins, stockworks, breccia zones in Miocene silicic/intmd volc rxs; [0.17 oz Au, 16 oz Ag/ton; Mn prospect with 55% MnO2, 15% Fe2O3]; epithermal gold |
| IXL | Replacement of mixed pre-Tertiary rock types in contact metasomatic zone of granitoid intrusion; skarn |
| Jessup | Veins, breccia zones, and contact metasomatic deposit in pre-Tertiary marble and metavolc rxs intruded by Tertiary silicic/intmd igneous rxs; skarn |
| Lake (Mopung Hills) | Veins, stockworks, and replacement in pre-Tertiary sed rxs, dominantly limestone and shale; simple antimony |
| Mountain Wells (La Plata) | Veins, pods in pre-Tertiary metavolc or metased rxs intruded by silicic/intmd igneous rxs; epithermal gold (?) |
| Sand Springs | Veins in Mesozoic and Miocene silicic/intmd volc rxs; placer Ti; [0.21 oz Au, 12.6 oz Ag/ton]; epithermal gold |
| Shady Run (Fondaway) | Veins, pods in Tr metavolc or metased rxs, including limestone and shale, intruded by quartz porphyry; skarn |
| Table Mountain | Veins, stockworks, breccia zones in mafic J igneous rxs and Tertiary (?) rhyolite; Co-Ni (1000 tons; Ti lode prospect; includes Dixie Valley; skarn-like |
| Toy (Browns, St. Anthony) | Contact metasomatic deposit in calcareous pre-Tertiary metased rxs near quartz monzonite intrusions; skarn |
| Truckee (Fireball, Leete) | Veins, stockworks, breccia zones in pre-Tertiary metamorphic rxs cut by Tertiary silicic/intmd volc rxs (dikes); epithermal gold (?) |
| Westgate | Replacement of pre-Tertiary sed rxs, dominantly limestone, and veins in metased or metavolc rxs; skarn |
| White Cloud (Coppereid) | Replacement of mixed rock types, including Tr limestone, in contact metasomatic zone of K granite; skarn |
| Wonder (Hercules) | Veins, stockworks, breccia zones in Olig/Miocene (22 my) silicic/intmd volc rxs; [0.18 oz Au, 16 oz Ag/ton]; epithermal gold |
| Holy Cross (Terrell, Wild Horse) | Veins, stockworks, bx zones in Tert silicic/intmd volc rxs; J/Tr sed rxs and Mesozoic intmd/silicic plutons; [0.15 oz Au, 38.7 oz Ag/ton]; epithermal gold/polymetallic skarn |
| Mineral Basin | Veins, stockworks, breccia zones, and replacement in scapolitized J gabbro and andesite; ore >55% Fe; skarn-like |
| Buckskin (Minnesota, Smith Valley) | Vein and replacement deposits in Mesozoic metased and metavolc rxs intruded by granodiorite and quartz monzonite porphyry; Ti lode prospect; skarn |
| Churchill | Contact metasomatic deposit in pre-Tertiary silicated limestone near a contact with granitic rocks; skarn |
| Como (Palmyra, Indian Springs) | Veins, stockworks, breccia zones in Tertiary silicic/intmd volc rxs; [0.07 oz Au, 1.7 oz Ag/ton, totals = production + reserves]; epithermal gold |
| Ramsey | Veins, stockworks, breccia zones in Miocene (10 my) silicic/intmd volc rxs (Hartford Hill Rhyolite & Kate Peak Fm); [0.19 oz Au, 0.035 oz Ag/ton]; epithermal gold |
| Red Mountain | Contact metasomatic deposit in pre-Tertiary sed and metased rxs intruded by granodiorite; placer gold and silver; 4.41 mil tons reserve, 47% Fe, 0.03% Cu; skarn |
| Talapoosa | Veins, stockworks, bx zones in Miocene (10 my) silicic/intmd volc rxs (Hartford Hill Rhyolite & Kate Peak Fm); [1.5 oz Au, 13.7 oz Ag/ton]; totals = prod.+reserves; epithermal gold |
| Yerington (Ludwig, Mason) | Veins, stockworks, breccia zones in porphyritic quartz monzonite (110 m.y.), and replacement of pre-Tertiary calcareous sed and volc rxs; porphyry copper and skarn |
| Broken Hills | Veins, stockworks, breccia zones, and replacement along faults in Tertiary silicic/intmd volc rxs; epithermal gold and (or) skarn |
| Mountain View (Granite, Reservation) | Veins, stockworks, breccia zones in Tertiary (?) silicic/intmd plutonic [and volcanic (?)] rxs; epithermal gold (?) |
| Nevada Scheelite (Leonard) | Contact metasomatic deposit in pre-Tertiary limestone intruded by Mesozoic granitic rocks; skarn |
| Rawhide (Regent) | Veins, stockworks, breccia zones, and replacement along faults in Miocene (16 my) silicic/intmd volc rxs; [0.67 oz Au, 10.1 oz Ag/ton]; epithermal gold |
| Quartz Mountain (Lodi) | Veins, stockworks, and breccia zones in Tertiary silicic/intmd volc rxs and contact metasomatic zone in pre-Tertiary limestone intruded by Mesozoic granitoids; epithermal gold and skarn |
| Ragged Top (Copper Valley) | Contact metasomatic deposit in Tr/J calcareous metased rxs intruded by granodiorite and diorite; skarn |
| Wild Horse (Green Antimony) | Lenses, pods, veins filling faults in J gabbro and diorite, [33.2% Sb, 0.64 oz Ag/ton]; replacement of J calcareous metaseds next to mafic/intmd intrusions; simple antimony and skarn |
| Nightingale | Contact metasomatic replacement of mixed pre-Tertiary metased rocks intruded by mafic/intmd plutonic rxs; U in ash-flow tuffs of Hartford Hill Rhyolite; skarn |
| Castle Peak | Pipes, veins, and disseminations in Miocene andesitic rxs (Alta Fm); [23,500 tons of ore, 0.44% Hg]; hot spring mercury (?)/epithermal or hot spring gold (?) |
| Gooseberry | Veins in Tertiary silicic/intmd volc rxs (Kate Peak Fm); up to 1.14 oz Au, 69 oz Ag/ton; epithermal gold |
| Comstock Lode | Veins, stockworks, breccia zones in Tert (13 my) silicic/intmd volc rxs (esp Alta Fm); includes Jumbo, Flowery, and Silver City districts; [0.43 oz Au, 10 oz Ag/ton]; epithermal gold |
| Choates | Veins of quartz-pyrite-stibnite filling fractures in granodiorite; average grade = 56% Sb with 0.06 oz Ag/ton; simple antimony |
| Donatelli | Veins in shear zone through bio-hbl granite near contact with pre-Tertiary met rxs; average grade = 29% Sb with 0.56 oz Ag/ton; simple antimony and skarn |
| Galena (Washoe Valley) | Veins, pods in Mesozoic metased rxs intruded by granodiorite; [0.3 oz Au, 2.6 oz Ag/ton]; skarn |
| Olinghouse (White Horse) | Veins, stockworks, breccia zones in Miocene silicic/intmd volc rxs cut by porphyritic granodiorite; [0.82 oz Au, 0.58 oz Ag/ton]; epithermal gold |
| Peavine (Granite Mt.) | Veins, pods, stockworks, bx zones in Tert silicic/intmd volc rxs or pre-Tert metavolc and metased rxs; [0.03 oz Au, 2.1 oz Ag/ton]; Ti as rutile in aplite and pegmatites; epithermal gold |
| Pyramid | Veins, stockworks, breccia zones in Olig/Miocene (21 my) silicic/intmd volc rxs (Hartford Hill Rhyolite); U in HHR and diabase dikes; [0.01 oz Au, 0.89 oz Ag/ton]; epithermal gold |
| Stateline Peak | U, dissem along fractures in ash-flow tuff of Hartford Hill Fm.; 1100 tons produced, >0.2% U3O8; other metals, veins in Meso metavolc rxs; volcanogenic uranium and epithermal gold (?) |
| Steamboat Springs | Veins, alteration in Tertiary (<3 my) silicic/intmd volc rxs (Kate Peak and Alta Fms); 0.17% Hg; hot spring mercury/hot spring gold |
| Wedekind (Glendale) | Stockworks, breccia zones in Miocene silicic/intmd volc rxs (Alta Fm); [0.23 oz Au, 57.1 oz Ag/ton; epithermal gold |

Table 3. Mines, prospects, and claims in the Reno 1° x 2° quadrangle, Nevada

| MINING DISTRICT | CARSON CITY | VOLTAIRE | DELAWARE | CHALK MOUNTAIN | COPPER KETTLE | DESERT | FAIRVIEW |
|---|---|---|---|---|---|---|---|
| COUNTY | Carson City | Carson City | Carson City/Douglas | Churchill | Churchill | Churchill | Churchill |
| MINES, PROSPECTS, and CLAIMS | Carson | =EAGLE VALLEY | =BRUNSWICK CANYON | Chalk Mt. Silver-Lead | Black Joe | =WHITE PLAIN | = DELL MOUNTAIN |
| | Lucky Strike | =WASHOE | =SULLIVAN | West Side Mines Co. | Emery-Fisk | Desert Peak Pumice | = GOLD BASIN |
| | North Carson | Kings Canyon | Ajax-Nevada | | K. D. Group | Desert Queen | Dell Mountain |
| | Sophie Group | Premier=Henry Quill | Alex Eske=Bobolink | | North Group=Iron Mt.=No. 3 | Fallon Eagle | Big Ledge |
| | Spot-Lucky Bird | | Bessemer=Iron King | | Rosebud | | Cyclone |
| | | | Bunker Hill=Empress Group | | South Group | | Dromedary Hump |
| | | | Capitol (Iron) | | Ute | | Fairview (?) |
| | | | Comstock Extension=Bidwell | | | | Fairview Eagle=Eagle Vein |
| | | | Dixon | | | | Fred Branch |
| | | | Edison-Nevada=June Ellen | | | | Gold Basin |
| | | | Julietta | | | | Grand Central |
| | | | Peak-A-Boo | | | | Lena Group |
| | | | Sally Group | | | | Mizpah=Austrian |
| | | | Tactite Thursday=War Bond=Old Discovery | | | | Nevada Crown=Gold Crown |
| | | | United Mining=Utopian | | | | Nevada Fairview=Snyder |
| | | | Valley View | | | | Nevada Hills |
| | | | Yerington iron | | | | Nevada Hills Florence (?) |
| | | | | | | | Ohio Group |
| | | | | | | | Shamrock Placer |

| MINING DISTRICT | IXL | JESSUP | LAKE | MOUNTAIN WELLS | SAND SPRINGS | SHADY RUN | TABLE MOUNTAIN | TOY |
|---|---|---|---|---|---|---|---|---|
| COUNTY | Churchill | Churchill | Churchill | Churchill | Churchill | Churchill | Churchill | Churchill |
| MINES, PROSPECTS, and CLAIMS | Anglo-American | Copper Queen | =HOPUNG HILLS | =LA PLATA | Dan Tucker | =FONDAWAY | Boyer | =ST. ANTHONY |
| | Black Prince | Gold King | Green=Hazel Group | Connell | Huck Salt | Quick-Tung=Shady Run | Cottonwood Canyon | =BROWNS |
| | Bonanza | Gold Ore | Hazel=James Say | Popcorn | Redtop | | Lovelock | Bonanza King |
| | Mottini | Hard-to-Find | | Red Bird | Sand Dune placer Ti | | White Rock | Hardscrabble |
| | Silver Range | Valley King | | Rosebud=DeKinder | Stardust | | DIXIE VALLEY | Payday and Lobo=United Tungsten |
| | COX CANYON | | | | Summit King | | Dixie Comstock | Toy=St. Anthony |
| | Gold Bar Group | | | | | | CORRAL CANYON | |
| | Gold Hill | | | | | | Bradshaw Copper | |
| | Revenue=Cirac | | | | | | | |

Table 3 (cont.). Mines, prospects, and claims in the Reno 1° x 2° quadrangle, Nevada

| MINING DISTRICT | TRUCKEE | WESTGATE | WHITE CLOUD | WONDER | HOLY CROSS | MINERAL BASIN | BUCKSKIN | CHURCHILL |
|---|---|---|---|---|---|---|---|---|
| COUNTY | Churchill | Churchill | Churchill | Churchill | Churchill/Lyon | Churchill/Pershing | Douglas | Lyon |
| MINES, PROSPECTS, and CLAIMS | =FIREBALL | Caddy=Silver Pride | =COPPEREID | = HERCULES | =TERRELL | Albitross | =MINNESOTA | B, H, & V |
| | =LEETE | Merkt=Fluorine Group | Clipper Canyon | Ciran=New Strike | =WILD HORSE | American Ore | =SMITH VALLEY | Old Soldier |
| | Erway | | Desert Star | Jackpot | Bimetal Group | Badger | Blue Metals Corundum | Ruth |
| | Fireball Group | | | Lansing | Black Butte | Deacon Hill | Buckskin | |
| | Nezelda | | | Little Jim | Bullion | Buena Vista | Guild-Bovard | |
| | | | | Nevada Wonder | Cinnabar Hill=Robinson Quicksilver | Cactus | Minnesota | |
| | | | | Purple Spar=Cyclone Group | Cripple Queen | Candor | | |
| | | | | Vulture | Last Hope=Green Shaft | Champion | | |
| | | | | Wolverton | Lee's Hot Springs | Chancellor | | |
| | | | | | Pyramid | Desert View | | |
| | | | | | Scotia | Fairview | | |
| | | | | | Water Shaft | Ford=Iron Horse | | |
| | | | | | Wingfield | Giant Iron | | |
| | | | | | BENWAY | Hematite | | |
| | | | | | Calico Hills | Iron Bluff=Alpha and Omega | | |
| | | | | | | Iron Croppings | | |
| | | | | | | Iron Horse | | |
| | | | | | | Iron King | | |
| | | | | | | Iron Mountain | | |
| | | | | | | Iron Queen | | |
| | | | | | | Iron Standard | | |
| | | | | | | Iron Warrant | | |
| | | | | | | Jupiter Iron | | |
| | | | | | | Locomotive | | |
| | | | | | | Magnetic | | |
| | | | | | | Mesabi | | |
| | | | | | | Monster Iron | | |
| | | | | | | Mountain Top | | |
| | | | | | | Nevada Iron Ore Co. | | |
| | | | | | | Pelican | | |
| | | | | | | Pennsylvania | | |
| | | | | | | Pittsburg Iron | | |
| | | | | | | Rover | | |
| | | | | | | SE Section 29 | | |
| | | | | | | Sea Gull | | |
| | | | | | | Section 31 | | |
| | | | | | | Segerstrom-Heizer | | |
| | | | | | | Thomas | | |
| | | | | | | Wild Horse | | |
| | | | | | | Wyoming | | |

Table 3 (cont.). Mines, prospects, and claims in the Reno 1° x 2° quadrangle, Nevada

| MINING DISTRICT | COMO | RAMSEY | RED MOUNTAIN | TALAPOOSA | YERINGTON | BROKEN HILLS | MOUNTAIN VIEW | NEVADA SCHEELITE |
|---|---|---|---|---|---|---|---|---|
| COUNTY | Lyon | Lyon | Lyon | Lyon | Lyon | Mineral | Mineral | Mineral |
| MINES, | =PALMYRA | DeLongchamps | Blackhawk | Talapoosa | =LUDWIG | Broken Hills=Lerchen | =GRANITE | =LEONARD |
| PROSPECTS, | =INDIAN SPRINGS | Ramsey | Boyion Iron | | =MASON | Kaiser=Baxter | =RESERVATION | Bell Flat |
| and | Boyle=Como-Eureka | Ramsey-Comstock | Dewey | | A DuBois | Silver Trailer | Northern Light | East End |
| CLAIMS | Mulley Logan | San Juan | Easter | | Anaconda=Empire Nevada | | Yerington Mt. Copper Co. | Hooper No. 1 & 2=Ajax=Primrose |
| | Pony Meadows | | Emma | | Ann-Mason=Mickey Pass | | | Laylander |
| | Rapidan | | Hecla | | Ballerstern | | | McCoy=Revely |
| | Star of the West | | Iron Blossom | | Barlow | | | Midnight |
| | Stone Cabin | | Morning Light | | Barton | | | Nevada Scheelite |
| | | | Norway Iron | | Bear-Lagomaisino | | | Red Ant |
| | | | Pearl Harbor=Tungsten Flat | | Black Rock Co. | | | Scheelite Queen |
| | | | Planit | | Blue Jay | | | |
| | | | Sheba | | Bluestone | | | |
| | | | Sunrise | | Brady | | | |
| | | | Sunset | | Brady & Co. | | | |
| | | | | | Bugbee | | | |
| | | | | | Casting Copper | | | |
| | | | | | Columbia-Geneva | | | |
| | | | | | Copper Giants | | | |
| | | | | | Copper Glance | | | |
| | | | | | Copper Grande | | | |
| | | | | | Divide Co. | | | |
| | | | | | Douglas Hill | | | |
| | | | | | Eastern | | | |
| | | | | | Gallagher | | | |
| | | | | | Green Top & Snowdrift | | | |
| | | | | | Grose & Wagner | | | |
| | | | | | Gruber & Murighrori | | | |
| | | | | | Guild placer | | | |
| | | | | | Hart & Berheimer | | | |
| | | | | | Hilltop | | | |
| | | | | | Homestake | | | |
| | | | | | Idaho | | | |
| | | | | | Jacobson & Seward | | | |
| | | | | | Jerry Paul | | | |
| | | | | | John Zeno | | | |
| | | | | | Jumbo | | | |
| | | | | | L. C. Hammaker | | | |
| | | | | | L. Burke | | | |
| | | | | | L. Gulich | | | |
| | | | | | Ludwig | | | |
| | | | | | MacArthur | | | |
| | | | | | Malachite | | | |
| | | | | | Mason Valley | | | |
| | | | | | McConnell | | | |
| | | | | | McMahen & Alexander | | | |
| | | | | | Montana-Yerington | | | |
| | | | | | Mounds & Wagon | | | |
| | | | | | Neeley | | | |
| | | | | | Nevada Douglas | | | |
| | | | | | Nevada Queen | | | |
| | | | | | Nevada Union Co. | | | |
| | | | | | Nevada-Denver | | | |
| | | | | | Nickerson & Carlson | | | |
| | | | | | Ouija | | | |
| | | | | | Parker | | | |
| | | | | | Pledger & Loverick | | | |
| | | | | | Predovich | | | |
| | | | | | Red Top | | | |
| | | | | | Ross & Cameron | | | |
| | | | | | Rosson & Bergman | | | |
| | | | | | Snowstorm | | | |
| | | | | | Spragg | | | |
| | | | | | Talco | | | |
| | | | | | Thanksgiving | | | |
| | | | | | Triple M. Mines Co. | | | |
| | | | | | Tully & VanAlstine | | | |
| | | | | | U. S. Group | | | |
| | | | | | Weidlein | | | |
| | | | | | Weed Heights | | | |
| | | | | | Western Nevada | | | |
| | | | | | Wisconsin Yerington | | | |
| | | | | | Yerington Consolidated | | | |
| | | | | | Yerington Exploration Co. | | | |

Table 3 (cont.). Mines, prospects, and claims in the Reno 1° x 2° quadrangle, Nevada

| MINING DISTRICT | RAWHIDE | QUARTZ MOUNTAIN | RAGGED TOP | WILD HORSE | NIGHTINGALE | CASTLE PEAK | GOOSEBERRY | COMSTOCK LODE |
|---|---|---|---|---|---|---|---|---|
| COUNTY | Mineral | Nye | Pershing | Pershing | Pershing/Washoe | Storey | Storey | Storey/Lyon |
| MINES, | = REGENT | =LODI | =COPPER VALLEY | =GREEN ANTIMONY | Alpine | Butters | Gooseberry | (Consolidated) Imperial |
| PROSPECTS, | Bethania | Arentz | Basalt Prospect | Long Lease | Angelia=Molib | Castle Peak | | (New) California |
| and | Black Eagle | Calico | Blue Wolf | Piute | Black Warrior Peak | Taylor-Branch | | (New) Savage |
| CLAIMS | Bullskin Mountain 1 | Desert | Coon Can | | Blue Jay | Washington Hill=Rout | | Alpha |
| | Crystal=Tom Kenyon | Exchequer | Copper King | | Crosby=White Blow-out | | | Andes |
| | Eagle | Franklin | Ragged Top | | Jaybird=Garfield Force | | | Baltimore |
| | Flynn | Gordon | Sheby (New Toy) | | MGL | | | Belcher |
| | Foster | Hasbrouck | Tungsten Bell | | Marvelous | | | Best and Belcher |
| | Gold Reef | July | | | Midnight Tungsten | | | Bullion |
| | Happy Return=Rechel | Kernick | | | Nightingale | | | C & C Shaft |
| | King=Donnelly | Milner | | | Star | | | Challenge and Confidence |
| | Mascot | Nye-Mineral | | | Winnemucca Lake | | | Chollar-Potosi |
| | Morning Star | Quartz Mountain Metals | | | | | | Comstock Lode |
| | Nevada New | San Felipe | | | | | | Consolidated Virginia |
| | Pilot Cone | San Rafael | | | | | | Crown Point |
| | Poor Boy | | | | | | | Curry |
| | Rawhide | | | | | | | Exchequer |
| | Rawhide Tungsten | | | | | | | Gould |
| | Rawhide Victor | | | | | | | Hale and Norcross |
| | Royal Nevada | | | | | | | Kentuck |
| | Scheelite Extension | | | | | | | Keyes=Belmont Uncle Sam |
| | Seminoe-Regent | | | | | | | Knickerbocker |
| | Silver Zone | | | | | | | Mexican |
| | Stockton | | | | | | | Monte Cristo |
| | Sunnyside=Great Eastern | | | | | | | North Bonanza |
| | Thorne Tungsten=Moonlight=Ada | | | | | | | Ophir |
| | Victor | | | | | | | Overman |
| | Wash Vein | | | | | | | Pet |
| | Yankee Girl=Grutt | | | | | | | Scorpion |
| | EAGLEVILLE | | | | | | | Sierra Nevada |
| | Eagleville | | | | | | | Union |
| | | | | | | | | Utah Shaft |
| | | | | | | | | Yellow Jacket |
| | | | | | | | | SILVER CITY |
| | | | | | | | | Alhambra |
| | | | | | | | | Alta |
| | | | | | | | | Amazon |
| | | | | | | | | Arrastra |
| | | | | | | | | Buckeye |
| | | | | | | | | Caledonia |
| | | | | | | | | Daney |
| | | | | | | | | Dayton |
| | | | | | | | | Devils Gate and American Ravine |
| | | | | | | | | Drysdale |
| | | | | | | | | Forman |
| | | | | | | | | Hayward-Santiago |
| | | | | | | | | Ida |
| | | | | | | | | Justice |
| | | | | | | | | Keystone |
| | | | | | | | | Kossuth |
| | | | | | | | | Lady Washington |
| | | | | | | | | Lucerne |
| | | | | | | | | New York |
| | | | | | | | | Occidental |
| | | | | | | | | Oest |
| | | | | | | | | Overland |
| | | | | | | | | Overman |
| | | | | | | | | Overman 2 |
| | | | | | | | | Silver Hill |
| | | | | | | | | South Comstock |
| | | | | | | | | Spring Valley |
| | | | | | | | | Succor |
| | | | | | | | | Trio=International Tungsten |
| | | | | | | | | Volcano |
| | | | | | | | | Woodville |
| | | | | | | | | FLOWERY |
| | | | | | | | | Flowery |
| | | | | | | | | Lady Bryan |
| | | | | | | | | JUMBO |
| | | | | | | | | Boss Jumbo |
| | | | | | | | | Golden Gate |
| | | | | | | | | Gopher |
| | | | | | | | | Hunt |
| | | | | | | | | Londons |
| | | | | | | | | Mahoney=Fink and Mahoney |
| | | | | | | | | Pandora=Monarch |
| | | | | | | | | Red Top |
| | | | | | | | | Selby Consolidated |
| | | | | | | | | Wild Goose |

Table 3 (cont.). Mines, prospects, and claims in the Reno 1° x 2° quadrangle, Nevada

| MINING DISTRICT | CHOATES | DONATELLI | GALENA | OLINGHOUSE | PEAVINE | PYRAMID |
|---|---|---|---|---|---|---|
| COUNTY | Washoe | Washoe | Washoe | Washoe | Washoe | Washoe |
| MINES, | Choates | Donatelli=Georgianne | =WASHOE VALLEY | = WHITE HORSE | = GRANITE MOUNTAIN | Armstrong |
| PROSPECTS, | Sunset | Sleepy Joe | Commonwealth=Union | Big Mouth Canyon | Copperfield | Bing |
| and | | | Denver | Buster=Maciza | Emma=Black Panther | Bluebird |
| CLAIMS | | | Ellen B | Butte | Fravel | Burris |
| | | | Galena Hill | Derby (=Wadsworth) Tungsten | Golden Fleece | Cinch |
| | | | Rocky Hill | Don Bero | Hazy=Updike | Comstock Eureka |
| | | | | Frank Free Canyon | Miller Titanium | Copper King |
| | | | | Gold Center | Nevada Central | Crown Prince |
| | | | | Gold Center Butte | Nevada Industrial | Divide |
| | | | | Green Hill | Paymaster | Franco-American=Nevada Dominion=Blondin |
| | | | | Green Mountain | Peavine Peak | Garrett |
| | | | | Keystone Nevada | Recall | Gogetter and Pup |
| | | | | North Fork | Red Metals | Golden Eagle |
| | | | | Olinghouse Canyon | Redelius=Big Ledge | Good Hope |
| | | | | Rainbow Canyon | Reno May | Guanomi |
| | | | | Renegade | Reno Mizpah | Hopeless |
| | | | | Secret Canyon=Bay State Nevada Gold Mining Co. | Section 34=Buena Visto | Independence |
| | | | | Sundown=Wadsworth Uranium Group | Shipton Rutile | Jackpot |
| | | | | Texas No. 2 | (Verdi) | Jones-Kincaid |
| | | | | Tiger Group | | Laura |
| | | | | | | Lost Pardner |
| | | | | | | Lowary=Maue-Mcray |
| | | | | | | Monarch |
| | | | | | | Owl Lode |
| | | | | | | Red Bluff |
| | | | | | | Ruth |
| | | | | | | Section 21 |
| | | | | | | Snap |
| | | | | | | Surefire |
| | | | | | | Thunderbird |
| | | | | | | Wet |

| MINING DISTRICT | STATELINE PEAK | STEAMBOAT SPRINGS | WEDEKIND |
|---|---|---|---|
| COUNTY | Washoe | Washoe | Washoe |
| MINES, | Antelope=Mars-Homestake | Steamboat Springs | =GLENDALE |
| PROSPECTS, | Barbara L | Wheeler Ranch | Arkell=Adelphia |
| and | Bastain | | Desert King |
| CLAIMS | Buckhorn=Antelope Range | | Wedekind=Reno Star |
| | Granite Peak | | |
| | Herbal | | |
| | Jeannie K=Cornelia C | | |
| | Lucky Day and Valley View | | |
| | O'Blarney | | |
| | Yellowjacket | | |

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| | |
|---|---|
| Comstock epithermal vein | Mosier, D. L., Singer, D. A., and Berger, B. R. |
| Creede epithermal vein | Mosier, D. L., Sato, T., Page, N. J., Singer, D. A., and Berger, B. R. |
| Epithermal quartz-alunite Au | Berger, B. R., |
| Hot spring Hg | Rytuba, J. J. |
| Hot spring Au-Ag | Berger, B. R. |
| W skarn | Cox, D. P. |
| Zn-Pb skarn | Cox, D. P. |
| Cu skarn | Cox, D. P., and Theodore, T. G. |
| Fe skarn | Cox, D. P. |
| Volcanic-hosted magnetite | Cox, D. P. |
| Porphyry Cu, skarn-related | Cox, D. P. |
| Polymetallic replacement | Morris, H. T. |
| Porphyry Cu | Cox, D. P. |
| Porphyry Cu-Mo | Cox, D. P. |
| Simple antimony | Bliss, J. D., and Orris, G. J. |
| Volcanogenic uranium | Bagby, W. C. |
| Mo porphyry, low-F type | Theodore, T. G. |
| Climax Mo | Ludington, Steve |
| Epithermal Mn | Mosier, D. L. |

| | |
|---|---|
| Replacement Mn | Mosier, D. L. |
| Volcanic-hosted Cu-As-Sb | Cox, D. P. |
| Sandstone U | Hodges, C. A. |

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