U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

CHARACTERIZATION OF MINERAL DEPOSITS IN ROCKS OF THE TRIASSIC TO JURASSIC MAGMATIC ARC OF WESTERN NEVADA AND EASTERN CALIFORNIA

by

Jeff L. Doebrich[1], Larry J. Garside[2], and Daniel R. Shawe[3]

Open-File Report 96-9

Prepared in cooperation with the Nevada Bureau of Mines and Geology

1996

[1]U.S. Geological Survey, Reno Field Office, MS 176, Mackay School of Mines, University of Nevada, Reno, Nevada 89557-0047

[2]Nevada Bureau of Mines and Geology, MS 178, University of Nevada, Reno, Nevada 89557-0088

[3]U.S. Geological Survey, Retired, 8920 West 2nd Ave., Lakewood, Colorado 80226

CONTENTS

PLATES

ABSTRACT

Mineral deposit studies in the Triassic to Jurassic magmatic arc of western Nevada and eastern California were conducted to characterize mineral deposits and systems hosted by the arc complex and to evaluate the arc complex for volcanogenic massive sulfide potential.

Early to Middle Jurassic sedimentary gypsum deposits represent the oldest economic concentration of minerals in the study area. Middle Jurassic arc-related hydrothermal mineral deposit types within the complex include porphyry Cu, Cu skarn, Fe skarn, polymetallic replacement, polymetallic vein, and aluminosilicate deposits. The majority of these deposits are related to the Yerington supersystem, which comprises at least three individual mineral systems (Yerington, Ann Mason, and Bear systems), each of which produced porphyry Cu and related skarn, replacement, and vein deposits. During the Middle to Late Jurassic there was an apparent evolution from Cu-Fe porphyry-skarn systems to Mo-W porphyry-skarn systems with associated Cu-Au quartz-tourmaline veins (for example, Risue Canyon and Meadow Lake mining districts). This metallogenic evolution is consistent with a maturing and thickening magmatic arc through time. However, the presence of Jurassic Mo-W systems may be a consequence of deeper erosion in these areas and may represent the eroded remnants of porphyry copper systems. Cretaceous deposit types related to emplacement of the Sierra Nevada batholith and unrelated to the evolution of the Triassic to Jurassic magmatic arc include W skarns (Gardnerville mining district), W veins, a low-F porphyry Mo deposit (Pine Nut deposit, Gardnerville mining district), and Au-Cu quartz-tourmaline veins (Peavine mining district). Tertiary deposits hosted by Triassic to Jurassic arc rocks include epithermal adularia-sericite and quartz-alunite veins (Ramsey and Peavine mining districts, respectively) and volcanogenic U deposits. Au-bearing polymetallic veins (for example, the Lucky Boy and Pamlico mining districts), barite veins, and volcanic-hosted magnetite deposits are of uncertain age and probably formed during more than one metallogenic event and more than one period of geologic time.

The apparent absence of volcanogenic massive sulfide deposits is a consequence of factors relating to the geologic setting of the Triassic to Jurassic arc complex exposed in the study area. These are (1) the dominance of shallow submarine and subaerial volcanism, (2) the scarcity of proximal volcanism in deep restricted basins, and (3) the absence of identified submarine felsic volcanic centers.

INTRODUCTION

PURPOSE

A study of mineral deposits hosted in the Triassic to Jurassic arc rocks of western Nevada and eastern California was conducted to identify and characterize individual mineral systems in these rocks, and ultimately to document the metallogenic evolution of that part of the arc exposed in the study area. Index maps showing the distribution of exposed Triassic to Jurassic rocks and mining districts in the study area are shown in figures 1 and 2, respectively. A mineral system is here defined as a spatial concentration of generally coeval and cogenetic mineral deposits with a characteristic geochemical signature. A mineral system may consist of a variety of deposit types.

It must be emphasized that only mineral deposits and mineral systems <u>hosted in the Triassic to Jurassic arc rocks</u> were examined in this study, <u>regardless of age of mineralization</u>. Most of the Triassic to Jurassic arc rocks within the study area are actually concealed beneath

Cenozoic volcanic and sedimentary rocks and alluvial sediments. An understanding of the characteristics of mineral deposits and systems hosted in the Triassic to Jurassic rocks (exposed and known concealed deposits) was used to analyze methodology for evaluating the unexposed parts of the Triassic to Jurassic arc complex for concealed mineral deposit potential (see Sawatzky and Raines, in press).

This report is the result of one of several studies that addressed various aspects of the Triassic to Jurassic magmatic arc in the study area. Other studies included geology and geophysics (Schweickert and others, in press b), geochemical studies (McCarthy and others, in press), and an evaluation for concealed deposits using numerical pattern analysis (Sawatzky and Raines, in press).

METHODS

This study represents an 18-month effort in compilation and synthesis of mineral deposit data derived from existing data bases and generated from field examinations, including district-scale geologic mapping, that was conducted from 1989 to 1991. The U.S. Geological Survey (USGS) Mineral Resource Data System (MRDS) and the U.S. Bureau of Mines (USBM) Mineral Industry Location System (MILS) were used as initial sources of mine and prospect data. Many existing records were updated and new mine and prospect records were added to the project's data base through field investigations. A deposit-type classification of most of the Triassic- to Jurassic-hosted mineral deposits in the study area was generated. Furthermore, a data base of mine and prospect rock geochemistry (Quade and others, 1990b) was enlarged through additional sampling and used to geochemically characterize deposit types.

The complexities of age classification of deposit types and mineral systems, given no new age determinations, made it difficult to distinguish between Mesozoic and Cenozoic mineralization in many cases. Nevertheless, an understanding of the metallogenic history of this part of the Great Basin and accurate age determinations done previously by others on some mineral systems permitted a preliminary age classification of all deposit types and mineral systems.

PREVIOUS INVESTIGATIONS

Numerous mineral deposit studies and mineral resource assessments have been undertaken within the study area by Federal and State agencies, industry, and academia. The USGS has conducted a number of deposit- and district-scale studies in the area (Becker, 1882; Harder, 1910; Hill, 1911; Knopf, 1918; Jones, 1920; Butler, 1945; Staatz and Bauer, 1953; Heyl and Bozion, 1964; Ashley and others, 1979). The USGS has also conducted multidisciplinary mineral resource studies of the Walker Lake and Reno 1° by 2° quadrangles (Stewart and others, 1984; Sidder, 1986; John and others, 1993) as well as mineral resource assessments of several Wilderness and Roadless areas (Dodge and Fillo, 1967; Harwood and others, 1982a, b; McKee and others 1982; Armstrong and others, 1983; Brem and others, 1983; John and others, 1983a, b, c). Other pertinent regional mineral studies by the USGS include those by Hill (1915) and Sherlock (1989). The Department of Energy conducted uranium resource evaluations in both the Reno and Walker Lake 1° by 2° quadrangles (Durham and Felmlee, 1982; Hurley and others, 1982). Harris and Pan (1990, 1991) have conducted quantitative mineral resource assessments of the Walker Lake 1° by 2° quadrangle for epithermal gold-silver deposits. The USBM evaluated the resource potential of the aluminosilicate deposit at the Blue Danube Mine in the Buckskin mining district (Binyon, 1946), the Dayton iron deposit in the Red Mountain mining district (Geehan, 1949), and the MacArthur copper oxide deposit in the Yerington mining district (Matson, 1952).

The California Division of Mines and Geology (CDMG) and the Nevada Bureau of Mines and Geology (NBMG) have conducted county mineral surveys (Sampson and Tucker, 1940; Ross, 1961; Bonham, 1969; Moore, 1969; Clark, 1977) as well as statewide inventories for deposits of gold (Clark, 1970; Bonham, 1976, 1986), silver (Bonham, 1980), copper (Jenkins, 1948), lead (Jones, 1983), zinc (Jones, 1984), iron (Reeves and others, 1958), tungsten (Stager and Tingley, 1988), molybdenum (Schilling, 1968, 1980), radioactive materials (Garside, 1973), barite (Papke, 1984) and gypsum (Papke, 1987), all of which include mineral deposits addressed in this study.

Several mining companies have explored, evaluated, and developed Triassic to Jurassic hosted deposits in the study area. The Anaconda Co. conducted numerous exploration programs in the area, most of which were concentrated in the Yerington mining district (Proffett, 1967, 1969; Gustafson, 1971; Einaudi, 1971; Heatwole, 1972; Howard, 1973; Souviron, 1976; Dilles and Wendell, 1982). Anaconda also developed and mined the Yerington porphyry copper deposit (Wilson, 1963; Howard, 1976). U.S. Steel Corp. explored the iron skarns of the Pumpkin Hollow deposit in the Yerington mining district (formerly known as the Lyon skarn deposits) (U.S. Steel Corporation, 1972). Conoco, Inc. explored for porphyry copper deposits in the southern Buckskin Range (Oriel, 1977) and the central Wassuk Range (Berger, 1975) and further evaluated the skarn deposits at Pumpkin Hollow (Conoco, Inc., 1982). Phelps Dodge Corp. and Bear Creek Mining Co. explored for concealed porphyry copper deposits in the Yerington mining district (Wilson, 1978) and in the southern Buckskin Range (Oriel, 1977). Climax Molybdenum Co. evaluated the Pine Nut porphyry molybdenum deposit in the southern Pine Nut range (Roxlo and Ranta, 1982). Occidental Minerals, Walker-Martel, and Idaho Mining Corp. explored the iron skarns of the Calico Hills area (Satkoski and others, 1985).

Many studies of Triassic to Jurassic-hosted deposits in the study area exist as graduate theses. Various aspects of porphyry copper deposits in the Yerington mining district were studied by Price (1977), Dilles (1984), and Carten (1986). Other porphyry-related studies include work by Hudson (1977, 1983), and Laraya (1973). The Meadow Lake mining district was studied by Gerlach (1963) and Bowman (1983). Additional studies of individual deposits, mining districts, and regions include work by Overton (1948), Klinger (1952), Lemaire (1954), Lawrence (1969), Dixon (1971), Tafuri (1973), Johnson (1977), Ponsler (1977), Smith (1981), and Gibson (1987).

ACKNOWLEDGMENTS

Analytical support for chemical analyses of rock samples was provided by USGS personnel in Denver, Colorado. Analysts were J. Bullock, J.M. Motooka, B.H. Roushey, R.T. Hopkins, B.M. Adrian, R.M. O'Leary, F. Tippitt, and C.M. McDougal. Keryl Flemming of the NBMG was very helpful in providing mineral deposit data and GIS support in the initial stages of the study. Joseph V. Tingley (NBMG) provided valuable assistance in compiling rock geochemical data and Harold F. Bonham (NBMG) assisted in field investigations. Kirk Swanson and Katherine Connors (USGS/Mackay School of Mines) provided much needed technical support in the preparation of illustrations. David A. John (USGS) provided useful insight into the metallogeny of the region during several fruitful discussions. Ted G. Theodore and David A. John helped improve the accuracy and clarity of this report through reviews of early drafts of the manuscript.

We thank AMAX Gold Exploration, Inc. for granting us permission to publish, in this report, information on the Pine Nut porphyry molybdenum deposit. We also extend our gratitude to the staff of the American Heritage Center, University of Wyoming, for their help in obtaining much valuable information from the Anaconda Geological Documents Collection.

GEOLOGY

Metavolcanic, metasedimentary, and plutonic rocks that represent part of a Middle Triassic to Late Jurassic continental-margin magmatic arc crop out at scattered localities throughout a large region of western Nevada and eastern California (fig. 1). A reconstruction of the geologic evolution of the arc is complicated by Jurassic extensional and compressional events, intrusion by Cretaceous plutons of the Sierra Nevada batholith, concealment beneath Cenozoic volcanic rocks, fragmentation by Cenozoic extensional and strike-slip faulting, and burial beneath Neogene basin fill. A complete description of the geology, structure, geochemistry, geophysics, and paleogeography of the Triassic to Jurassic magmatic arc within the study are is presented by Schweickert and others (in press b).

Triassic to Jurassic strata can be separated into four stratigraphic successions that are recognized throughout the study area. These are briefly described here from oldest to youngest. The first and oldest succession is a Middle to Late Triassic (Anisian to Karnian) shallow-marine to subaerial volcanic and volcaniclastic succession that includes the volcanics of McConnell Canyon in the Singatse Range (Proffett and Dilles, 1984, in press; Dilles and Wright, 1988) and the metavolcanic rocks of Brunswick Canyon east of Carson City (Bingler, 1977). The second succession is a Late Triassic (Karnian to Norian) platform to basinal marine carbonate-rich succession that includes the limestone of Mason Valley in the Singatse Range (Proffett and Dilles, 1984, in press), at least the upper carbonate member of the Oreana Peak Formation of Noble (1962, 1963) in the southern Pine Nut Mountains, the Luning Formation in the southern Gabbs Valley Range (Muller and Ferguson, 1936, 1939; Ekren and Byers, 1985), and part of the Pamlico Formation of Oldow (1978) in the Garfield Hills. The third succession is a latest Triassic to early Middle Jurassic (Norian to Bajocian) basinal clastic succession that includes the Gardnerville Formation of Noble (1962, 1963) and the Sailor Canyon Formation in the northern Sierra Nevada (Harwood and others, in press). The fourth and youngest succession is a Middle Jurassic subaerial volcanic and volcaniclastic succession that includes the volcanics of Artesia Lake and the volcanics of Fulstone Spring in the Singatse and Buckskin Ranges (Dilles and Wright, 1988; Proffett and Dilles, in press), the Veta Grande, Gold Bug and Double Spring Formations of Noble (1962, 1963) in the southern Pine Nut Mountains, and the Peavine sequence north and west of Reno (Garside, in press). For a more comprehensive discussion of the Triassic to Jurassic stratigraphy and paleogeography of the region, see Stewart (in press).

Triassic to Jurassic plutonic rocks in the study area can be divided into five groups based on age and regional distribution and are briefly described below in chronological order. The first and oldest group is Middle or earliest Late Triassic intrusions in the northern Wassuk Range and include the Wassuk diorite (Dilles and Wright, 1988) and the composite Strosnider Ranch pluton (Proffett and Dilles, 1984). The second group is latest Early Jurassic plutons in the Pine Grove Hills-Wassuk Range and include the granodiorite of Lobdell Summit (Stewart and others, 1981;

Stewart and Reynolds, 1987), and the granite of Baldwin Canyon (Stewart and others, 1981). The third group is Middle Jurassic batholithic plutons in the Yerington area and include the composite Yerington batholith (Dilles, 1984, 1987), the Shamrock batholith (Proffett and Dilles, 1984), the Sunrise Pass pluton (Dilles and Wright, 1988; Castor, 1972), and east-west-trending quartz monzonite porphyry dikes (Dilles, 1984; Dilles and Wright 1988). The fourth group is Middle to Late Jurassic plutons in the northern Sierra Nevada and include the Emigrant Gap pluton (James, 1971; Harwood and others, 1995; Schweickert and others, in press a), the granodiorite of French Lake (Lahren and others, 1988; Schweickert and others, in press a), and the Haypress Creek pluton (an early Late Jurassic to Early Cretaceous composite pluton) (John, 1983; John and others, 1994). The fifth group is Late Jurassic plutons in the West Walker River area (northern Sweetwater Mountains) and include the West Walker pluton (Schweickert, 1972, 1976; Robinson, 1985; Robinson and Kistler, 1986), the granite of Desert Creek (Schweickert, 1972; Brem, 1984; Stewart and others, 1989), and the granite of East Fork (Stewart and others, 1989; Brem, 1984). For a more comprehensive discussion of all Mesozoic plutonic rocks in the region see John and others (in press)

A correlation of stratigraphy, plutonism, and structural events is displayed in figure 3, which is a graphical representation of our current state of knowledge of the geotectonic evolution of the Triassic to Jurassic magmatic arc exposed in the study area. It is important to note, however, that uncertainties remain regarding the paleogeography of the arc and the relative position and displacement of delineated Mesozoic terranes that comprise the study area (see Stewart, in press). The following summary is based on a "fixist" model (Stewart, in press) which assumes that the relative positions of delineated terranes have not changed significantly since they originally formed. This model allows for regional deformation to have occurred at different times and with varied intensities in different parts of the region and allows for the presence of different geologic environments in different parts of the region at the same time.

During the Middle to Late Triassic a volcanic and volcaniclastic succession was deposited in a shallow marine to subaerial environment and locally intruded by comagmatic(?) diorite (Proffett and Dilles, 1984; Dilles and Wright, 1988; Proffett and Dilles, in press). As volcanism waned in the Late Triassic, subsidence occurred, one or more intra-arc or fringing basins developed (Schweickert and others, in press b), and a basinal to platform carbonate-rich succession was deposited conformably on the older volcanic succession. Continued subsidence and (or) sea-level rise during the latest Triassic to early Middle Jurassic coincided with the deposition of a thick basinal clastic succession. However, the upper part of this succession is characterized by nonmarine sedimentary rocks and evaporites (for example, gypsum at the Adams, Ludwig, and Regan mines), which suggests that the region became emergent during the end of this period and may correspond to a period of crustal extension (fig. 3) (Schweickert and others, in press b). The emplacement of the granodiorite of Lobdell Summit may have occurred during and in response to this extensional event. As emergent conditions began during the Middle Jurassic, a series of volcanic, plutonic, and structural events ensued. Subaerial volcanic deposits (volcanics of Artesia Lake, Veta Grande Formation, and Gold Bug Formation) were folded during a compressional event that preceded the emplacement of the Yerington and Shamrock batholiths (Proffett and Dilles, 1984; Dilles and Wright, 1988; Stewart, in press). There is accumulating evidence that following this Middle Jurassic compressional event, there was a Middle Jurassic extensional event that accompanied the emplacement of the Yerington batholith and other plutons (Dilles, 1984; Dilles and Wright, 1988; Schweickert and others, in press b). Subsequent subaerial volcanic deposits (volcanics of Fulstone Spring, Double Spring

Formation, Tuttle Lake Formation, and Peavine sequence) are all relatively undeformed and are thus distinguished from the Middle Jurassic volcanic rocks that were deposited and folded prior to the emplacement of the Yerington batholith (Schweickert and others, in press b). The Middle to Late Jurassic emplacement of the Desert Creek, West Walker, Haypress Creek, Emigrant Gap, and French Lake plutons and scattered mafic intrusions represent the last documented magmatic episode in the evolution of the Triassic to Jurassic magmatic arc (Schweickert and others, in press b).

Cretaceous plutons related to the Sierra Nevada batholith are widespread within the study area and represent the overprinting of the Cretaceous Sierran arc onto the Triassic to Jurassic magmatic arc. Consequently, remnants of the Triassic to Jurassic magmatic arc are present as roof pendants and septa within a basement of the Cretaceous Sierra Nevada batholith (see Schweickert and others, in press b)

Cenozoic extensional deformation has affected most of the study area. Yerington-style high- and low-angle normal faults, Basin-and-Range-type normal faults, and Walker Lane-type strike-slip faults have further fragmented the pendants and septa of Triassic to Jurassic arc rock (Proffett, 1977; Proffett and Dilles, 1984; Stewart, 1988; Hardyman and Oldow, 1991). Furthermore, Oligocene to Miocene silicic ash-flow tuffs, Miocene andesitic volcanic rocks, Miocene to Pleistocene bimodal basalt-rhyolite volcanic rocks and sedimentary rocks, and Quaternary unconsolidated alluvium cover large parts of the area and fill Neogene basins (Stewart and Carlson, 1976; Stewart and others, 1982; John and others, 1993; Greene and others, 1991).

METALLOGENIC EPISODES

The metallogenic history of the study area can be divided into three distinct episodes. These are defined here as (1) the Middle Jurassic Yerington episode, (2) the Cretaceous Sierra Nevada episode, and (3) the Tertiary Great Basin episode.

The Yerington metallogenic episode corresponds to the emplacement of the Middle Jurassic Yerington batholith and the evolution of related hydrothermal systems that produced several large porphyry copper, copper skarn and iron skarn deposits in and around the Yerington mining district (fig. 2) (Dilles, 1984; 1987; Einaudi, 1982; Conoco, 1982). The emplacement of the Yerington batholith was one of several igneous events that contributed to the formation of the Triassic to Jurassic magmatic arc on the North American continental margin (see the section "Geology"). The batholith was emplaced at relatively shallow depths ($\leq$2.5 km) (Dilles, 1984, 1987) and is distinguished from Triassic and Cretaceous plutons by its high Sr content (>1,000 ppm) (Dilles, 1987), high K_2O content (Dilles, 1987; John and others, 1994) and sodic and sodic-calcic alteration assemblages (Carten, 1986; Dilles, 1984). The Middle Jurassic Shamrock batholith, although apparently unmineralized, also contains sodic and sodic-calcic alteration assemblages (Battles, 1991; John and others, 1994).

The Sierra Nevada metallogenic episode corresponds to the emplacement of the Cretaceous Sierra Nevada batholith and the evolution of related hydrothermal mineralizing systems that produced low-F porphyry molybdenum, W skarn, and Cu-Au quartz-tourmaline vein deposits (Cox and others, 1991; Roxlo and Ranta, 1982; Stager and Tingley, 1988). The Sierra Nevada batholith represents the more deeply eroded parts of the Cretaceous Sierran arc that was overprinted on the Triassic to Jurassic magmatic arc along the North American continental margin. In contrast to the Yerington batholith, hydrothermal alteration was generally weak in the

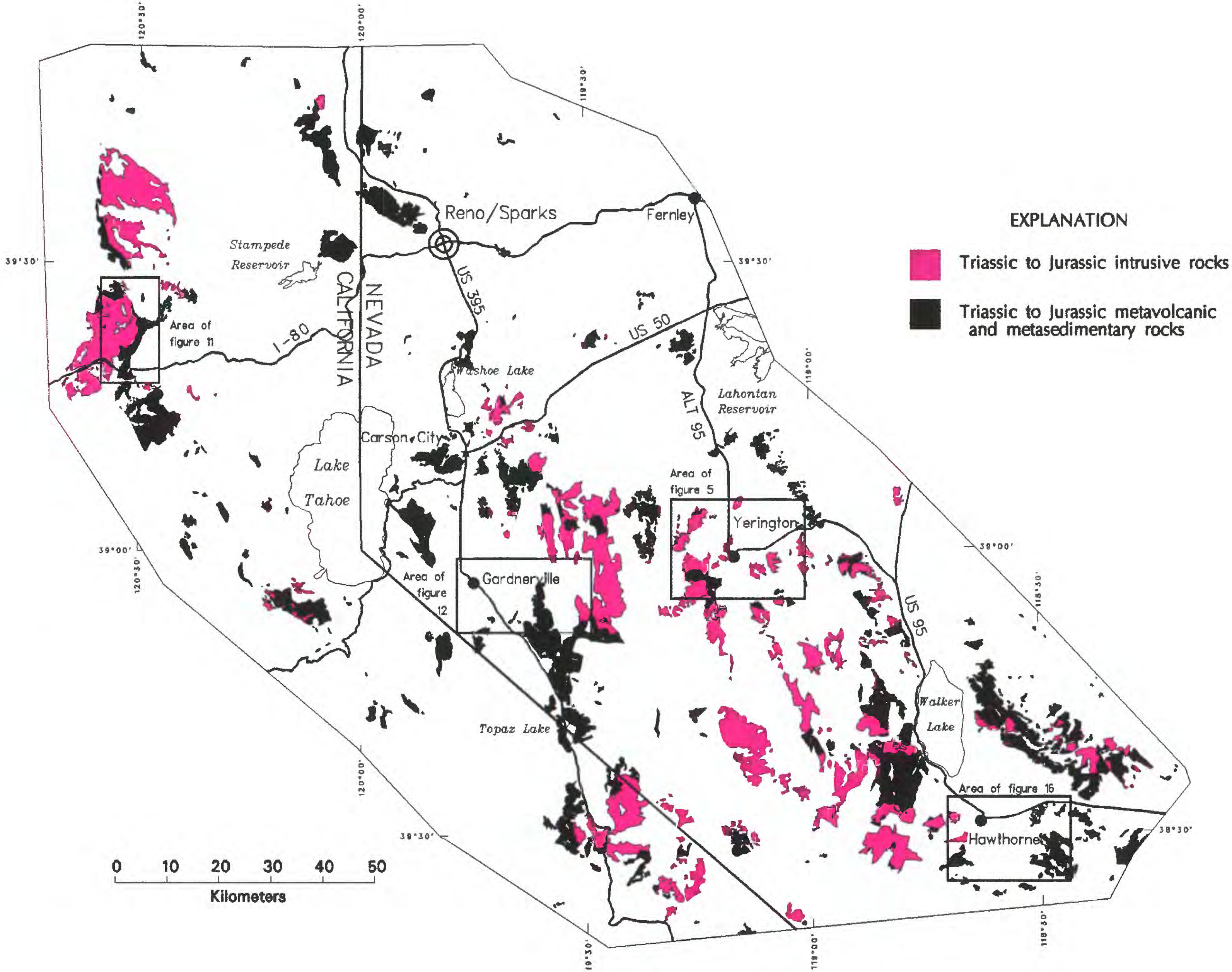


Figure 1. Index map of study area showing distribution of exposed Triassic to Jurassic rocks and areas of figures 5, 11, 12, and 16. Geology modified from 1:250,000-scale 1° by 2° quadrangle maps by Stewart and others (1982) (Walker Lake), Greene and others (1991) (Reno), Saucedo and Wagner, (in press) (Chico), Wagner and others (1981) (Sacramento).

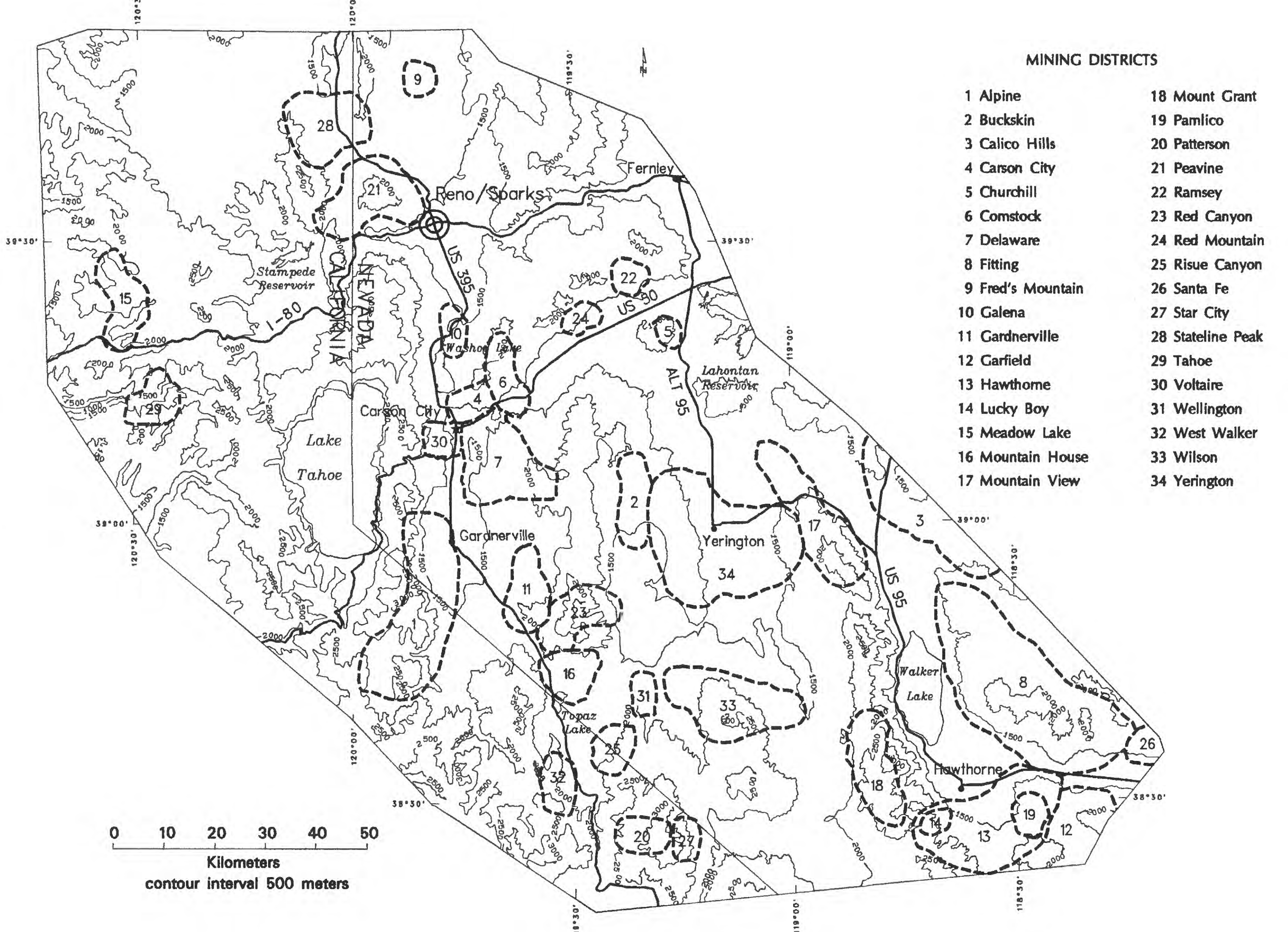


Figure 2. Index map of study area showing mining districts (dashed lines) referred to in this report.

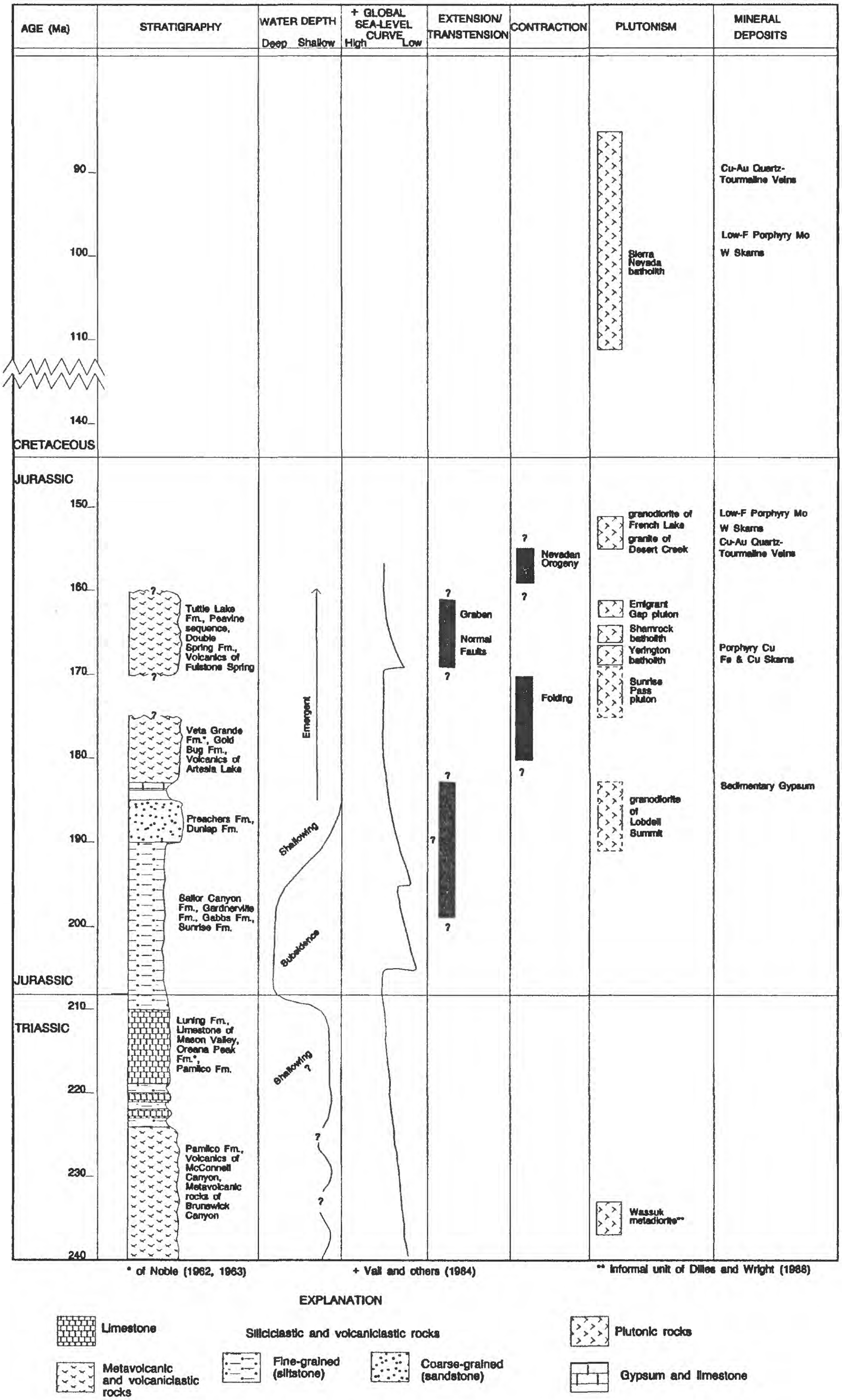


Figure 3. Chart summarizing geologic and metallogenic history of the study area from Triassic to Cretaceous time (modified from Schweickert, written commun., 1991). Time scale used is that of Palmer (1983). Stratigraphy is generalized; order of formations in groupings does not necessarily indicate relative stratigraphic position but regional correlation of formation. Question marks indicate uncertain time-stratigraphic position. Dashed boxes indicate possible age range of pluton.

Sierra Nevada batholith (John and others, 1994). The depth of emplacement of present exposures of the batholith was approximately 7 km, considerably greater than the Yerington batholith. Depth estimates are based on metamorphic assemblages of intruded rocks (Kerrick and others, 1973), hornblende compositions (Ague and Brimhall, 1988) and hornblende geobarometry (Johnson and Rutherford, 1989) (see John and others, 1994). The greater depth of emplacement is also reflected in the types of related mineral deposits, that is, Mo-W for the Sierra Nevada batholith versus Cu-Fe for the Yerington batholith; see Newberry and Einaudi (1981), Barton and others (1988), and Barton (1990).

The Tertiary Great Basin metallogenic episode corresponds to a period of Tertiary extension and magmatism, and related hydrothermal activity that was widespread throughout the Great Basin (Cox and others, 1991; Seedorff, 1991; Gans and others, 1989; Wernicke and others, 1987). Epithermal Au-Ag veins (adularia-sericite and quartz-alunite), polymetallic veins, and hot-springs Au-Ag-Hg deposits were the most common deposit types formed during this episode and some of these deposits, particularly the quartz-alunite Au-Ag veins, are proposed to represent the upper parts of concealed porphyry copper systems (Wallace, 1979; Hudson, 1983).

MINERAL DEPOSIT TYPES

The following are descriptions of some of the more important characteristics of deposit types hosted by Triassic and Jurassic rocks in the study area. An attempt has been made to classify deposits by age so as to reveal the differences between Triassic to Jurassic arc-related metallogenic processes and those which followed.

EARLY TO MIDDLE JURASSIC MINERAL DEPOSITS

Sedimentary Gypsum Deposits

There are at least nine known deposits or occurrences of bedded gypsum and anhydrite in Mesozoic rocks of western Nevada (Papke, 1987). Although they are found in several different depositional environments, it is suspected that they are all Jurassic in age (Stewart, 1980, p. 66; Papke, 1987). Three gypsum deposits, the Adams, Ludwig, and Regan Mines, are found in Jurassic arc rocks within the study area.

At the Adams Mine, about 9 km northeast of Carson City, bedded gypsum and anhydrite and a thin overlying limestone crop out in an area of predominantly metavolcanic rocks (Garside, in press). Bedding attitudes in the sulfate rocks vary greatly; the thickness cannot be estimated (Papke, 1987). The sulfate unit may have been remobilized, and it is possible that it and the overlying limestone are a pendant in adjacent, possibly hypabyssal, andesite and microdiorite. However, Schryver (1961) mapped the limestone and gypsum as a fault block in the metaigneous rocks (see Archbold, 1969). A Quaternary gypsite deposit (Mound House) is located nearby. It was apparently derived from the nearby bedrock deposit at the Adams Mine. The Adams Mine is an open pit about 300 m long, 200 m wide, and over 20 m deep. Production has been for use in plaster, cement manufacture, and for agricultural use (Papke, 1987).

Bedded gypsum at the Ludwig Mine near Ludwig, 10 km southwest of Yerington, lies stratigraphically above a limestone unit and below a quartzitic sandstone. In the mine area, a fault is reported to separate the limestone and gypsum (Jones, 1920; Papke, 1987; Archbold, 1969). The age of this sedimentary sequence is apparently between latest Early and late Middle

Jurassic (Proffett and Dilles, in press). The open pit at the Ludwig Mine is about 175 m in diameter and up to 25 m deep. It produced gypsum from 1911 to about 1930.

The Regan Mine is located about 15 km southeast of Yerington. Although the exposure of gypsum is isolated, it seems likely that it correlates with the gypsum at the Ludwig Mine, as the limestone of Ludwig is exposed just to the northeast (Proffett and Dilles, 1984; Archbold, 1966; Papke, 1987). Up to 20 m of gypsum is exposed in a pit about 125 m in diameter. An unknown amount of production is reported from the 1930's and 1940's (Papke, 1987).

The gypsum deposits described above appear to correlate to the same time-stratigraphic position in the arc's overall volcanosedimentary stratigraphy (fig. 3). The presence of the gypsum deposits indicates that conditions were shallowing or emergent over a widespread area (fig. 3).

MIDDLE JURASSIC MINERAL DEPOSITS

Porphyry Copper Deposits

All known porphyry copper deposits in the study area are located in the Yerington mining district, southern Buckskin Range, and northern Wassuk Range (fig. 2; appendix 1). The Yerington deposit yielded 165 million tons of ore averaging 0.6 percent Cu between 1952 and 1978 (Carten, 1986). Other deposits that have not been developed include the Ann Mason deposit with estimated resources of 495 million tons of ore averaging 0.4 percent Cu (Dilles, 1984), the Bear-Lagomarsino deposit with estimated resources of 735 million tons of ore averaging 0.44 percent Cu (Howard, 1980) and the MacArthur deposit with estimated resources of 13 million tons of oxide ore averaging 0.40 percent Cu (Heatwole, 1978).

Porphyry copper deposits are hosted by the Middle Jurassic Yerington batholith, which was emplaced into Late Triassic to Middle Jurassic volcanic and sedimentary rocks. The Yerington batholith is a composite complex that ranges in composition and texture from equigranular quartz monzodiorite to granite porphyry. Porphyry copper deposits are centered on several dike swarms of granite porphyry that emanated from late porphyritic granite cupolas. Cenozoic normal faulting and tilting has rotated the entire batholith and all of the porphyry copper deposits westward approximately 90 degrees, such that a present-day plan view represents a Jurassic vertical cross section through an entire porphyry system (Proffett, 1967, 1977; Geissman and others, 1982; Dilles, 1984; Carten, 1986).

Each mineral system displays well-developed alteration patterns. In general, an early sodic-calcic alteration assemblage is present in the roots of the system, whereas a potassic alteration assemblage is present higher in the system. Copper sulfide minerals (chalcocite, bornite, chalcopyrite) are commonly coincident with areas of potassic alteration and are present with magnetite in veinlets and in the potassically altered wallrocks. Minor amounts of molybdenite may also be present. The deposits are consistently devoid of any appreciable precious metals. A late sodic alteration assemblage is often superimposed on the lower parts of the system and a broad, pervasive quartz-sericite-pyrite alteration zone is superimposed on the upper parts of the system (Carten, 1986; Dilles, 1984; Wilson, 1978). Locally, illitic and aluminosilicate (andalusite, corundum, pyrophyllite, diaspore) alteration assemblages are present in the highest levels of a system (Hudson, 1983).

A concordant U-Pb zircon age of 168.5$\pm$0.4 Ma for a granite porphyry dike (Dilles and Wright, 1988) indicates that all associated porphyry copper deposits are also of the same age. Furthermore, a concordant U-Pb zircon age of 169.4$\pm$0.4 Ma for the early quartz monzodiorite phase suggests that the entire Yerington batholith was emplaced within a 1 million year period (Dilles and Wright, 1988).

The Yerington porphyry copper deposits, collectively with their associated skarn deposits, represent the most significant episode of Jurassic mineralization in the area (the Yerington metallogenic episode). The entire Yerington mining district currently contains a resource of greater than 1 billion tons of 0.4 percent copper in porphyry copper deposits. For a more detailed discussion of these deposits, see the section "Yerington Supersystem".

Copper Skarn Deposits

All of the copper skarn deposits in the study area that are known to be Jurassic in age are located in the Yerington mining district (fig. 2; appendix 1). Most are present within an 8-km-long by 3-km-wide septum of Late Triassic to Middle Jurassic volcanic and sedimentary rocks that is bounded by the Yerington batholith on the north and the Shamrock batholith on the south. Copper skarns represent a minor source of copper in the Yerington mining district compared to that produced and available from porphyry copper deposits. Recorded production of copper from copper skarn deposits in the Yerington mining district is approximately 3.5 million tons of ore containing 1.5 to 5 percent Cu. This includes production from the Bluestone (1.5 million tons of 1.5-3.5 percent Cu), Mason Valley (1.5 million tons of 1.5-3.5 percent Cu), Casting Copper (450,000 tons of 3 percent Cu), Douglas Hill (70,000 tons of 5 percent Cu), McConnell (20,000 tons of 3 percent Cu), and Western Nevada (4,000 tons of 3 percent Cu) Mines (Einaudi, 1982; Harris and Einaudi, 1982).

Jurassic copper skarn deposits are located primarily within Late Triassic limestone units in the vicinity of the Yerington batholith intrusive stocks. Although late Cenozoic normal faulting and tilting has considerably disrupted the original distribution of deposits, pre-faulting and pre-tilting reconstructions have allowed for the determination of the deposits' original positions in the overall magmatic-hydrothermal system (Proffett, 1977; Geissman and others, 1982).

A contact aureole of grandite(Ad_{25-70})-diopside(Hd_{0-15}) hornfels extends as much as 1,800 m from the early quartz monzodiorite phase of the Yerington batholith (Einaudi, 1982; Harris and Einaudi, 1982). Two types of copper-bearing skarn were superimposed on the hornfels aureole. Iron-rich skarns, formed closest to the batholith and are characterized by andradite gangue, relatively low total sulfide content, and low pyrite:chalcopyrite ratios. Magnesium-rich skarns formed farther from the batholith contact and are characterized by salite-andradite gangue, relatively high total sulfide content, and high pyrite:chalcopyrite ratios (Einaudi, 1982; Harris and Einaudi, 1982). For a more detailed description of the Yerington copper skarn deposits, see the section "Yerington Supersystem".

In addition to copper, copper skarn deposits are generally anomalous in silver, arsenic, and cobalt (fig. 4). Deposits in the Yerington mining district also contain considerable amounts of antimony and bismuth (appendixes 2 and 3).

The age of formation of these copper skarn deposits is the same as the age of the associated porphyry copper deposits. Therefore, just as the 168.5-Ma age of the granite porphyry stock (as stated above) represents the age of porphyry copper mineralization, it also represents the age of copper skarn mineralization.

The genetic association with the Middle Jurassic porphyry copper deposits make the Yerington copper skarn deposits additional products of the Yerington metallogenic episode. For further discussion of copper skarns in the Yerington mining district, see the section "Yerington Supersystem".

Iron Skarn Deposits

Jurassic iron skarn deposits (Cox, 1986b) are present within Triassic and Jurassic carbonate-bearing sequences that have been intruded by Jurassic quartz monzodiorite, granodiorite, and quartz monzonite stocks. In most cases the stocks are part of the composite Yerington batholith.

The Minnesota Mine deposit (appendix 1) is the only iron skarn in the study area that has seen production, although conflicting numbers exist as to how much ore was produced. Moore (1969) claims that a total of 3.7 million metric tons of ore was produced during the life of the mine (1944-1966), though Heatwole (1973) states that the deposit yielded 6 million metric tons of ore containing 54 percent iron. At Pumpkin Hollow (fig. 5; appendix 1) six discrete deposits are concealed beneath Cenozoic rocks and alluvium in Mason Valley. Total reserve estimates for all deposits are 350 million tons of ore containing 26 percent magnetite and 0.42 percent Cu (Pincock, Allen, and Holt, 1977). The Calico deposit (appendix 1) is concealed beneath Tertiary volcanic rocks and is said to occupy a volume of rock 1.7 km long, 180 m wide, and greater than 600 m thick that represents 720 million tons of ore averaging 30-35 percent iron (Lawrence, 1969). The Dayton deposit contains 9.7 million metric tons of ore containing 43 percent iron (Butler, 1945).

Both endoskarn and exoskarn can exist at any one deposit. Massive magnetite, with varied amounts of pyrite, constitutes ore. Gangue minerals include anhydrous prograde phases (salite, grandite, dolomite) and hydrous retrograde phases (actinolite, tremolite, talc, serpentine, chlorite). In deposits associated with the Yerington batholith, the prograde anhydrous phases are superimposed on carbonate units that were dolomitized during emplacement of the granodiorite stock. Formation of the hydrous phases accompanied brecciation of the anhydrous skarn and "marble front" fracture-controlled copper mineralization (Reeves and others, 1958; Roylance, 1966; Heatwole, 1973; Smith, 1984).

Iron skarn deposits in the area contain anomalous amounts of cobalt (Satkoski and others, 1985) (fig. 4). Furthermore, those deposits associated with the Yerington batholith locally contain zones enriched in copper, molybdenum, lead, zinc, and gold (Heatwole, 1973; Wright, 1976; Pincock and others, 1977; Lawrence, 1969)

The age of iron skarn formation is the same as the age of the associated intrusive activity. Therefore those deposits associated with the Yerington batholith are 168-169 Ma in age based on concordant U-Pb zircon ages determined from the quartz monzodiorite stock and granite porphyry dike (Dilles and Wright, 1988). The age of iron skarn deposits associated with other Mesozoic stocks are of uncertain age, but are believed to be Jurassic due to their overall similarity with those associated with the Yerington batholith.

The iron skarn deposits of the study area exhibit characteristics of both calcic- and magnesian-iron skarn deposits. The geologic setting (continental margin), associated igneous rocks (monzodiorite to granodiorite), local zinc enrichment (Calico deposit), and retrograde skarn mineral assemblage (actinolite, tremolite, talc, serpentinite) are characteristic of magnesian-iron skarns (Einaudi and others, 1981). The anomalous cobalt and locally anomalous gold (Pumpkin Hollow, E-2 ore body; Calico deposit) prograde skarn mineral assemblage (epidote, salite, grandite), and sodic endoskarn alteration (Calico deposit) are characteristic of calcic-iron skarns which normally form in oceanic island arc settings (Einaudi and others, 1981).

MIDDLE JURASSIC TO TERTIARY MINERAL DEPOSITS

Polymetallic Replacement Deposits

Polymetallic replacement deposits are small and sparse in the study area, and include the Winters Mine in the Red Canyon mining district and the La Panta Mine in the Pamlico mining district (fig. 2; appendix 1). Production has been small or nonexistent at most of the deposits. Production of the largest deposits did not exceed a few thousand tons of ore.

Some polymetallic replacement deposits constitute irregular pod-like or lens-like bodies in carbonate rocks, and others form irregular replacement veins in carbonate rocks, quartzite, shale, schist, or volcanic rocks. Silicification in the form of jasperoid formation and dolomitization commonly occurred in and near replacement deposits in carbonate rocks. Alteration products associated with replacement deposits in other rocks such as shale and schist include chloritized and argillized rocks. Wallrocks may also contain disseminated pyrite and barite (Morris, 1986).

Several of the replacement deposits have a rather simple metal association, for example lead, antimony, and silver. Others are more complex and contain in addition to those metals, significant amounts of iron, copper, zinc, bismuth, arsenic, molybdenum, tungsten, uranium, and gold. The La Panta Mine in the Pamlico mining district was mined principally for gold. In the simpler types of replacement deposits, metallic minerals may be limited to argentiferous galena or tetrahedrite, and in places stibnite. More complex deposits contain also pyrite, chalcopyrite, native copper, magnetite, and (or) hematite. Oxidation products such as limonite, malachite, azurite, cerussite, and anglesite may be present.

Polymetallic replacement deposits are probably gradational, by variation in mineral content, particularly by development of calc-silicate minerals, into tungsten- or copper-iron skarn deposits. Although none of the polymetallic replacement deposits have been dated isotopically, they are inferred to be the same age as proximal intrusive rocks, which are generally Jurassic and Cretaceous stocks. As a result, this type of deposit likely formed in more than one time period and during more than one metallogenic episode.

Polymetallic and Gold Veins, Undivided

Numerous gold-bearing quartz, fissure-filling, and polymetallic veins are scattered throughout the study area. They are present in rocks of all compositions and all ages. Collectively, these deposit types constitute, by far, the largest group of individual deposits and occurrences in the study area. However, production from polymetallic and gold-bearing veins in the study area mostly has been small. With exception, the Hawthorne mining district (including the Lucky Boy and Pamlico mining districts (fig. 2)) has produced significant lead (1,000,000 lb), copper (200,000 lb), silver (750,000 oz), and gold (2,000 oz) (Lincoln, 1923). The Buckskin Mine in the southern Buckskin mining district (fig. 2; appendix 1) was in production intermittently in the first half of the century and then again briefly in 1985-86. The Peavine and Galena mining districts (Washoe County, Nevada; fig. 2) have produced lesser amounts of base and precious metals. Most of the smaller veins elsewhere in the study area probably have been mined or prospected principally for gold and silver.

Veins are of two general types, quartz veins and fissure-filling veins. Quartz veins, generally about 2 cm to as much as 1 m wide and less than 200 m long, are the more abundant deposit type. They consist of massive white quartz commonly sheared and brecciated and filled with limonitic silica (chalcedony). In places, the veins also contain minor to large amounts of calcite, ankerite, ferrodolomite, rhodochrosite, barite, and (or) tourmaline. Common sulfide minerals are pyrite, galena, and sphalerite; chalcopyrite is present in some quartz veins, and tetrahedrite-tennantite is found in many veins. Oxidized veins may contain cerussite, anglesite, chalcocite, malachite, azurite, and (or) chrysocolla. The most abundant metals are iron, copper, lead, and zinc, although arsenic and antimony locally are abundant and small amounts of bismuth, cadmium, vanadium, tungsten, silver, and gold may be present.

Fissure veins are sheared zones that commonly are strongly iron mineralized and locally are manganese mineralized or silicified. Presence of vein quartz and (or) barite on some mine dumps suggests that the fissure veins are transitional into quartz or barite veins. Common sulfide minerals and tetrahedrite-tennantite are found in the veins, and where weathered, secondary copper minerals such as malachite and chrysocolla are common.

Ages of most of the quartz and fissure veins are poorly established. Generally ages are inferred on the basis of known ages of nearby intrusive rocks and thus may range in age from Jurassic to Tertiary. These types of deposits are likely related to many different mineral systems that evolved during all three of the metallogenic episodes defined above.

Aluminosilicate Deposits

Aluminosilicate deposits hosted within Triassic to Jurassic arc rocks are located in the Buckskin Range (Blue Danube Mine (formerly the Blue Metal Mine) and Top prospect) as well as in the southwestern Gillis Range and northern Garfield Hills (Green Talc and Dover Mines and Deep and Bismark prospects) (appendix 1). All these localities have been previously evaluated for abrasive-quality corundum. However, the very fine grained size and disseminated nature of the corundum as well as its erratic distribution and intimate association with other minerals would make profitable mining and processing difficult. Consequently production has been insignificant. Nevertheless, the high alumina content in most of the deposits (locally as much as 75 percent Al_2O_3 at the Green Talc Mine) permits them to be considered as resources for refractory material (Binyon, 1946; Klinger, 1952).

The aluminosilicate deposits in the study area are present within Triassic volcanic and Jurassic sedimentary and plutonic rocks and represent the products of advanced argillic alteration near the tops of known and postulated porphyry copper mineralizing systems (Hudson, 1983). These deposits are commonly characterized by the mineral assemblage corundum-andalusite-quartz-rutile±lazulite, which has replaced secondary biotite and sericite. Furthermore, a diaspore-pyrophyllite-quartz±zunyite±topaz±specular hematite assemblage has partially to completely replaced the corundum-andalusite assemblage (Hudson, 1983). Tourmaline is locally abundant. Similar alteration assemblages are recognized within advanced argillic alteration zones associated with porphyry copper deposits in Indonesia (Lowder and Dow, 1978).

The aluminosilicate alteration zones commonly are depleted in sodium, potassium, calcium, magnesium, manganese, copper, and cobalt. Locally they contain several times the background value in boron (Hudson, 1983), most likely due to the presence of tourmaline (Klinger, 1952; Hudson, 1983).

The formation of aluminosilicate deposits was cogenetic with the formation of the sericitic and potassic alteration assemblages, thus the age of the aluminosilicate deposits is the same as the age of those alteration assemblages. K-Ar age determinations on sericite and secondary biotite indicate that some localities are clearly Cretaceous in age (94-95 Ma; southwestern Gillis Range) (Hudson, 1983), whereas the age of aluminosilicate deposits at other localities is uncertain and may be either Jurassic and related to the Yerington batholith or Miocene (for example, southern Buckskin Range) (Hudson, 1983). Nevertheless, evidence suggests that aluminosilicate deposits formed during more than one time period and metallogenic episode and are associated with known and postulated porphyry copper systems.

LATE JURASSIC TO CRETACEOUS MINERAL DEPOSITS

Low-F Porphyry Molybdenum Deposits

The Pine Nut deposit, located in the Gardnerville mining district (fig. 2) at the southern end of the Pine Nut Range is the only drill-defined porphyry molybdenum deposit within the study area. However, indications of similar types of deposits are present at several localities, particularly in the Risue Canyon area of the Wellington Hills, the Star City area of the Sweetwater Mountains, and in the English Mountain area of the Meadow Lake mining district (fig. 2; appendix 1). A Cretaceous porphyry molybdenum system with associated W-Cu-Ag-bearing skarn (New Boston-Blue Ribbon prospect) is located just outside the southeast boundary of the study area (Harris, 1991).

At the Pine Nut deposit, molybdenite mineralization was temporally and spatially related to a biotite quartz monzonite stock that was emplaced into a folded sequence of Triassic metavolcanic and metasedimentary rocks of the Oreana Peak Formation of Noble (1962, 1963). A weakly developed stockwork of quartz+molybdenite±pyrite±epidote veinlets forms a shell-like cap above, and partially overlaps, the apical zone of the stock. A pervasive quartz-sericite-pyrite alteration zone was overprinted by a stockwork of quartz-potassium feldspar veinlets in the upper part of the stock (DeLong, 1977; Roxlo and Ranta, 1982). For a more thorough discussion of this deposit see the section on the "Pine Nut System".

In the Risue Canyon area of the Wellington Hills, disseminated molybdenite and ferrimolybdite are found within a 900-m-long weathered granitic dike (Michell, 1945), which might be related to the granite of Desert Creek. In the Star City area of the Sweetwater Mountains, molybdenite-bearing quartz veins and quartz-sericite altered zones are present within the granite of East Fork (Brem and others, 1983). In the English Mountain area of the Meadow Lake mining district, a molybdenite-bearing dike and stockwork veining are associated with the granodiorite of French Lake.

Most radiometrically dated porphyry-molybdenum deposits in the western Great Basin are Cretaceous or Tertiary in age (Schilling, 1968; Cox and others, 1991). However, a Middle to Late Jurassic porphyry molybdenum system is present in the Cucomungo area of southwest Esmeralda County, Nevada (Briner, 1980). Molybdenum mineralization at the Pine Nut deposit was clearly related to the emplacement of the quartz monzonite stock and therefore is the same age as the stock. However, the age of the stock is unknown. Sericite from an alteration envelope surrounding a molybdenite-bearing vein within the granite of East Fork in the Star City area yielded a Late Cretaceous age (Brem and others, 1983). The molybdenum-bearing dikes, veins, and stockworks in the Risue Canyon area of the Wellington Hills, and in the English Mountain area of the Meadow Lake mining district, appear to be related to Middle to Late Jurassic plutonism (granite of Desert Creek and granodiorite of French Lake, respectively; see the section "Geology"). However, an age discrepancy exists for the granite of Desert Creek (see John and others, 1994).

The uncertainty in ages of porphyry molybdenum deposits makes it difficult to relate these deposits to particular metallogenic episodes or geologic events. Nevertheless some evidence suggests that porphyry molybdenum deposits formed during two periods: in the Late Jurassic and related to the final magmatic phases of the Triassic to Jurassic magmatic arc, and in the Cretaceous and related to the Sierra Nevada batholith.

Tungsten Skarn Deposits

Tungsten skarn deposits are widely scattered in the study area and most of them are small, with less than 1,000 units WO_3 production (1 unit of WO_3 equals 20 lb of WO_3, which equals 15.86 lb of tungsten). Total production has been about 30,000 units, most of this coming from the Gardnerville mining district (fig. 2) in Douglas County, Nevada (13,000 units), and the Alpine Mine in Alpine County, California (about 10,000 units, estimated). Grade of the skarn deposits averages about 0.5 percent WO_3, although small pods of ore in the Divide Mine in the Gardnerville mining district ran as high as about 15 percent WO_3 (Stager and Tingley, 1988, p. 46).

Tungsten skarn deposits in the study area are almost universally in Triassic to Jurassic carbonate strata adjacent to granitic intrusive bodies. Localization of skarn deposits generally has been along irregular contacts that have been faulted, or where intrusive bodies form reentrants into host carbonate rocks. A few tungsten skarn deposits, such as at the Alpine Mine in Alpine County, California, contain both exoskarn and endoskarn.

Tungsten skarns commonly are surrounded by a zone of iron-poor silicate minerals such as grossularite, diopside, wollastonite, clinozoisite, tremolite, and idocrase (Stager and Tingley, 1988, p. 19). This zone grades outward into a halo of marble that in turn merges into unaltered carbonate rocks.

Tungsten skarns within the study area generally exhibit elevated values of molybdenum, zinc, and manganese relative to other deposit types sampled (fig. 4). Scheelite is universally the tungsten-bearing mineral in this type of deposit. Commonly molybdenum is present in the scheelite crystal structure in varied amounts, in places abundant enough to designate the mineral as powellite. Gangue minerals of the skarns are predominantly iron-rich silicate minerals such as andradite, epidote, hedenbergite, hornblende, and actinolite. Quartz and calcite are also present, and small to large amounts of magnetite, pyrite, pyrrhotite, molybdenite, chalcopyrite, sphalerite, galena, tetrahedrite-tennantite, and (or) fluorite may be present (Stager and Tingley, 1988).

Tungsten skarn deposits in the study area formed at the contacts of Cretaceous granitic intrusive bodies related to the Sierra Nevada batholith, and possibly in association with a Late Jurassic pluton (granite of Desert Creek) in the Risue Canyon area of the Wellington Hills. Tungsten skarn mineralization, thus, is believed to be Late Jurassic to Cretaceous in age. The Late Jurassic occurrences are believed to be related to the latest magmatic stage in the evolution of the Triassic to Jurassic magmatic arc, whereas the Cretaceous occurrences are related to the Sierra Nevada batholith.

Tungsten Veins

Tungsten-bearing veins in the study area are scarce and quite small. However, a large tungsten-bearing vein, the Silver Dyke vein in the Silver Star (or Camp Douglas) mining district, Mineral County, Nevada, is present just outside the southeast boundary of the study area. The Silver Dyke vein produced about 50,000 units of WO_3 (Stager and Tingley, 1988, p. 130), indicating that such deposits if found elsewhere could have important tungsten potential. Grade of the Silver Dyke vein was about 1-1.5 percent WO_3 (Stager and Tingley, 1988, p. 131).

The Silver Dyke vein is a large composite quartz vein 7-60 m wide and more than 4.5 km long that extends west-northwesterly through the Excelsior Mountains (Garside, 1979). The vein is a fissure-filling along a major fault that cuts Permian marine clastic rocks, Cretaceous volcanic and volcanic-sedimentary rocks and mafic-silicic intrusive rocks, and Tertiary andesite and rhyolite tuff (Garside, 1979). Near the Silver Dyke vein, andesite has been propylitically altered (Garside, 1979).

Scheelite is the only ore mineral in the Silver Dyke vein and it carries as much as 0.5 percent Mo (Stager and Tingley, 1988, p. 131). The major gangue mineral in the Silver Dyke vein is quartz; small grains of albite are abundant and adularia, pyrite, and chalcopyrite are also present. Near the surface, the quartz forms cockscombs or is banded and contains finely divided silver telluride (hessite), gold-silver telluride (petzite), and minor free gold (Garside, 1979; Ross, 1961, table 6.7). Some of the small tungsten-bearing veins throughout the study area contain wolframite as well as scheelite; molybdenite, bornite, galena, sphalerite, and (or) tetrahedrite-tennantite may also be present.

The Silver Dyke vein has been dated as Miocene in age (17.3$\pm$0.2 Ma, Garside and Silberman, 1978), which may represent a Tertiary modification of a vein formed initially in the Mesozoic. Most small tungsten veins throughout the region are considered to be Late Jurassic to Cretaceous in age based on their proximity to intrusive rocks of that age.

Generally, tungsten veins are associated with porphyry molybdenum systems at depth. A Cretaceous porphyry molybdenum system with associated W-Cu-Ag-bearing skarn is located approximately 11 km north of the Silver Dyke vein (Harris, 1991). Though the two deposits are probably unrelated, their presence may indicate a porphyry molybdenum province in the region bordering the southeast part of the study area.

Cu-Au Quartz-Tourmaline Veins

Tourmaline-bearing quartz veins and replacement deposits, commonly copper- and gold-bearing, are found in unusual concentration in western Nevada and adjacent eastern California in Triassic to Jurassic arc rocks and the Cretaceous plutons which intrude them. Mines and prospects which exploit the tourmaline-bearing deposits are found in a zone approximately 115 km long and 75 km wide (L.J. Garside, unpub. data, 1991). Within the study area, these include the vein deposits of the Meadow Lake mining district, the Utopian Mine in the Delaware mining district, the Rocky Hill Mine in the Galena mining district, and several occurrences in the Peavine and Stateline Peak mining districts (fig. 2; appendix 1). Tourmaline-bearing aplite/pegmatite dikes, associated with Late Cretaceous plutons are also relatively common in the area, suggesting a genetic relationship between plutons and mineralization. A group of copper- (especially bornite-) bearing veins in the Genesee mining district near Taylorsville (30 km north of the study area) may be a related mineral deposit type. Tourmaline is known to be present in only a few of the Genesee mines, but there has been little recent work on them, and fine-grained tourmaline may not have been recognized by early workers.

Most of the wallrocks for the veins are intermediate-composition metavolcanic rocks of Triassic and Jurassic age; at a few localities, the host is metarhyolite or silicic metaignimbrite.

Granodiorite, commonly of Late Cretaceous or presumed Late Cretaceous age, is the host for a significant number of deposits.

The quartz-tourmaline veins are usually mineralogically simple. In addition to black tourmaline, probably schorl, and milky to clear quartz, the veins contain pyrite+bornite and (or) chalcopyrite±magnetite, and very rarely chalcocite, pyrrhotite, molybdenite, arsenopyrite, tetrahedrite, sphalerite, and galena. Sulfide-mineral content may be 10 vol. percent or more in major veins, and locally massive sulfide bodies are present.

Wallrock alteration products of quartz-tourmaline veins are rather inconspicuous; commonly only epidote is observed to be somewhat concentrated near the veins. Replacement appears to have been a significant mineralizing process, as open-space textures characteristic of lower temperature veins are generally absent. There are sericitic alteration envelopes around some veins; chlorite is concentrated in the walls at others.

Ages of most of the quartz-tourmaline veins are not known with certainty. However the presence of a number of veins in Late Cretaceous granodioritic rocks in western Nevada places a lower limit on their ages. Also, a K-Ar isotopic age on sericite in altered wallrock fragments in a vein from the Flying Dutchman Mine, 7 km south of Chilcoot, California, suggests that at least the veins in that area are Late Cretaceous (89 Ma; Garside and others, 1992) and are closely related in age to nearby plutons. In the Meadow Lake mining district, the numerous Cu-Au quartz-tourmaline veins are present within the granodiorite of French Lake (151 Ma; Garside and others, 1992) and the Permian to Middle Jurassic volcanic and sedimentary rocks that it intrudes. The veins are cut off by a Cretaceous (100 Ma; Evernden and Kistler, 1970) granodiorite. Bowman (1983) related the vein mineralization to hydrothermal fluids generated during and immediately following consolidation of the Late Jurassic granodiorite of French Lake. Near Taylorsville, California, 35 km to the north of the study area, tourmaline-bearing vein and porphyry-style mineral deposits are present in and adjacent to a Cretaceous(?) granitic stock (Lights Creek stock; Putman, 1975; Storey, 1978); thus, mineralization age there is also not well constrained but may be Cretaceous. Somewhat similar copper-gold mineral deposits to the south in the Genesee mining district may also be, by analogy, Cretaceous in age. The Walker Mine in the southern part of this mining district has been considered by some workers (Kilbreath and Leger, 1978; Kilbreath, 1979) to be a metamorphosed volcanogenic exhalative deposit. The mine was not examined during this study, but it has many features similar to nearby hypogene tourmaline-bearing copper-gold quartz veins and is herein considered to be such a vein.

The wide distribution and possible age variation presents somewhat of a problem in explaining the origin of the quartz-tourmaline veins of western Nevada and eastern California. The numerous occurrences of quartz-tourmaline veins and tourmaline-bearing pegmatites and their wide distribution over a large area suggests a boron-enriched province. Although there is evidence that many of the deposits are Late Cretaceous in age, others within and outside the study area are Jurassic or possibly older.

Volcanic-Hosted Magnetite Deposits

Iron deposits of western Nevada are predominantly volcanic- (and cogenetic pluton-) hosted or are replacements in carbonate rocks near epizonal intermediate-composition plutons (Reeves and Kral, 1955; Reeves and others, 1958; Horton, 1962; Shawe and others, 1962; Reeves, 1964). Magnetite deposits hosted in Triassic to Jurassic volcanic arc rocks are generally small deposits (probably 1 million tons of ore or less) and include the Bessemer Mine in the

Delaware mining district and several occurrences in the Peavine mining district (fig. 2; appendix 1). Volcanic-hosted magnetite deposits are hydrothermal metasomatic vein-like and replacement deposits associated with the emplacement of intrusions; these intrusions may be cogenetic with the volcanic units or considerably younger (for example, Cretaceous intrusions of the Sierra Nevada batholith). The more extensive and complex calc-silicate mineralogy of the carbonate-hosted proximal skarns (see preceding section of this report) of the study area is obviously related to host rock reactivity and calcium content; the lower calcium content of the volcanic host rocks resulted in development of a somewhat restricted set of calc-silicate minerals.

The skarn and skarn-like volcanic-hosted iron deposits of the study area are commonly replacement deposits that are vein-like, pods, or irregular lenticular bodies along faults. Although incompletely studied, these deposits appear to be mineralogically simple and differ only slightly from the model types described in the literature (Cox, 1986b, d, models 18d, 25i; Einaudi and others, 1981; Meinert, 1984; Sangster, 1969; Einaudi and Burt, 1982; Gross, 1984, model 19.3). Although sodium scapolite (marialite) is associated with at least one deposit (Hudson, 1977), and possibly unrecognized at others, the most common calc-silicate mineral is epidote; garnet is apparently uniformly rare or absent. Silicified rock and quartz veins are also commonly present. In addition to magnetite, hematite and sparse pyrite and chalcopyrite are found at some properties. The most interesting mineral association is that of black tourmaline (schorl?) either with vein-like deposits (for example, Peavine Peak area) or in the wallrocks of such bodies (for example, Bessemer mine). Volcanic-hosted tourmaline-bearing hematite replacement deposits in the Fitting mining district (Dover and Green Talc mines) are also herein included with this group of volcanic-hosted deposits. Black tourmaline, especially if fine grained, was apparently not recognized by many early workers. Thus, it may be present but unreported at a number of volcanic-hosted magnetite deposits in the study area. Tourmaline also is present with small amounts of magnetite in gold- and copper-bearing quartz-tourmaline veins (see above). The presence of magnetite with tourmaline at and near some of these hypothermal and possibly skarn-related quartz-tourmaline veins suggests a relatively close connection between these deposits and the volcanic-hosted magnetite deposits. The presence of extensive Na-silicates in volcanic-hosted magnetite deposits has been noted elsewhere (Einaudi and Burt, 1982, table 2). Tourmaline and scapolite are recognized at several study area localities, mainly in the Peavine mining district. The tourmaline is an indication of pluton-related boron metasomatism, as well as an indication of the commonly reported sodium-metasomatism (sodium scapolite, for example) of volcanic-hosted magnetite deposits.

Volcanic-hosted iron deposits of western Nevada are geochemically simple (see appendixes 1-3). Copper is commonly anomalous, probably due to trace amounts of copper sulfide minerals. Barium may be somewhat enriched in some samples, as are boron (from tourmaline) and bismuth. Samples from the Signal Peak area of the Meadow Lake mining district are anomalous in gold and silver; other sampled volcanic-hosted iron deposits are apparently not. Gold is a significant constituent of magnetite-bearing copper-gold-tourmaline veins, a possible related deposit type (see this deposit type description above and the section "Meadow Lake System"). Anomalous tungsten noted in samples from some deposits or occurrences is also to be expected in skarn-like deposits, as magnetite is a common constituent of some tungsten skarn deposits. The relatively high lower detection limit of tungsten (appendix 2) does not allow further interpretation of this association.

These deposits appear to have formed during more than one time period and metallogenic event. In addition to those hosted by Triassic or Jurassic metavolcanic rocks, some are hosted by cogenetic(?) Jurassic subvolcanic diorite. Other deposits are proximal or somewhat distal to epizonal granodiorite plutons that are mostly Cretaceous in age. No absolute age data are available for the volcanic-hosted magnetite deposits; however, because of their common proximity to plutons of Cretaceous or probable Cretaceous age, many are believed to be Cretaceous. Some (for example, Capitol or Eason property southeast of Carson City) are present in Jurassic or Cretaceous diorite.

CRETACEOUS TO TERTIARY MINERAL DEPOSITS

Zinc Skarn Deposits

Zinc skarn deposits (Einaudi and others, 1981; Einaudi and Burt, 1982; Dawson and Sangster, 1984; Cox, 1986a) are relatively uncommon in Nevada and California, in comparison to other metal-bearing skarns (see Jones, 1984). Just outside the southwest border of the study area, the Cooney Zinc Mine is clearly a zinc skarn deposit (Einaudi and others, 1981) and several enigmatic or poorly known deposits or occurrences may be zinc skarns.

At the Cooney Zinc Mine, zinc and lead-bearing skarn, reported to consist of hornblende, pyroxene, epidote, and garnet, is developed in limestone along a N. 40° W. zone traceable for over 100 m. It is reported that samples cut across a 12-m-wide lead-zinc sulfide ore body averaged 18 percent zinc, 10 percent lead, and 4-6 ounces per ton silver (Sampson and Tucker, 1940).

At the Guy Walt's Zinc property (appendix 1), an unusual group of very pale-orange-weathering-, light-gray siliceous calc-silicate bands are present within what is interpreted to be the upper part of a metavolcanic unit of the Peavine sequence (L.J. Garside, unpub. data, 1991). There, 1-2 m wide bands of light-colored, finely laminated(?) and slump(?) folded rocks are present with a few beds of darker, tuffaceous siltstone in a sequence of rocks that are predominantly metabasalt. The siltstone and basalt are metamorphosed to spotted biotite-sericite hornfels and biotite semi-schist, apparently as a result of thermal metamorphism by a Cretaceous pluton exposed a few hundred meters to the east. The protolith of the calc-silicate bands is unknown but may be a calcareous siliciclastic sediment. Iron-rich sphalerite is present in the calc-silicate bands, with traces of chalcopyrite, pyrite, and, reportedly (Kaare and Barries, 1948), galena. The sulfide minerals are most likely skarn related, although a less likely interpretation is that the bands are metamorphosed siliceous zinc-bearing exhalites laid down in a marine setting. Fine slump(?) folding and sedimentary layering is preserved as alternating thin bands of fine-grained silica and epidote-group minerals, and poikiloblastic scapolite also is present.

Two samples of sphalerite-bearing ore taken from the Guy Walt's Zinc property (nos. 4524 and 4850), in addition to zinc, contain anomalous manganese, bismuth, and cadmium, moderately anomalous copper and cobalt, and no anomalous lead or silver. In one sample arsenic is anomalous, and tungsten is highly anomalous (appendixes 2 and 3). This geochemical suite, especially bismuth and tungsten, is more likely to be related to a skarn deposit than to a zinc-rich exhalite.

A finely laminated gossan exposed in Minnehaha Canyon in the southern Pine Nut Mountains (SE¼ sec. 29, T. 11 N., R. 22 E.) is reported to contain high zinc concentrations (D.M. Hudson, oral commun., 1987). Calc-silicate skarn minerals, including garnet, were noted at the locality, and the deposit is most likely a zinc-bearing skarn (J.G. Price, oral commun., 1989).

These deposits are inferred to be related to nearby Cretaceous intrusive bodies and, thus, are products of the Sierra Nevada metallogenic episode.

Barite Veins

Several barite vein deposits form a northwest-trending belt in the southeastern part of the study area, extending southeastward from the northern Gillis Range east of Walker Lake, Mineral County, Nevada. Most of the known barite veins have had little or no production. However, the Crystal vein may have produced as much as about 25,000 tons of barite (Papke, 1984, p. 106). Vein barite as a mineral is commonly rather pure, although most vein barite has inclusions of wallrock or contains varied amounts of quartz, calcite, and sulfide minerals such that selective mining has been required to produce an economic product. Most of these deposits are small northwest-striking veins, 0.3-1.5 m wide and generally less than 200 m long. The veins are in Mesozoic andesitic rocks, though a few of the smaller veins are in sedimentary rocks associated with the andesites.

In addition to barium, barite veins commonly are enriched in a number of metals including silver, lead, zinc, copper, arsenic, bismuth, and antimony. Barite may contain minor to major amounts of quartz and calcite gangue. Indeed, the barite-bearing veins appear to grade by increase in quartz and calcite into types that are essentially quartz or calcite veins. Metallic minerals present include galena, sphalerite, pyrite, chalcopyrite, and tetrahedrite-tennantite. Copper carbonate minerals are common.

The ages of formation of the barite veins is uncertain. Generally, ages are inferred on the basis of known ages of nearby intrusive rock. Therefore, the barite veins may be Cretaceous to Tertiary in age and may be the products of more than one metallogenic episode.

Uranium-Bearing Deposits

Uranium-bearing deposits in the study area are scarce, are of a variety of types, and are difficult to group into standard deposit models. However, most of the deposits can be classified as veins, although some deposits may also be closely associated with albitized zones in felsic plutonic rocks. Uranium production has been small and from only a few deposits in the region. A few tens of tons of ore, grading as high as 0.26 percent U_3O_8 and 2.8 percent Cu, have been shipped from the Flyboy claims in Lyon County, Nevada (Garside, 1973, p. 76).

Most of the vein deposits that have produced uranium were prospected for that metal; thorium is present in some of them. Other metals present in minor and varied amounts are copper, zinc, silver, and gold. A variety of uranium minerals has been identified in the vein and pegmatite deposits, including uranophane, uranothorite, kasolite(?), gummite(?), torbernite(?), autunite(?), and samarskite(?). The thorium minerals thorite and huttonite have been identified in some deposits. Quartz is a common gangue mineral; tourmaline is present in some uranium-bearing vein deposits. Sulfide minerals such as pyrite, chalcopyrite, galena, sphalerite, and molybdenite may be present, and where deposits are oxidized, copper carbonate and copper silicate minerals may be conspicuous (Garside, 1973).

Albitization of felsic intrusive rocks is common in the vicinity of uranium veins and pegmatitic bodies. Epidote is associated with albite in some altered zones (Garside, 1973).

No uranium deposits in the study area have been radiometrically dated. They are inferred to be Cretaceous or Tertiary in age on the basis of the known age of associated igneous rocks.

TERTIARY MINERAL DEPOSITS

Adularia-Sericite Epithermal Gold-Silver Veins

The renewed interest in gold-silver deposits in the past decade has resulted in a very large number of individual descriptions of epithermal deposits. As a consequence, there has been an increase in knowledge of deposit types and in the development and refinement of models for these deposits (Buchanan, 1981; Giles and Nelson, 1983; Hayba and others, 1985; Mosier and others, 1986; Heald and others, 1987; Bonham, 1988). Epithermal mineral deposits have been divided by many authors into high and low sulfidation types on the basis of vein and alteration mineralogy (see Hayba and others, 1985). The low sulfidation type is commonly referred to as the adularia-sericite type because of the common presence of adularia in vein and wallrocks and sericite in the wallrocks adjacent to the veins.

In the study area, there are at least a dozen mining districts in which the majority of production comes from epithermal mineral deposits of the adularia-sericite type. Except for the Comstock Lode mining district (fig. 2; appendix 1), nearly all of the mineralization is contained completely or almost completely within the closely associated Tertiary volcanic host rocks. The discussion of these other mining districts is beyond the scope intended for the present report, which is mineral deposits hosted in rocks of the Triassic to Jurassic arc.

The Comstock Lode mining district, which includes the Gold Hill and Silver City areas to the south of the main part of the lode, is an epithermal deposit of the adularia-sericite (quartz-adularia) or low sulfidation type. Since its discovery in 1859, it has produced more than 8 million ounces of gold and 190 million ounces of silver (Bagby and Ashley, 1990). Mineralization in the mining district was concentrated along and in the hanging wall of the north-northeast-striking, east-dipping Comstock fault. The fault is at least 11 km long and is intersected near its southern end by the northwest-striking Silver City fault, which is over 3 km long (Bonham, 1969; Gianella, 1936). In the northern part of the Lode, mineralization and accompanying hydrothermal alteration took place mainly in the Tertiary volcanic rocks exposed at the surface; however, pre-Tertiary metasedimentary (Gardnerville? Formation) and metavolcanic rocks are cut by epithermal veins in the underground workings. Near Silver City, exposed Mesozoic rocks are also mineralized, especially along the Silver City fault (Becker, 1882; Gianella, 1936).

Bonanza ores of the Comstock Lode are present sporadically along zones of crushed quartz stockworks that make up the veins of the Lode and other mineralized structures. The ores consist of quartz, with sparse to abundant calcite, and contain abundant sphalerite, galena, chalcopyrite, and pyrite accompanied by lesser amounts of argentite, gold, and polybasite (Bonham, 1969). In the Silver City veins, sulfide contents typically are less (1-2 vol. pct.), but the character of the mineralized rocks is similar. Adularia is present in veins in the Comstock Lode as well as in the Occidental Lode, a parallel mineralized structure 2.5 km to the east. Vikre (1989) describes four hydrothermal alteration assemblages that have formed in rocks of the mining district. Propylitic alteration effects are widespread, have only a general relation to mineralized zones, and may be somewhat older than the Miocene vein mineralization. Zeolitic alteration was locally superimposed on propylitic alteration, but also had little spatial association to ore mineralization. Quartz-alunite (± pyrophyllite and diaspore; Bagby and Ashley, 1990) alteration was extensive in the northern Virginia Range. In the Virginia City-Silver City area, this alteration assemblage appears to be cut by veins of the Comstock Lode and in the vicinity of the Lode is generally older (Vikre and others, 1988).

Vikre (1989) considers the quartz-sericite-adularia alteration assemblage that is directly associated with the Comstock Lode and its associated veins to have been the youngest alteration event there. However, a younger (12-9 Ma) quartz-alunite alteration event is documented at several mineralized areas northwest of the Comstock Lode in the Virginia Range (Vikre and others, 1988).

Hudson and Smith (1991) describe the only published detailed geochemical study of the Comstock mining district. It represents multielement analyses of nearly 250 oxidized surface samples. They found that positive silver and gold anomalies are restricted to the lodes. Additionally, altered wallrocks (other than propylitized rocks) in the Comstock Lode and, in general, the Silver City and Occidental Lodes were found to be enriched in arsenic, cadmium, mercury, molybdenum, lead, thallium, boron, bismuth, copper, antimony, and tellurium, relative to unaltered rocks. In some areas manganese, zinc, and fluorine are also enriched. Cobalt, nickel, and in some areas barium, fluorine, manganese, and zinc are reported to be depleted. Propylitically altered rocks show little variance from unaltered rocks except for slight enrichment of fluorine and locally, thallium (Hudson and Smith, 1991). The most consistent indicator (pathfinder) elements in the lodes appear to be thallium, silver, gold, and arsenic.

Although there is some dispute concerning the details of the timing of alteration and mineralization on the Lode and other mineralizing systems of the area, K-Ar ages of about 13 Ma on adularia from the Comstock and Occidental Lode appear to be reasonable estimates of the age of main-stage mineralization (see Vikre and others (1988) for a recent summary of K-Ar and fission track dates). The Comstock and other adularia-sericite gold-silver veins in the area are products of a Tertiary magmatic-hydrothermal episode that affected a large part of the Great Basin (Seedorff, 1991; Cox and others, 1991).

Quartz-Alunite Epithermal Gold-Silver Veins

The quartz-alunite type of epithermal deposit (also called high sulfidation, acid sulfate, or enargite-gold) has been described by a number of authors as being distinct from a low-sulfidation or adularia-sericite type (Ashley, 1982; Bonham and Giles, 1983; Heald and others, 1987; Mosier and others, 1986; Bonham, 1988; Sillitoe, 1993). This type of alteration is characterized by extensive areas of silicified, argillized, and alunitized rocks (usually intermediate-composition volcanics; for example, Hall, 1982) and the common presence of enargite-group minerals in the ore.

In the study area there are 10 to 12 areas of extensive argillically altered (and locally advanced argillic) rocks mainly in Tertiary andesitic volcanic rocks. Some of these areas have not been studied in enough detail to confirm their association with a high-sulfidation state mineralizing system, but a number are clearly of this type. Of these, only the Peavine mining district northwest of Reno (fig. 2; appendix 1) is known to contain significant mineral deposits associated with advanced argillic alteration in the Triassic to Jurassic arc rocks described in this report .

The Peavine mining district has recorded production of only about 1,200 oz of gold, 76,000 oz of silver, 187,000 pounds of copper, and 43,000 pounds of lead (Bonham, 1969). Actual production has probably been more, because data are incomplete; however, an unknown amount of production from Mesozoic Cu-Au quartz-tourmaline veins and skarn-hosted mineralization in the mining district is also included. The district consists of numerous mines and prospects within a large area of predominantly argillically and advanced argillically altered rocks on the south and east flanks of Peavine Peak. This altered area extends eastward, across the hills north of Reno, to the area of the Wedekind Mine in the mining district of the same name. U.S. Highway 395 can be considered the dividing line between districts, although they are probably parts of the same mineralizing system (see Hudson, 1977).

Peavine Peak consists of metavolcanic and metavolcaniclastic rocks of the Jurassic(?) Peavine sequence which are intruded by Cretaceous granodiorite (Bell and Garside, 1987). The Mesozoic rocks are overlain by Miocene andesite flows and cut by andesite and microdiorite plugs, all of which are at least locally altered hydrothermally.

Within this area, irregular to linear silicified zones, commonly composed of hydrothermal breccias, are surrounded by bleached, white and reddish argillized rocks. The bleached, light-colored rocks are derived from rocks that have been affected by both hypogene hydrothermal alteration and supergene alteration of pyritic rocks. Mineralization was apparently concentrated in only a few of these silicified zones, possibly where late gold-silver plus base-metal-bearing fluids were able to permeate through the rocks.

The ore minerals in the Peavine mining district apparently are present as disseminations and breccia fillings (Hudson, 1977); distinct, sharp-walled veins are uncommon. Quartz is the most common gangue mineral and barite is rarely observed. Hypogene ore minerals include pyrite (by far the most abundant sulfide), tetrahedrite, chalcopyrite, enargite, sphalerite, and galena.

The hydrothermally altered area extending from Peavine Peak to the Wedekind mining district is nearly 20 km long and 5 km wide. Hydrothermal alteration appears to have been generally associated with the Miocene andesite and microdiorite plugs. According to Hudson (1977), alteration zones consist of an inner assemblage, commonly in a hydrothermal breccia zone, of quartz, alunite, diaspore, and pyrite or hematite. Outward from this zone, Hudson (1977) reports envelopes of progressively less intense alteration, the first of which consists of quartz, pyrophyllite, dickite, diaspore, and pyrite. A sericitic alteration envelope is next (quartz, sericite, pyrite, and rutile), followed by propylitic alteration assemblage (calcite, epidote, clinozoisite, kaolinite, chlorite, rutile, actinolite, sericite, albite, and montmorillonite).

Geochemical sampling of select mineralized rocks in the Peavine and adjacent related Wedekind mining district (Quade and others, 1990b) demonstrates the presence of a suite of elements typically found in this deposit type (Bonham, 1988). Elements noted as anomalous in samples of vein and mineralized wallrocks include copper, zinc, lead, gold, silver, arsenic, antimony, and barium. Additionally, sporadic anomalous concentrations of bismuth and tin are found.

Potassium-argon ages on alteration minerals and overlying unaltered volcanic units indicate that the age of mineralization most likely is 15-16 Ma (Garside and others, 1993). As with adularia-sericite gold-silver veins described above, quartz-alunite gold-silver veins in the study area are products of a Tertiary magmatic-hydrothermal episode that affected a large part of the Great Basin (Seedorff, 1991; Cox and others, 1991).

ROCK GEOCHEMISTRY

Introduction

The rock geochemistry data base consists of 360 "mineralized" rock samples from Triassic- to Jurassic-hosted mines and prospects in the study area. Of these, 185 were collected as part of a previous study (Tingley, 1990; Quade and others, 1990b) and 175 were collected during this study (appendixes 2 and 3). All analytical data were subdivided by deposit type and analyzed statistically. In most cases, frequency distributions are highly skewed and therefore the median was used to approximate an "average" value (see table 1). A summary of minor and trace element abundances for various deposit types is illustrated in the histograms of figure 4 and addressed in the deposit-type descriptions above.

Analytical Methods

Samples were analyzed at the USGS analytical facilities in Denver, Colorado, and in a USGS mobile lab in Reno. Semiquantitative 35-element DC-ARC atomic emission spectroscopy (DC-ARC AES) was used in the analyses for Ag, B, Ba, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, W, and Zn. Inductively coupled plasma atomic emission atomic emission spectroscopy (ICP-AES) was used in the analyses for As, Bi, Cd, and Sb. Flame atomic absorption (Flame AA) was used in the analysis for Au.

Statistics

Only those deposit types with a statistically significant number of samples are shown in the histograms of figure 4. Sample population sizes are shown in table 1. Furthermore, only those elements that have a significant number of unqualified values are plotted (for example, Sn and W are commonly at or below their detection limits and, thus, are not presented here). In order to include all samples in the statistical analysis, qualified values (values noted as below lower detection limits and values noted as above upper detection limits) were quantified. Values noted as below the lower detection limit were assigned a value of 0.7x(lower detection limit). Values noted as above the detection limit were assigned a value of (upper detection limit)/0.7.

An R-mode factor analysis was conducted on the two most diversified data sets, polymetallic veins, undivided and Au veins, undivided to determine if geochemical subdivisions could be identified and correlated with vein deposit subtypes known to be present. Optimum solutions were selected on the basis of correlation coefficients of element pairs, the value of correlation of elements for each factor (factor loading), as well as expected element correlations of element suites.

A six-factor solution was selected as the optimum solution for the polymetallic vein data set. The element suites for each factor are as follows:

1: Pb, Zn, Cd, Ag, Sb
2: W, Mo, Bi
3: Cr, Ni
4: Fe, Co, Sn
5: Ba, Ti, Ag
6: Au, As

The metal associations in factors 1, 2, and 6 consistently hold together from a nine-factor solution through a six-factor solution. Factor 1 is consistent with true polymetallic veins, and more specifically carbonate-hosted Pb-Ag veins. Factor 2 is consistent with W-Mo veins, factor 6 with Au-bearing polymetallic veins, and factor 5 with argentiferous barite veins. Factors 3 and 4 may have no significance, may simply reflect strong elemental affinities (such as, Cr-Ni and Fe-Co), or may reflect a mafic to intermediate composition host rock.

A seven-factor solution was selected as an optimum solution for the Au veins data set. The element suites for each factor are as follows:

1: Bi, Ag, Pb, Sb, Cu
2: Au, W, Co, Cu, B
3: Cd, Zn, Cr
4: Ti, Ba, Sn
5: As, Fe, B
6: Ni, Cr, Co
7: Mn, Mo

The metal associations in factors 1 and 2 consistently hold together from a ten-factor solution to a seven-factor solution. Factor 1 is consistent with veins containing argentiferous galena and (or) tetrahedrite and is similar to factor 1 for the polymetallic vein set. Factor 2 is consistent with Cu-Au quartz-tourmaline veins, which indicates that there are vein deposits classified as Au veins, undivided that may have chemical affinities to Cu-Au quartz-tourmaline veins.

Conclusions

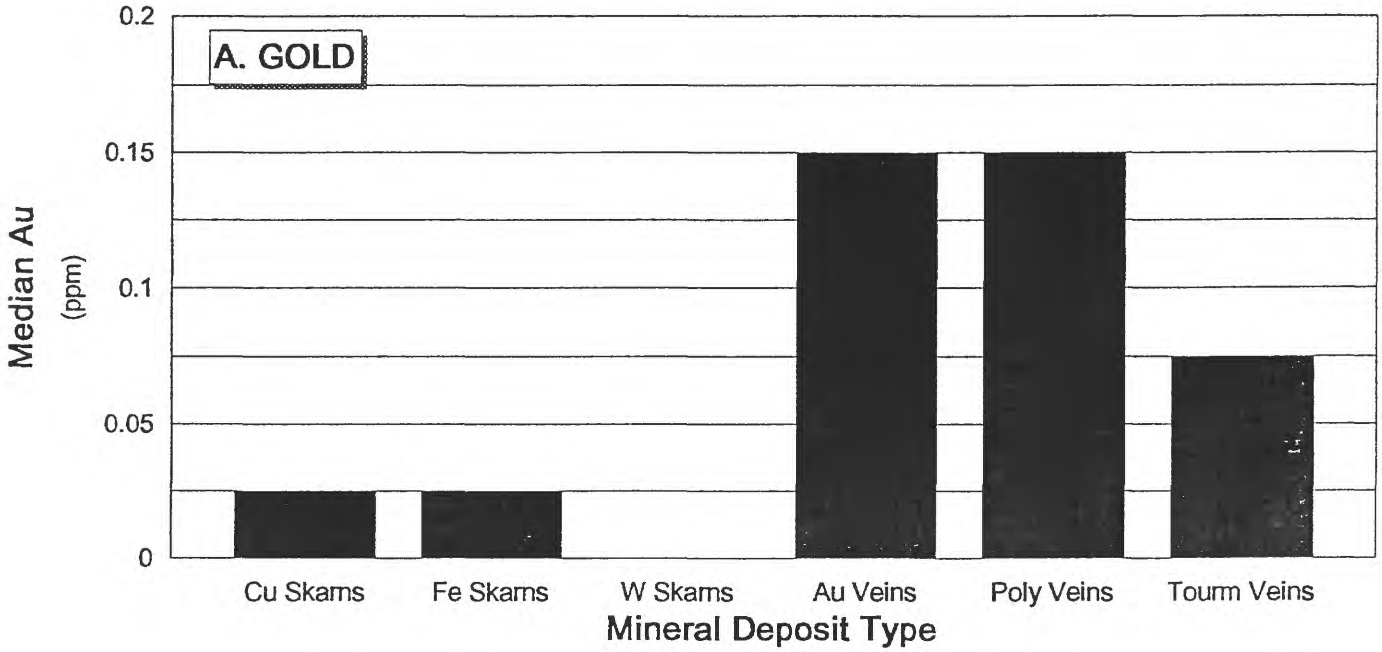
A review of geochemical data for samples collected from mines and prospects in the study area shows that (1) copper skarns have elevated values of silver and bismuth, relative to other types of skarn deposits (fig. 4), (2) tungsten skarns have elevated values of zinc, manganese, and molybdenum relative to other deposit types sampled (fig. 4), and (3) copper and iron skarns have elevated values of nickel, and iron skarns have extremely elevated values of cobalt, relative to other deposit types sampled (fig. 4). These conclusions are considered preliminary as some of the sample populations are small. Furthermore, R-mode factor analysis of data from large diverse data sets, such as polymetallic veins, yielded results consistent with known associations in the field and may be useful in subdividing large diverse deposit-type classifications into more geochemically specific deposit-type classifications.

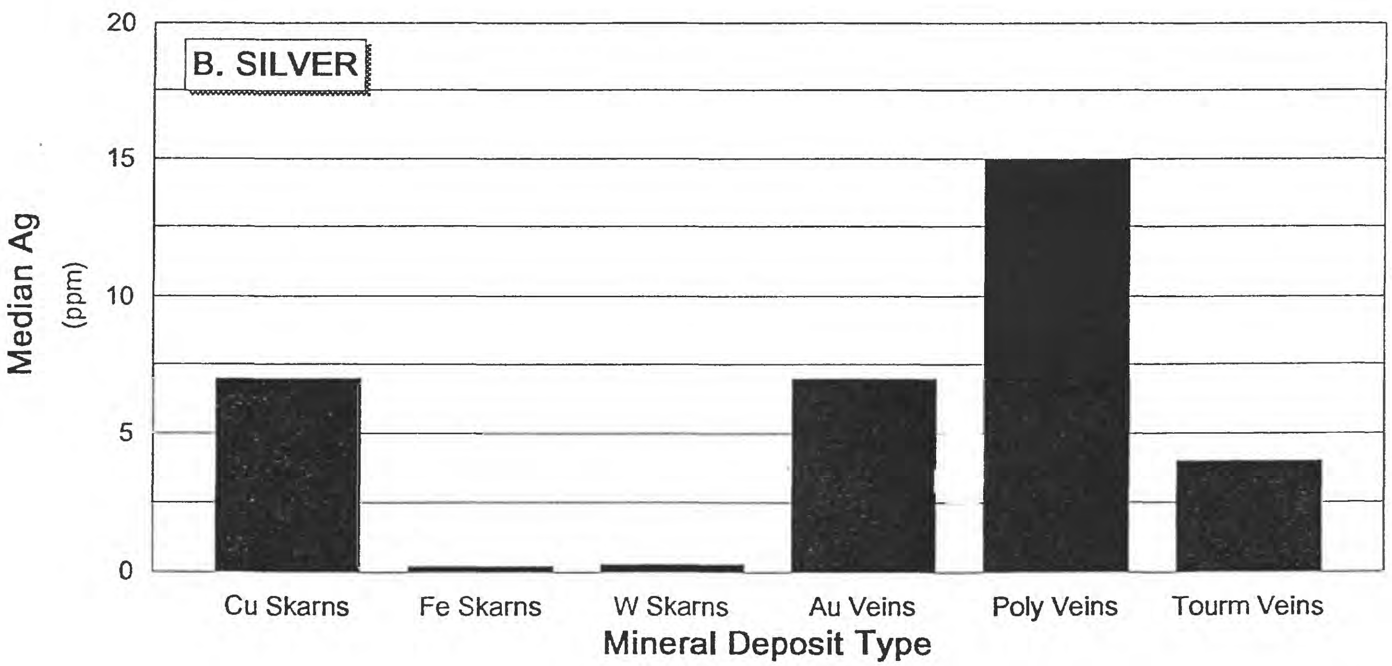
Table 1.--Median abundances of minor and trace metals for selected mineral deposit types.

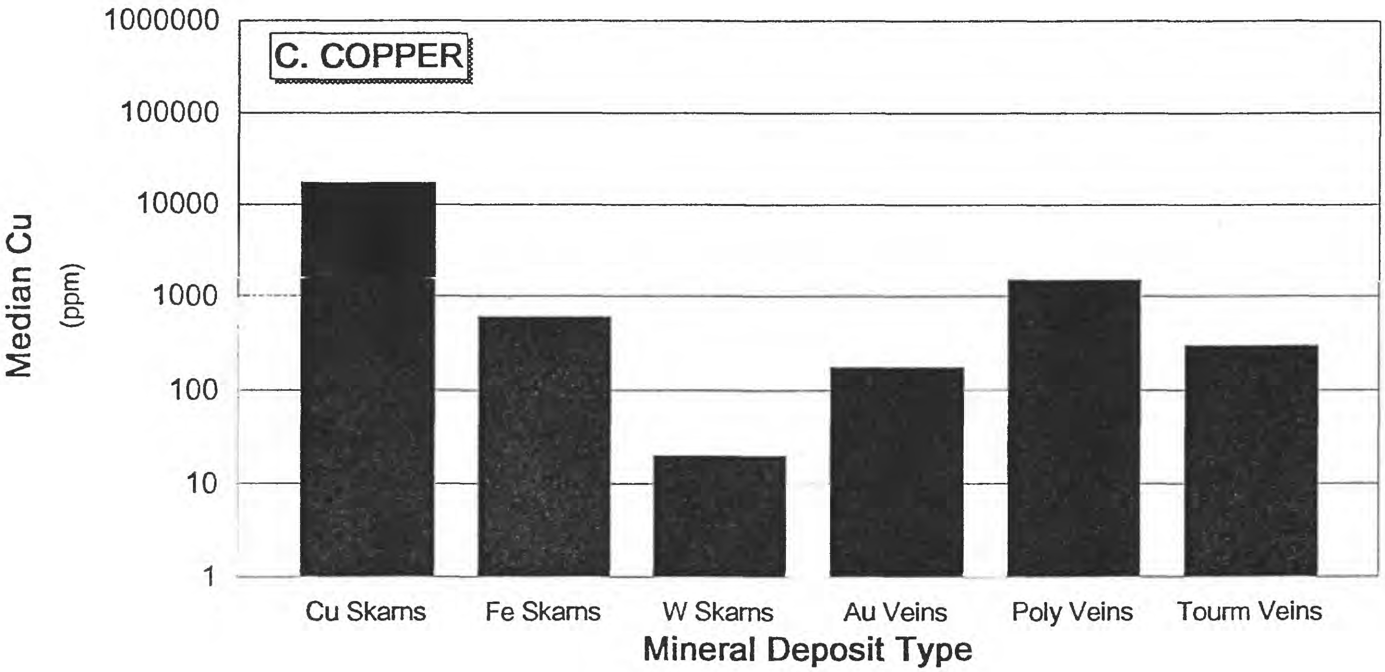
(All values in parts per million (ppm); Ag, B, Ba, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, W, and Zn by semiquantitative 35-element DC-ARC atomic emission spectroscopy; As, Bi, Cd, and Sb by inductively coupled plasma atomic emission spectroscopy; Au by flame atomic absorption; L is less than lower detection limit indicated in parentheses; n is sample population size. Skarn deposits: copper, iron, and tungsten. Vein deposits: Au (undivided), polymetallic (poly), and Cu-Au quartz-tourmaline (tourm)).

	Cu Skarns	Fe Skarns	W Skarns	Au Veins	Poly Veins	Tourm Veins
n	18	16	20	68	125	40
Au	0.025	0.025	L(0.05)	0.15	0.15	0.075
Ag	7.	0.25	0.3	7.	15.	4.
Cu	17500.	600.	20.	175.	1500.	300.
Pb	30.	15.	30.	50.	100.	17.5
Zn	100.	100.	140.	100.	100.	100.
As	51.	8.15	3.2	56.	66.	20.
Sb	24.	1.9	0.5	5.65	32.	2.
Bi	33.5	2.55	1.1	1.55	2.4	1.05
Cd	1.15	0.225	0.68	0.25	1.3	0.16
Ba	60.	10.	85.	300.	500.	200.
B	7.5	5.	5.	20.	20.	2000.
Mn	850.	300.	3000.	500.	500.	200.
Mo	2.5	2.5	20.	5.	2.5	3.5
Cr	7.	17.5	7.	10.	10.	10.
Ni	20.	30.	4.2	4.25	3.5	10.
Co	20.	50.	7.	10.	10.	20.

Figure 4. Median abundances of minor and trace metals for selected mineral deposit types. Skarn deposits: copper, iron, and tungsten. Vein deposits: gold (undivided), polymetallic (poly), and copper-gold quartz-tourmaline (tourm). Note that figures C, E, and H have logarithmic scales. A, gold. B, silver. C, copper. D, lead and zinc. E, arsenic, antimony, and bismuth. F, cadmium. G, barium. H, boron and manganese. I, molybdenum. J, chromium, nickel, and cobalt. Note that histograms for copper, arsenic, antimony, bismuth, boron, and manganese have logarithmic scales. Sample population size used in determining median values are as follows: copper skarns, n=18; iron skarns, n=16; tungsten skarns, n=20; gold veins, undivided, n=68; polymetallic veins, n=125; copper-gold quartz-tourmaline veins, n=40.







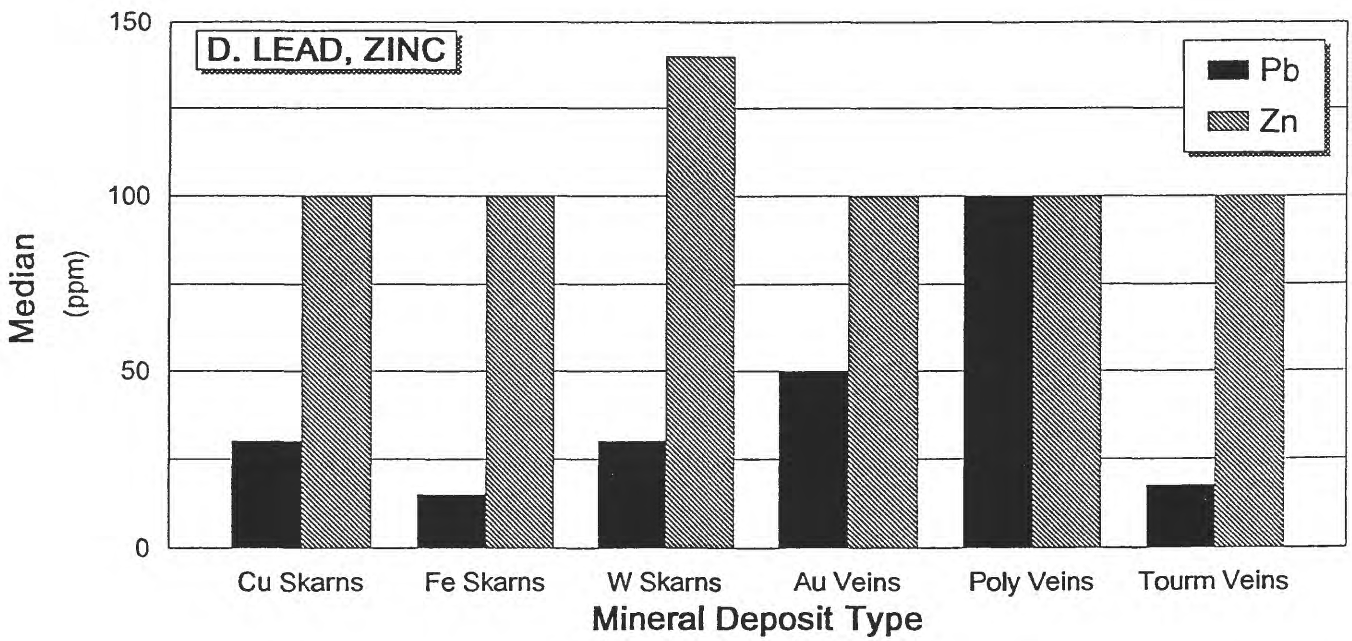


Figure 4. Continued

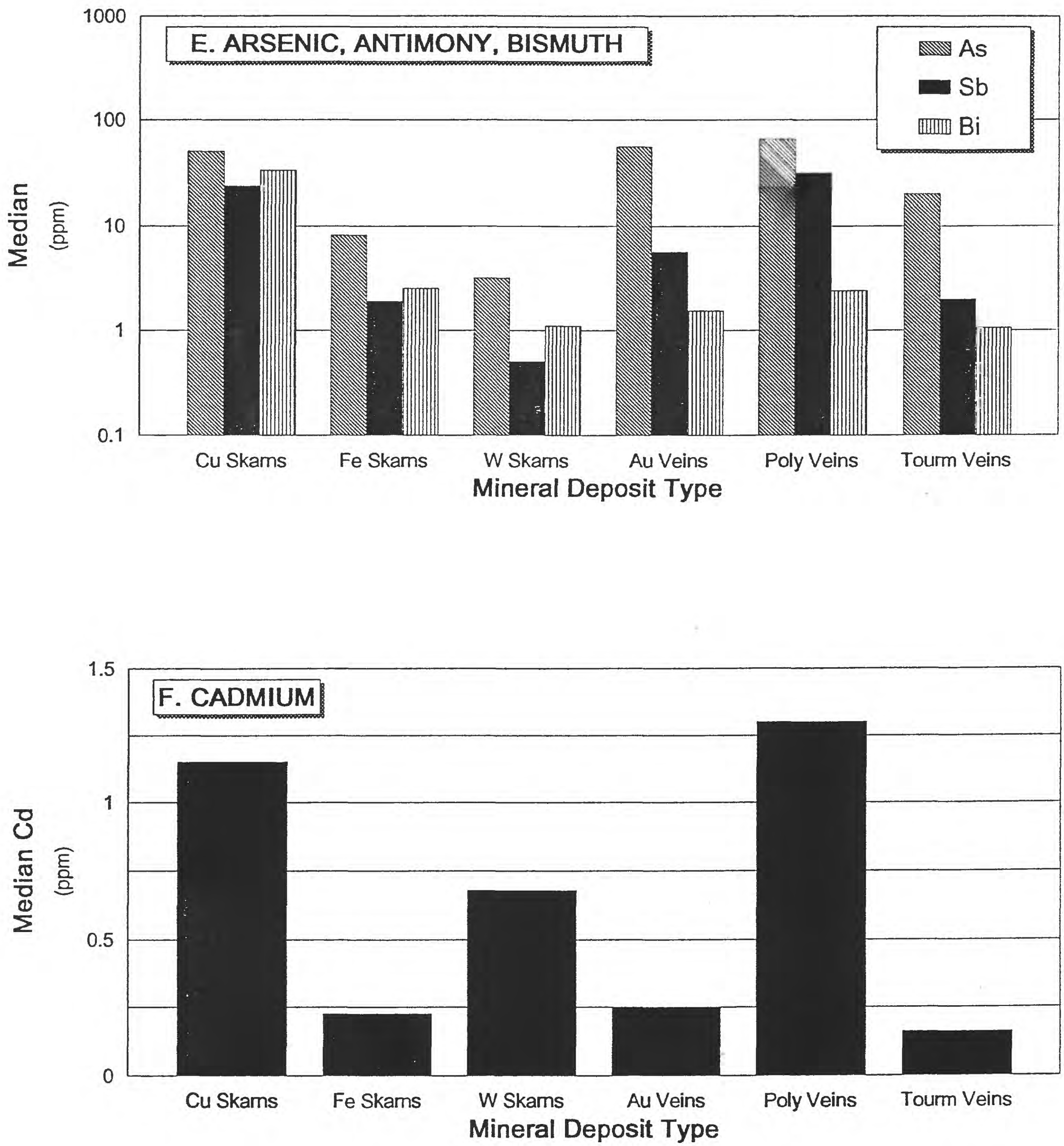
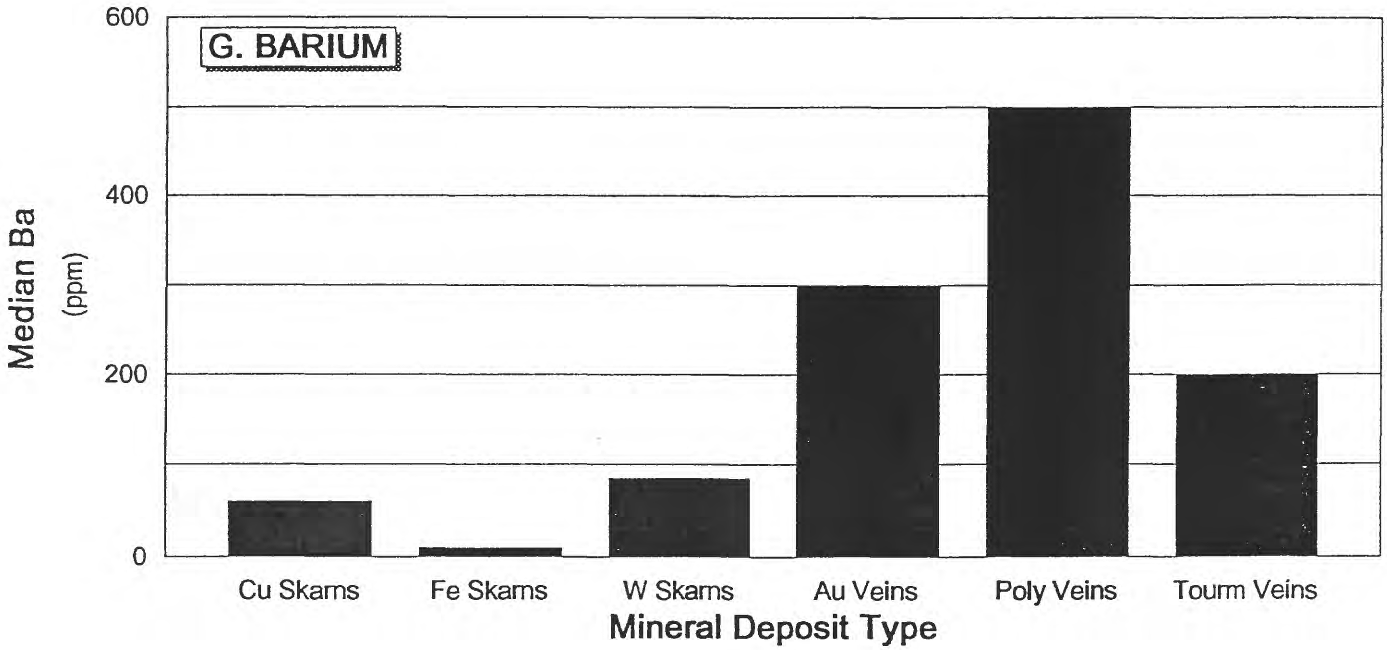


Figure 4. Continued.



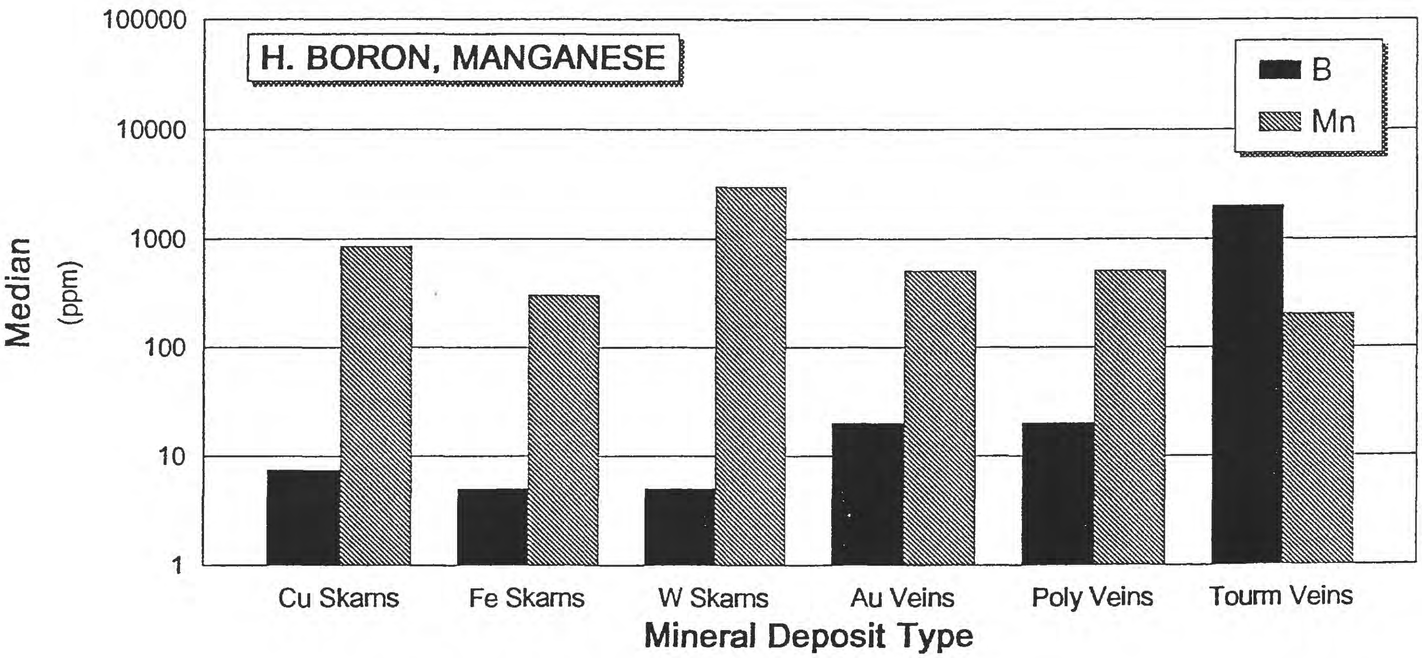
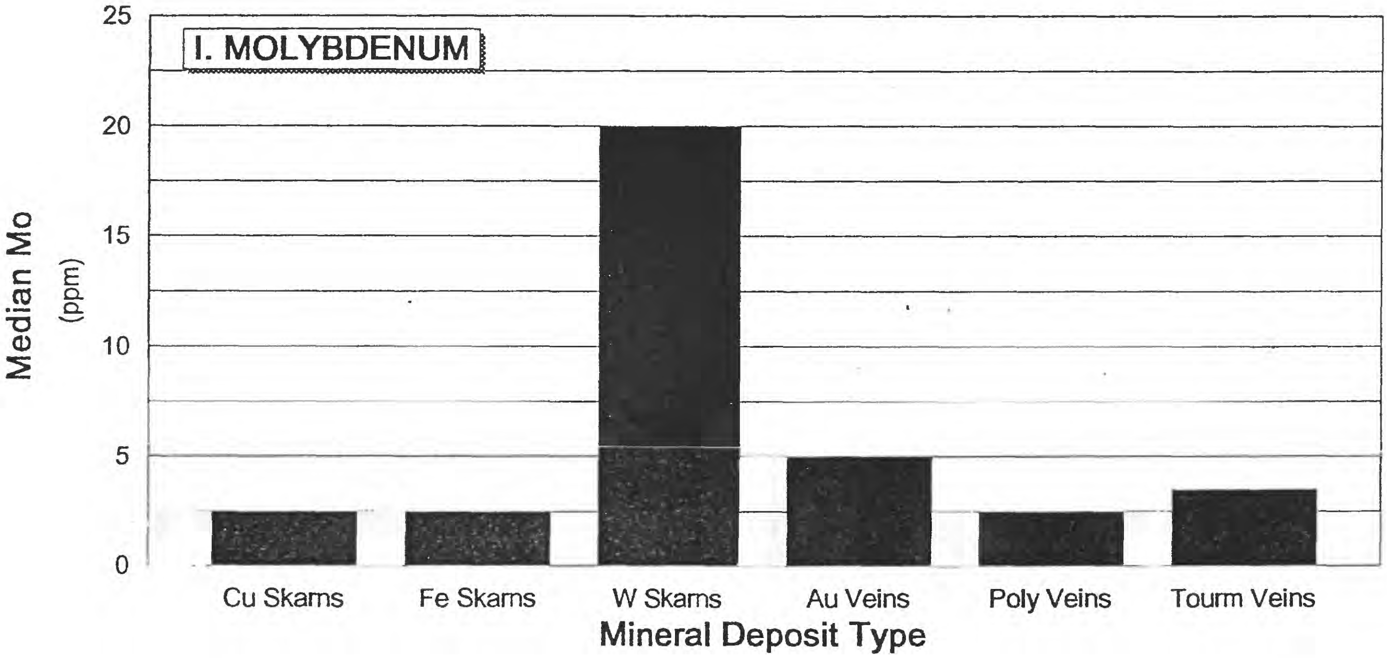


Figure 4. Continued.



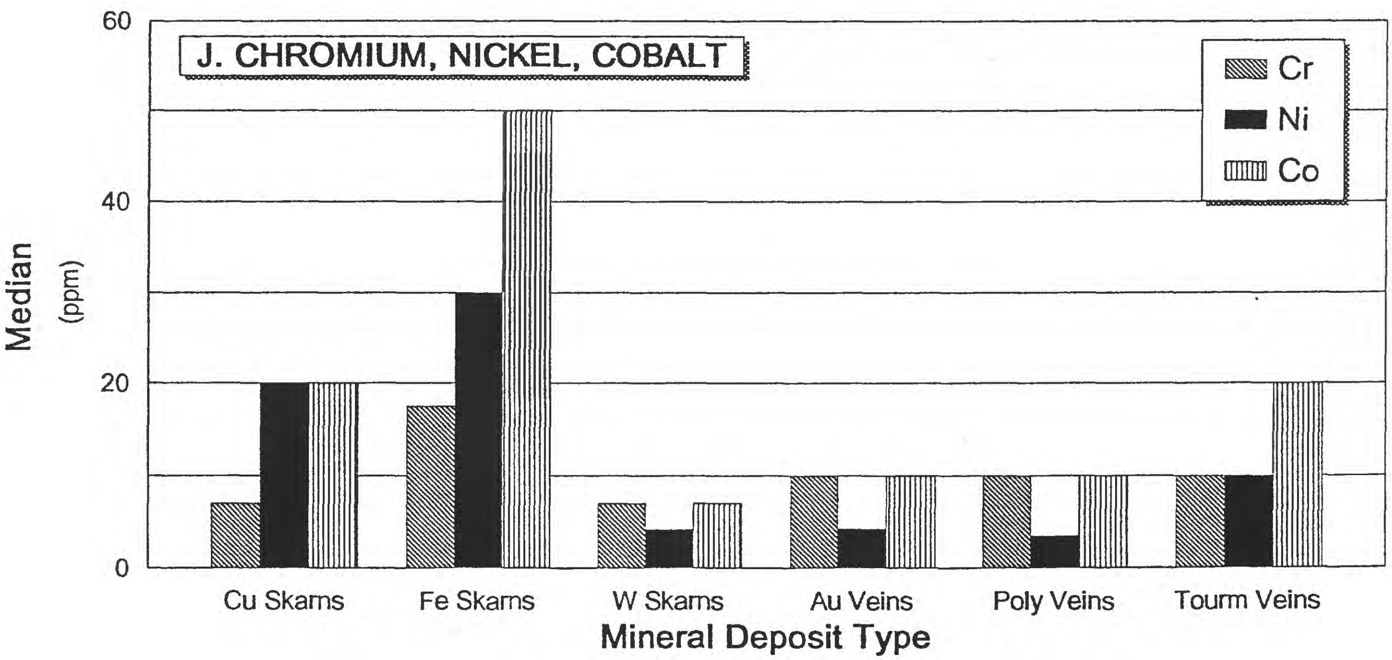


Figure 4. Continued.

THE APPARENT ABSENCE OF VOLCANOGENIC MASSIVE SULFIDE DEPOSITS--A DISCUSSION

There are no known volcanogenic massive sulfide (VMS) deposits within the study area. Though previous investigations have suggested that some occurrences might be VMS type deposits (Sherlock, 1989), all such localities were visited and found to be epigenetic deposits and unrelated to any potential VMS mineralizing system. These include the occurrences at Fred's Mountain (Cu-stained shear zones in biotite schist), the Antelope Mine (Cu-Au quartz tourmaline veins), the Red Metals Mine (volcanic-hosted(?) Cu skarn and Cu-Au quartz-tourmaline veins), the Utopian Mine (Cu-Au quartz-tourmaline veins), and the Minnehaha gossan (magnetite zinc-bearing(?) skarn).

An understanding of the geologic setting of the Triassic to Jurassic arc rocks of the study area reveals several factors that indicate these rocks are unfavorable for the occurrence of VMS deposits. These are (1) the dominance of shallow submarine and subaerial volcanism, (2) the scarcity of proximal volcanism in deep restricted basins, and (3) the lack of identified submarine felsic volcanic centers.

As in most continental-margin magmatic arcs, the Triassic to Jurassic volcanic rocks in the study area were deposited in a subaerial to shallow marine environment (Schweickert and others, in press b). The shallow, near-shore, high-energy environment is not conducive to the formation and preservation of VMS deposits. Should there be phreatic eruptions and associated hydrothermal fluid expulsion in the near-shore environment, the lack of hydrostatic pressure would cause dispersal of metalliferous fluids and prevent the accumulation of sulfide minerals on the sea floor (Sawkins, 1990). Furthermore, the high-energy nature of the near-shore environment and the associated constant influx of terrigenous material would cause dilution and erosion of any accumulating sulfide material.

The Early to Middle Jurassic Gardnerville and Sailor Canyon Formations represent accumulations of epiclastic and volcanogenic sediments, with minor distal volcanic and volcaniclastic materials, that were locally deposited in deep restricted basins (Schweickert and others, in press b). These formations might be expected to host Besshi-type VMS deposits (Cox, 1986c). However, within the study area, the scarcity of any evidence of proximal volcanism within these sedimentary sequences precludes the occurrence of such deposits. Besshi-type deposits, although sediment-hosted, are related to submarine magmatic activity, as are all VMS deposits. Consequently, most Besshi-type deposits are not far removed, laterally or stratigraphically, from volcanic rocks, usually pillow basalt or mafic sills. Examples of Besshi-type VMS deposits are the Rio Tinto (Mountain City) deposit in northern Elko County, Nevada (Coats and Stephens, 1968), and the Green Mountain deposit in the southern Foothills copper belt, California (Mattinen and Bennett, 1986). At the Rio Tinto deposit, VMS ore is present within carbonaceous shales of the Ordovician Valmy Formation. The Valmy Formation consists mostly of epiclastic and carbonate rocks but also contains subordinate pillow basalt and diabase (Coats and Stephens, 1968). At the Green Mountain deposit, a VMS sheet-like body is present within the epiclastic rocks of the Jurassic Mariposa Formation. However, coeval mafic sills indicate proximity to a magmatic heat source. Mattinen and Bennett (1986) propose that the Green Mountain deposit formed within a back-arc basin that received clastic material from both a magmatic-arc and continental source.

The lack of identified submarine felsic volcanic centers within the Triassic to Jurassic arc rocks of the study area further diminishes the potential for the occurrence of volcanic-hosted

VMS deposits in these rocks. All Triassic to Jurassic rhyolitic units are believed to be either subaerial, intrusive into subaerial volcanic rocks, or shallow submarine (Schweickert and others, in press b). A strong and consistent association between VMS deposits (excluding Besshi-type) and submarine felsic magmatism exists worldwide, regardless of tectonic setting. Kuroko-type deposits (Singer, 1983b) exhibit an undisputed affiliation with explosive felsic volcanism (Sato 1974; Ohmoto and Takahashi, 1983; Spence and deRosen-Spence, 1975). Even Cyprus-type deposits (Singer, 1983a) are now being shown to exhibit temporal and spatial associations with felsic (or fractional differentiated) magmatism (Alabaster and Pearse, 1985; Mukasa and Ludden, 1987; Kelly and Robinson, 1990). The VMS deposits of the West Shasta (Devonian) and East Shasta (Permian to Triassic) mining districts, California, are present within island arc complexes and are hosted by rhyolite units that overlie mafic to intermediate volcanic rocks (Albers and Robertson, 1961; Albers and Bain, 1985; Doe and others, 1985). The Middle to Late Jurassic VMS deposits of the Foothills copper belt, California, are present within a mature ensimatic magmatic arc and are all related to submarine calc-alkalic felsic volcanic centers that overlie and interfinger with mafic to intermediate tholeiitic volcanic rocks (Kemp, 1982).

The absence of exposed VMS deposits in the study area does not preclude the possibility that they may be concealed within the study area or be present in coeval arc rocks outside the study. In the northern Sierra Nevada, the Middle to Late(?) Jurassic Tuttle Lake Formation conformably overlies the deep distal basinal epiclastic and tuff deposits of the Sailor Canyon Formation. Recent work in the English Mountain area, in the northwestern part of study area, has indicated that the Tuttle Lake Formation consists of debris flows generated by slumping parts of a nearby vent and (or) were produced by local phreatic explosions that blasted apart hypabyssal intrusions at shallow levels beneath the seafloor (Templeton and Hanson, 1991). Further examination of the Tuttle Lake Formation for VMS-type occurrences would be feasible. Several VMS occurrences are located in the Late Triassic to Middle Jurassic Happy Creek Volcanic Complex in the Jackson Mountains, Humboldt County, northwest Nevada (Sherlock, 1989; Sorensen and others, 1987; Russell, 1984). The Happy Creek Volcanic Complex is interpreted to be an intra-oceanic magmatic arc that formed on the lower slope-basinal margin of the North American craton (Russell, 1984). Additional VMS occurrences are located in a Permian to Triassic volcano-sedimentary rock sequence in the South Pueblo Mountains of Humboldt County, Nevada, and Harney County, Oregon (Howard, 1974). However, if VMS deposits are concealed within the study area, they will most likely be found associated with yet unrecognized, relatively deep submarine felsic volcanic centers (Kuroko-type) or proximal mafic-volcanic-rock-bearing submarine sedimentary sequences (Besshi-type).

SUMMARY

The deposit-type characterizations presented above outline changes in style of hydrothermal mineralization through time. Each of the three metallogenic episodes defined above are characterized by a distinct group of mineral deposit types. However, the presence or absence of any particular deposit type may be a function of current level of erosion.

The Middle Jurassic Yerington metallogenic episode is characterized by porphyry copper deposits and related copper skarn and iron skarn deposits. These deposits are all associated with the Yerington batholith, which was emplaced at relatively shallow depths ($\leq$2.5 km) (Dilles, 1987) (fig. 3). The presence of molybdenite-bearing intrusive rocks and stockwork veins, and tungsten skarns, associated with Late Jurassic stocks (fig. 3), suggests that there was an evolution from copper-iron porphyry-skarn systems to molybdenum-tungsten porphyry skarn systems through time in the Jurassic. This would be consistent with a magmatic arc that was thickening and maturing through time.

The Cretaceous Sierra Nevada metallogenic episode is characterized by low-F porphyry molybdenum deposits and related tungsten skarn and vein deposits, and Cu-Au quartz-tourmaline veins, all of which are related to the emplacement of the Sierra Nevada batholith. These deposit types generally reflect higher temperatures and greater depths of emplacement, relative to deposit types associated with the Middle Jurassic Yerington batholith. This is a function of exposure of the more deeply eroded parts of the Cretaceous Sierran arc.

The Tertiary Great Basin metallogenic episode is characterized by high-level epithermal gold-silver vein deposits. These deposits are products of a magmatic-hydrothermal episode that was widespread throughout the Great Basin. These deposits probably represent the only non-arc-related mineral deposits in the study area and are probably related to extension-driven magmatism (Seedorff, 1991).

MINERAL SYSTEMS

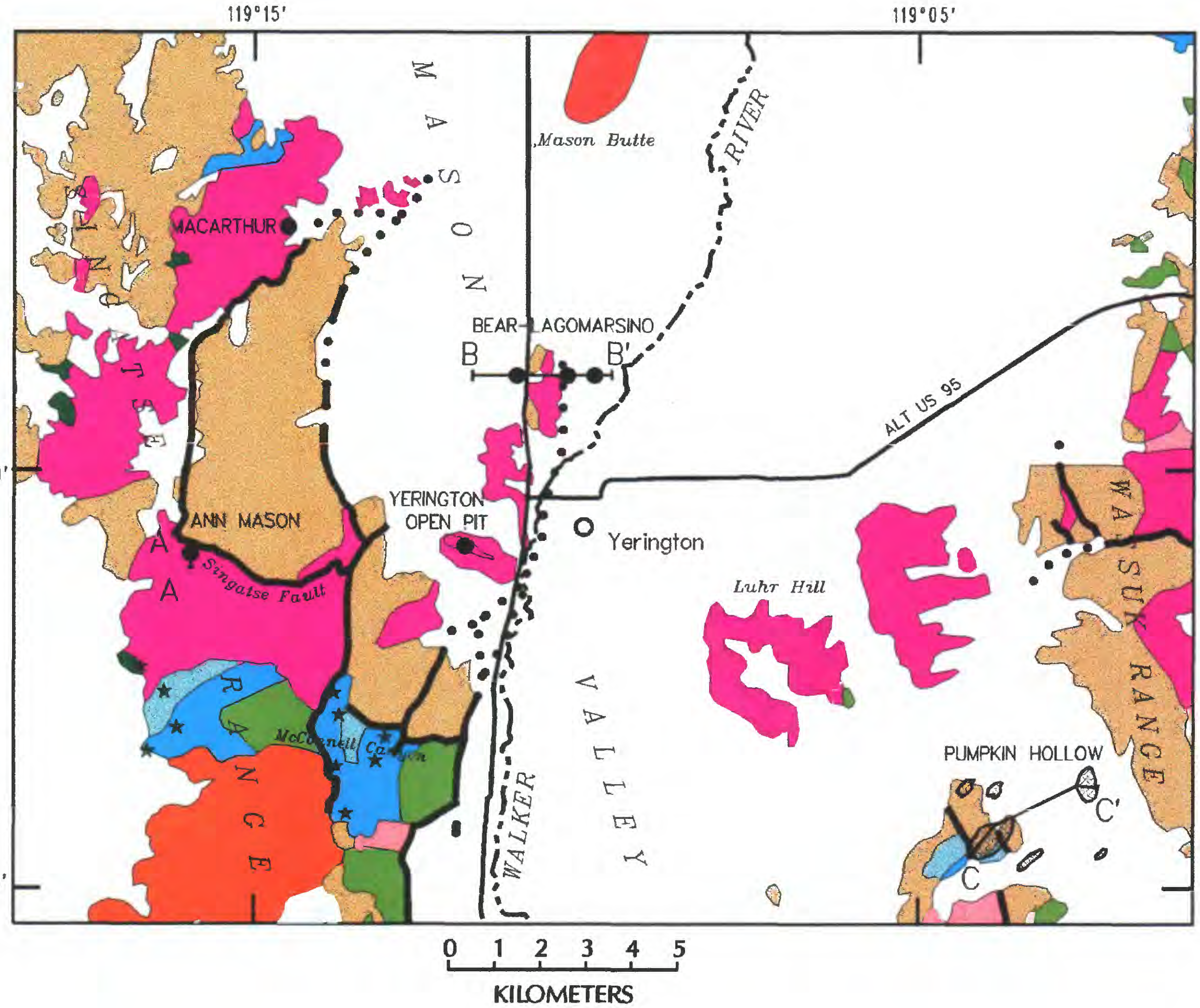
The following are descriptions of several mineral systems hosted by the Triassic to Jurassic arc rocks in the study area. A mineral system is here defined as a spatial concentration of generally coeval and cogenetic mineral deposits with a characteristic geochemical signature. Thus, a mineral system may consist of a variety of mineral deposit types.

YERINGTON SUPERSYSTEM

Yerington Batholith

The Yerington supersystem is here defined as all mineral systems associated with the emplacement of the Yerington batholith. The Yerington batholith is a 168- to 169-Ma composite plutonic suite (Dilles and Wright, 1988) that was emplaced into a folded succession of Late Triassic to Early Jurassic volcanic and sedimentary rocks (volcanics of McConnell Canyon, limestones of Mason Valley and Ludwig, Gardnerville Formation, and volcanics of Artesia Lake) in the east-central part of the study area. Late Tertiary normal faulting and tilting has rotated blocks 60°-90° westward so that a structural cross section of the batholith, with stratigraphic tops to the west and representing paleodepths of 0 to 8 km, is now intermittently exposed from the Pine Nut Mountains on the west, through the Buckskin Range and Singatse Range, to the northern Wassuk Range on the east (fig. 5) (Dilles, 1987; Geissman and others, 1982; Proffett, 1977). The batholith has a plan area of approximately 250 km^2 (after removal of Tertiary extension), with dimensions of 12x25 km elongated in a west-northwest to east-northeast direction (Dilles, 1987).

The Yerington batholith is composed of three general intrusive phases. The informally named equigranular McLeod Hill quartz monzodiorite, Bear quartz monzonite, and porphyritic Luhr Hill granite (Carten, 1986; Dilles, 1987) represent successive intrusive phases that are in turn volumetrically smaller (75, 19, and 6 vol. pct., respectively), more deeply emplaced (tops at <1, 1.5, 2.5-5 km, respectively), and more silica rich (approx. 60, 66, and 68 wt. percent SiO_2, respectively) (Dilles, 1987). The Bear quartz monzonite is a flat-topped intrusion emplaced into the central part of the McLeod Hill quartz monzodiorite and commonly consists of a 100- to 300-



EXPLANATION

- Alluvium and sedimentary rocks (Cenozoic)
- Volcanic rocks (Cenozoic)
- Granitic rocks (Jurassic?)
- Granitic rocks (Jurassic)
- Shamrock batholith (Jurassic; 166 Ma)
- Yerington batholith (Jurassic; 169 Ma)
- Volcanic rocks (Jurassic)
- Clastic sedimentary rocks (Jurassic)
- Limestone and volcanic rocks (Triassic)
- Volcanic rocks (Triassic)

Contact

Fault–Dotted where concealed

Figure 5. Generalized geologic map of Yerington district showing location of mineral deposits (modified from Stewart and others, 1982; Greene and others, 1991). See figure 1 for location. Also shown are locations of cross sections shown in subsequent figures (A-A', see fig 8; B-B', see fig. 9; C-C', see fig. 6). ● - porphyry copper deposit; ★ - copper skarn deposits; cross-hatched areas in southeast are surface projections of iron skarn ore bodies.

m wide border phase of graphic-porphyritic granite along its upper contact with the McLeod Hill quartz monzodiorite. The porphyritic Luhr Hill granite is seriate-porphyritic and forms cupola-shaped intrusions into the central part of the batholith. Cupolas of the Luhr Hill granite grade upward into granite porphyry dikes and dike swarms which are temporally and spatially associated with porphyry copper deposits immediately above the apices of the cupolas. These centers of porphyry copper mineralization represent individual mineral systems within the Yerington supersystem. These include what are here defined as the Yerington, Ann Mason, and Bear systems, which, even after production from the Yerington deposit, represent a combined resource of greater than 1.2 billion tons of copper ore containing approximately 0.4 percent Cu (Carten, 1986; Dilles, 1984; Howard, 1980).

Dilles (1987) documents that the Yerington batholith is the plutonic equivalent of high-K orogenic arc andesite and dacite and proposes that the batholith formed in two stages. The first stage involved differentiation of primitive basalts to high-K andesite magmas that crystallized to form the McLeod Hill quartz monzodiorite. The second stage involved differentiation of the high-K andesite magma to form the Bear quartz monzonite and Luhr Hill granite. Based on mineral crystallization sequences, estimated pressures, and estimated crystallization temperatures, H_2O content of the successively generated magmas increased from <3 weight percent H_2O for the McLeod Hill quartz monzodiorite to 4-5 weight percent H_2O for the Bear quartz monzonite and Luhr Hill granite. Temporal and spatial variations in mineral compositions (for example, amphibole, Fe-Ti-oxides, biotite, augite, apatite) suggest that rapid magmatic oxidation was temporally and spatially linked to exsolution of magmatic aqueous fluids. Salts, Cu, Fe, and S were strongly partitioned into this high-density "ore" fluid which concentrated at the top of the Luhr Hill cupola. Fluid overpressuring caused fracturing which permitted the upward emplacement of granite porphyry dikes as well as ascension of mineralizing fluids (Dilles, 1987).

A variation diagram of Cu vs. SiO_2 (Dilles, 1987) shows a depletion of Cu from magmas during differentiation and suggests that approximately 80 percent of the copper (approximately 50 ppm Cu) was extracted from the entire Luhr Hill granite from 3 to 8 km paleodepth. Extraction of 50 ppm Cu from a minimum estimated volume of 65 km^3 of the Luhr Hill granite would yield about 10 million tons of copper, more than sufficient to produce the known 6 million tons of copper deposited in the Yerington supersystem as whole.

Yerington System

Yerington porphyry copper deposit

The Yerington open-pit mine (fig. 5) is centered on the Yerington porphyry copper deposit, and most of what follows is taken from a study of this deposit by Carten (1986). The Yerington Mine yielded 165 million tons of ore averaging 0.6 percent copper between 1952 and 1978. Late Tertiary normal faulting and tilting of the system has exposed 1,800 m of structural cross section (paleovertical relief) (Carten, 1986).

At the Yerington deposit, the Luhr Hill granite has been subdivided into two intrusive units, the Luhr Hill complex and the Walker River complex by Carten (1986). Four episodes of porphyry dike emplacement are evident at the Yerington deposit. The informally named Nevada-Empire porphyry (part of the Luhr Hill intrusive complex), Walker River porphyry (part of the Walker River intrusive complex), Mason porphyry, and Post Office porphyry represent successive dike intrusions that were emplaced into McLeod Hill quartz monzodiorite and Bear quartz monzonite. Dikes of the Nevada-Empire porphyry and Walker River porphyry emanate from separate overlapping cupola-like stocks and are temporally and spatially related to two separate episodes of porphyry copper mineralization and associated alteration (Luhr Hill and Walker River subsystems, respectively). The emplacement of the Mason porphyry occurred during the waning stages of the hydrothermal activity and was not accompanied by a mineralizing event. The Post Office porphyry was emplaced after hydrothermal activity had ceased (Carten, 1986).

At the Yerington deposit, relatively simple patterns of hydrothermal alteration and copper mineralization are complicated by the overlap of two distinct hydrothermal subsystems associated with the successive emplacement of the Luhr Hill complex followed by emplacement of the Walker River complex. The Walker River complex was emplaced along the same path as the Luhr Hill complex but at a slightly deeper level. Consequently, the upper part of the Walker River complex, and its associated patterns of alteration and mineralization, coincides with the lower part of the Luhr Hill complex (see Carten, 1986, for illustrations).

Though temporally and spatially separate, the two hydrothermal subsystems appear to be similar in most aspects, particularly in the character and distribution of alteration assemblages and mineralized zones, as described below.

<u>Early sodic-calcic alteration</u>: Sodic-calcic alteration formed early at structurally low levels of each system along the upper contact of the cupola. This assemblage is characterized by the replacement of primary potassium feldspar by oligoclase and the replacement of primary mafic minerals by actinolite. Monomineralic veinlets of quartz, plagioclase, tourmaline, and actinolite are commonly associated with this assemblage (Carten, 1986).

<u>Potassic alteration</u>: Potassic alteration formed at structurally high levels of the system, were centered on the porphyry dikes that emanated from the cupola, and formed simultaneously with the early sodic-calcic alteration. This alteration assemblage is characterized by the replacement of primary amphibole by shreddy biotite and the replacement of primary plagioclase by potassium feldspar. Potassic alteration commonly formed alteration envelopes around monomineralic veins of quartz+biotite+magnetite, but became pervasive where vein density was sufficiently high (Carten, 1986).

<u>Late sodic and sericitic alteration</u>: Following the coupled sodic-calcic and potassic alteration episodes of both the Luhr Hill and Walker River subsystems, low temperature sodic and sericitic alteration affected the lower and upper levels of the Walker River subsystem, respectively. Due to the intrusion of the Walker River complex, the Luhr Hill hydrothermal subsystem was unable to sufficiently cool to produce low temperature alteration mineral assemblages. Sodic alteration assemblages are characterized by the alteration of primary and secondary potassium feldspar to albite and primary and secondary biotite to chlorite and epidote. Sericitic alteration assemblages are characterized by the mineral assemblage quartz-sericite-pyrite (Carten, 1986).

Primary deposition of Cu-Fe sulfide minerals was temporally and spatially associated with episodes of potassic alteration. However, sulfide minerals were remobilized during late sodic and sericitic alteration episodes. Chalcocite-bornite, chalcopyrite, and magnetite were deposited in veins and in wallrock altered to biotite ± potassium feldspar. Mineral zonation from the center of potassic alteration zones outward consists of chalcocite-bornite, chalcopyrite ± magnetite, and magnetite. Zones of most intense potassic alteration coincide with zones containing > 0.4 percent copper which in turn coincide with zones of greatest vein density

(Carten, 1986).

Pumpkin Hollow iron-copper skarn deposits

It is uncertain, without full reconstruction of tectonic blocks, which mineral system the Pumpkin Hollow iron skarns are associated with or if they represent a separate mineralizing system. However, approximate reconstruction suggests that these skarn deposits may be related to the Yerington Cu-Fe porphyry-skarn mineral system (J.H. Dilles, oral commun., 1991). At least six discrete concealed skarn deposits have been identified beneath valley fill in the Pumpkin Hollow area of eastern Mason Valley (fig. 5). These are referred to as the north, northwest, south, southeast, east, and E-2 orebodies. The north, south, and southeast orebodies were initially discovered during an aeromagnetic survey by U.S. Steel Corporation (USS) in 1960. Subsequent aeromagnetic surveys and drilling programs by USS, The Anaconda Co., and Conoco, Inc. led to the discovery of the remaining orebodies and an economic assessment of all orebodies. In general, the north and south orebodies are dominantly iron (magnetite) skarns, the southeast and east orebodies are mixed iron and copper (chalcopyrite) skarns, and the northwest and E-2 orebodies are dominantly copper skarns. Furthermore, the E-2 orebody contains significant precious metals (5 million tons at 0.35 g/t Au and 8.3 g/t Ag) (Conoco, 1982), and the northwest deposit contains a halo of anomalous molybdenum (for example, 119 m at 431 ppm Mo) (Wright, 1976). Total reserve estimates for all orebodies are 350 million tons of ore averaging 26 percent magnetite and 0.42 percent Cu. However, copper-bearing deposits alone represent about 125 million tons of ore averaging 0.81 percent Cu (Pincock and others, 1977; Conoco, 1982; Smith, 1984).

The Pumpkin Hollow skarn deposits are clearly related to the early quartz monzodiorite phase of the Yerington batholith and are cut by granite porphyry dikes which are associated with porphyry copper deposits in other parts of the batholith (fig. 6). Endoskarn zones in the quartz monzodiorite grade into exoskarn zones which are exclusively within the Late Triassic massive limestone unit (limestone of Mason Valley). For the most part the Triassic to Jurassic volcanosedimentary section at Pumpkin Hollow correlates with the McConnell Canyon section exposed in the Singatse Range (Einaudi, 1975; Smith, 1984). Figure 6 illustrates the current configuration of the south and east orebodies within the faulted and tilted section, whereas figure 7 is a schematic reconstruction of the same area prior to late Tertiary faulting and tilting. From the reconstruction it is clear that the south and east orebodies formed within the Late Triassic limestone of Mason Valley on opposite sides of a quartz monzodiorite stock. Low-angle listric faults have displaced the tops of many of the orebodies, as well as rotated them 60°-90° westward. For example, the southeast orebody is a faulted segment of the south orebody. Younger high-angle normal faults have further segmented some of the deposits (fig. 5) (Pincock and others, 1977; Conoco, 1982).

In general, a gradational zonation of skarn mineralogy from endoskarn to exoskarn is evident at most deposits. A traverse from fresh quartz monzodiorite (containing 3-4 vol. pct. primary magnetite) to dolomitic marble would encounter five zones as follows: (1) albite-clinozoisite endoskarn zone; plagioclase converted to albite-clinozoisite-epidote and hornblende and pyroxene converted to actinolite, (2) epidote-actinolite-salite endoskarn zone; plagioclase converted to epidote and mafic minerals converted to actinolite-salite, (3) grandite-salite endoskarn zone; plagioclase and mafic minerals converted to grandite-salite, (4) magnetite-salite exoskarn zone; anhydrous prograde skarn containing 25-75 volume percent magnetite, and (5)

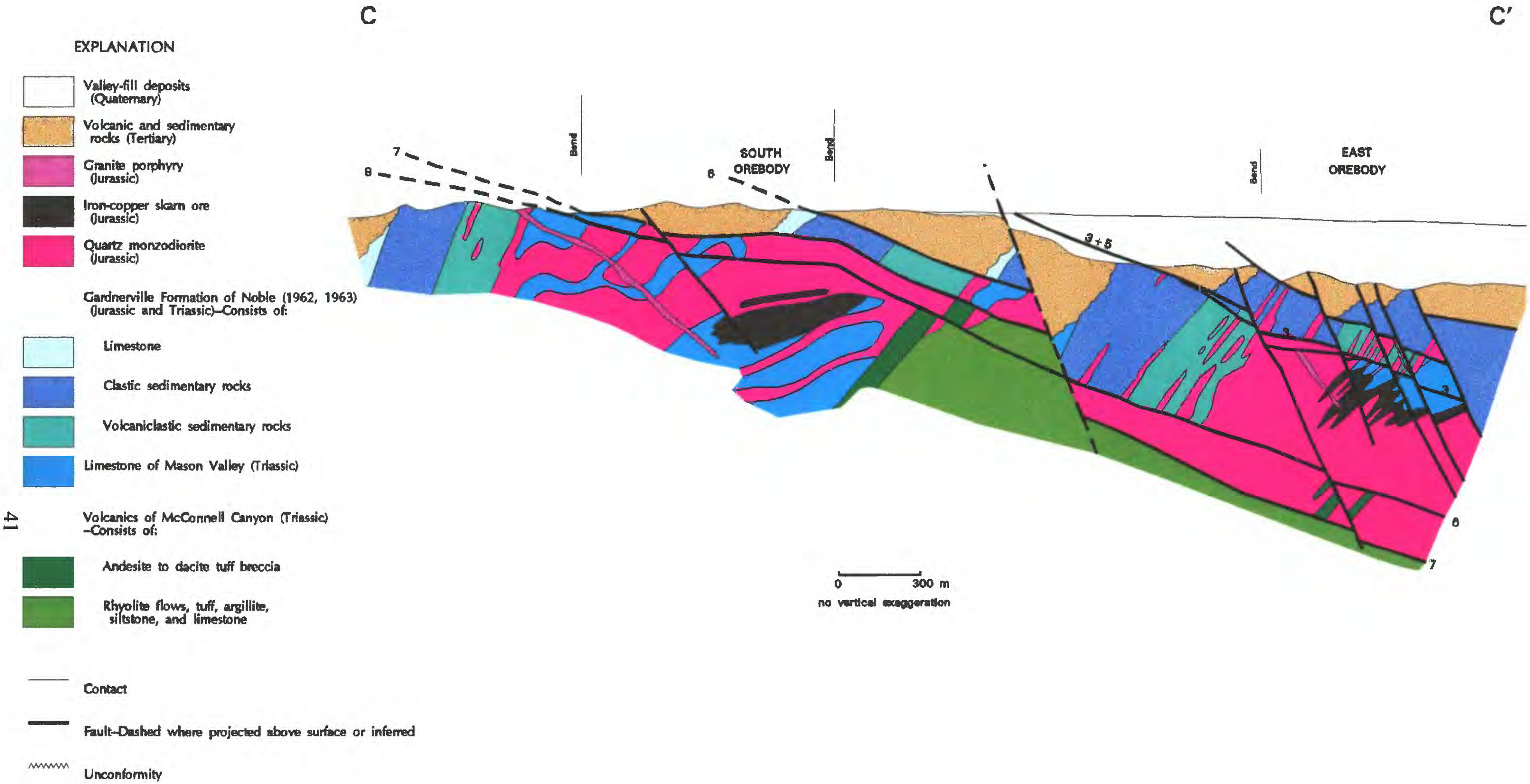


Figure 6. Cross section through Pumpkin Hollow area, Yerington district, showing concealed iron-copper skarn deposits (modified from Einaudi, 1975). Section runs southwest to northeast; see figure 5 for location. Numbered faults refer to those in reconstructed cross section that shows late Tertiary faulting removed (see fig. 7).

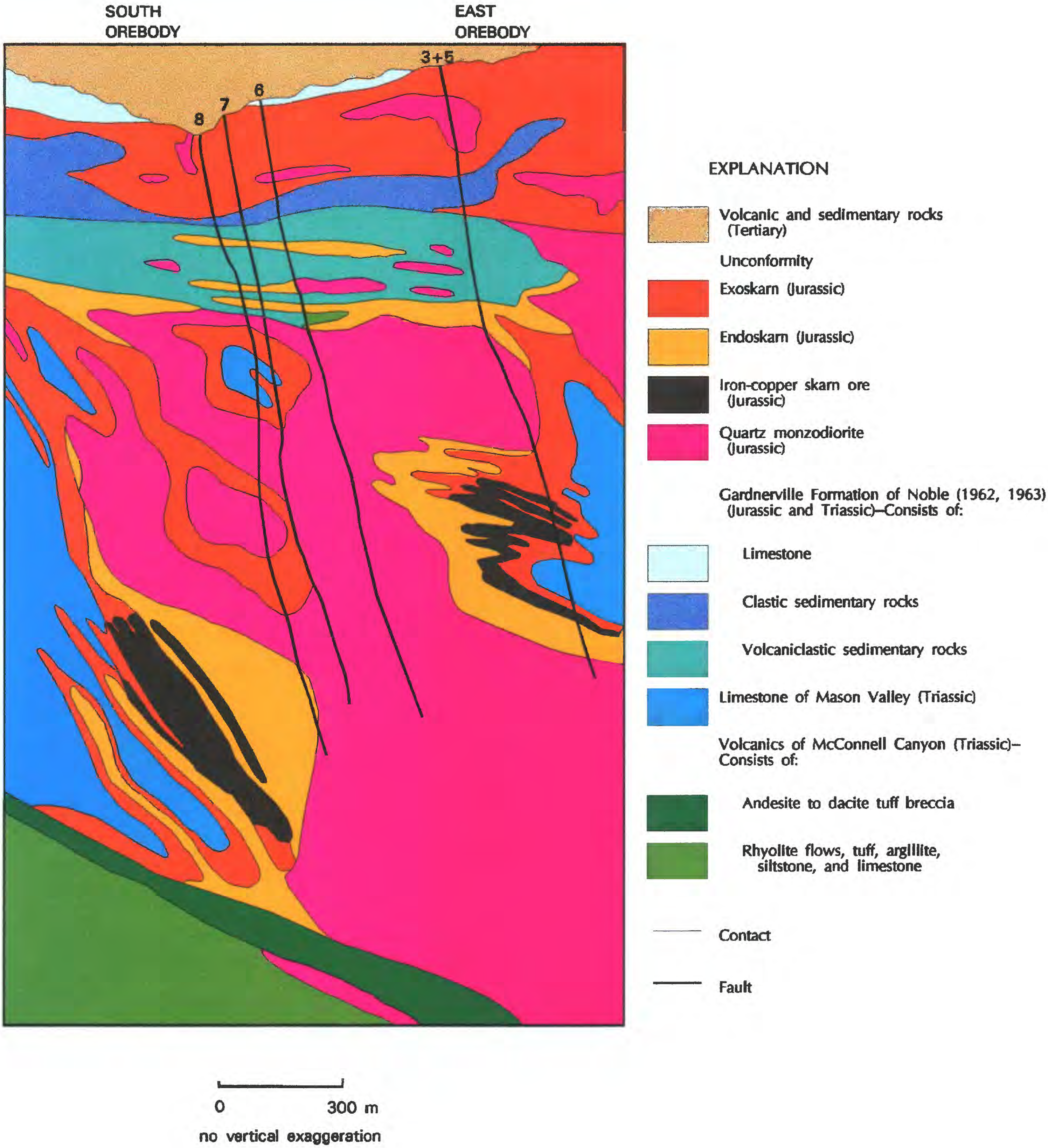


Figure 7. Schematic reconstruction of cross section shown in figure 6. Reconstruction shows concealed iron-copper skarn deposits in Pumpkin Hollow area, Yerington district, after late Tertiary faulting is removed (modified from Einaudi, 1975). Numbered faults refer to those in original cross section (see fig. 6).

copper-bearing "marble front" skarn zone--magnetite-salite skarn converted to calcite-talc-actinolite-chalcopyrite-pyrite-pyrrhotite-serpentine-chlorite (Smith, 1984).

The occurrence of epidote is most diagnostic of endoskarn. Garnet increases in abundance within the endoskarn toward the contact with limestone. Though the fresh quartz monzodiorite contains 3-4 volume percent primary magnetite, magnetite is absent from the endoskarn zones and has been concentrated in the exoskarn zone immediately adjacent to the intrusive contact. The copper-bearing "marble front" skarn zone represents fracture-controlled retrograde hydrous alteration of a brecciated prograde anhydrous magnetite-salite skarn (Smith, 1984).

Ann Mason System

The Ann Mason system is here defined as the Ann Mason porphyry copper deposit (Dilles, 1984; 1987) and related Cu-skarn deposits (Einaudi, 1982; Harris and Einaudi, 1982).

Ann Mason porphyry copper deposit

The Ann Mason porphyry copper deposit (fig. 5) is located 1 km west of Singatse Peak and lies concealed within the Yerington batholith approximately 300-900 m below the present surface. Estimated resources are 495 million tons of ore containing an average of 0.4 percent copper (Dilles, 1987).

All major intrusive phases of the Yerington batholith are present at the Ann Mason deposit except for the main phase of the Bear quartz monzonite. However, the border phase of the Bear quartz monzonite is present (fig. 8a). The distribution and nature of alteration assemblages and mineralized zones are similar to that described above for the Yerington deposit (figs. 8a-d), except that molybdenum contents are significantly higher and are highest within the core of the system (fig. 8e). Sodic-calcic alteration assemblages are present deep in the system where the porphyritic Luhr Hill granite is more stock-like in nature, whereas potassic alteration assemblages and associated copper ore are present at high levels of the system within and around Luhr Hill granite porphyry dikes. Although there is evidence for multiple dike intrusions, there appears to have been only one episode of hydrothermal activity, unlike the two overlapping episodes at the Yerington deposit (Dilles, 1987).

A late sodic alteration assemblage (albite-chlorite), not found at the Yerington deposit, is present within the core of the Ann Mason deposit. This episode of alteration was responsible for removing copper from the interior of the deposit and redepositing it in peripheral areas (Dilles, 1984) and thus creating the erratic copper grade distribution shown in figure 8d. Phase petrology, metasomatic chemical changes, and fluid-inclusion characteristics, and stable isotope characteristics indicate that these late fluids were seawater rather than heavy meteoric waters (Dilles, 1984; Dilles and others, in press).

Tourmaline breccias with quartz and minor pyrite represent the last hydrothermal event at the Ann Mason deposit. The breccias contain sericitized clasts and were produced by boiling solutions under hydrostatic pressure at approximately 200° C (Dilles, 1984).

Copper skarn deposits

All significant copper skarn deposits in the Singatse Range that are associated with the

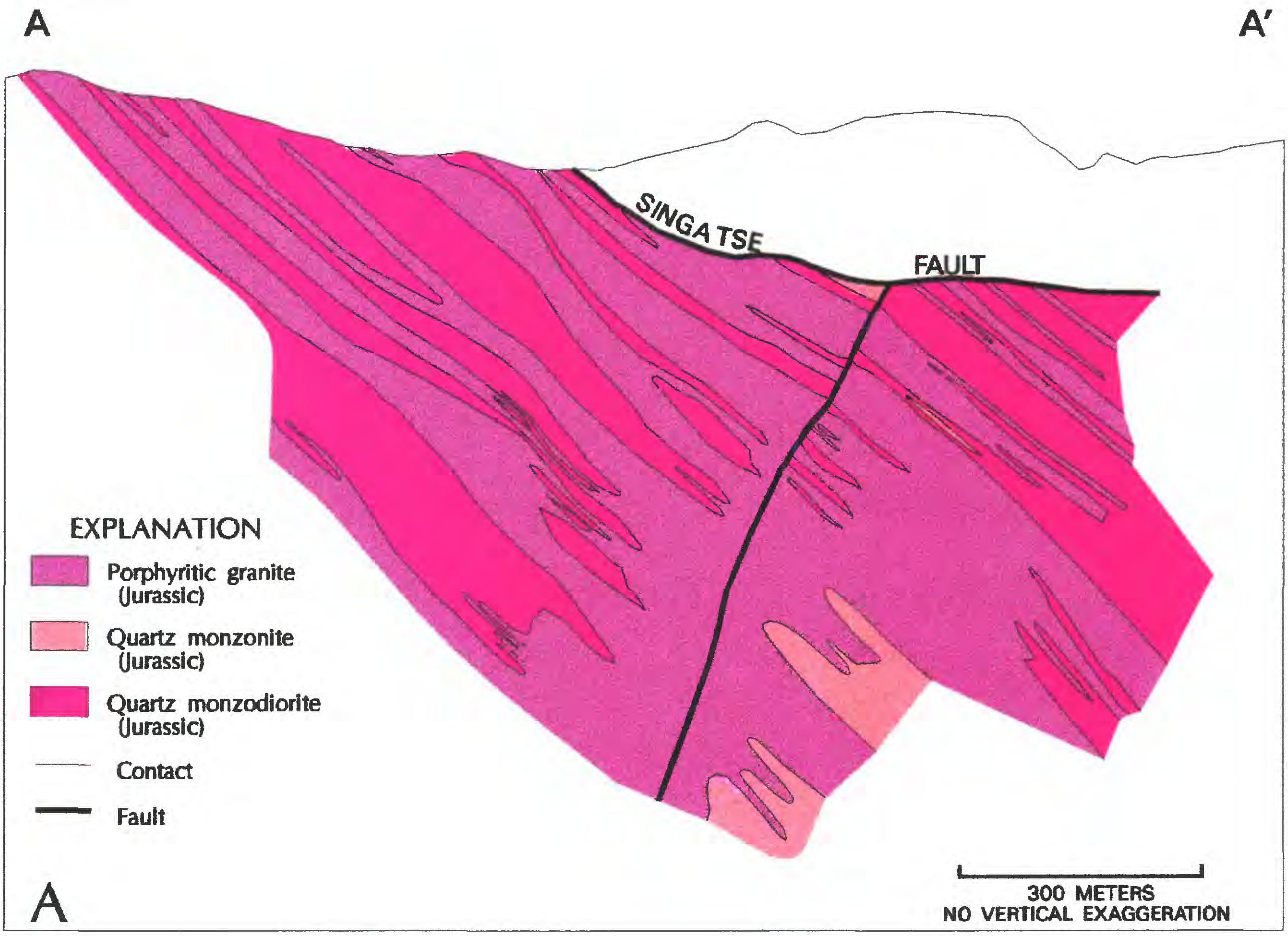
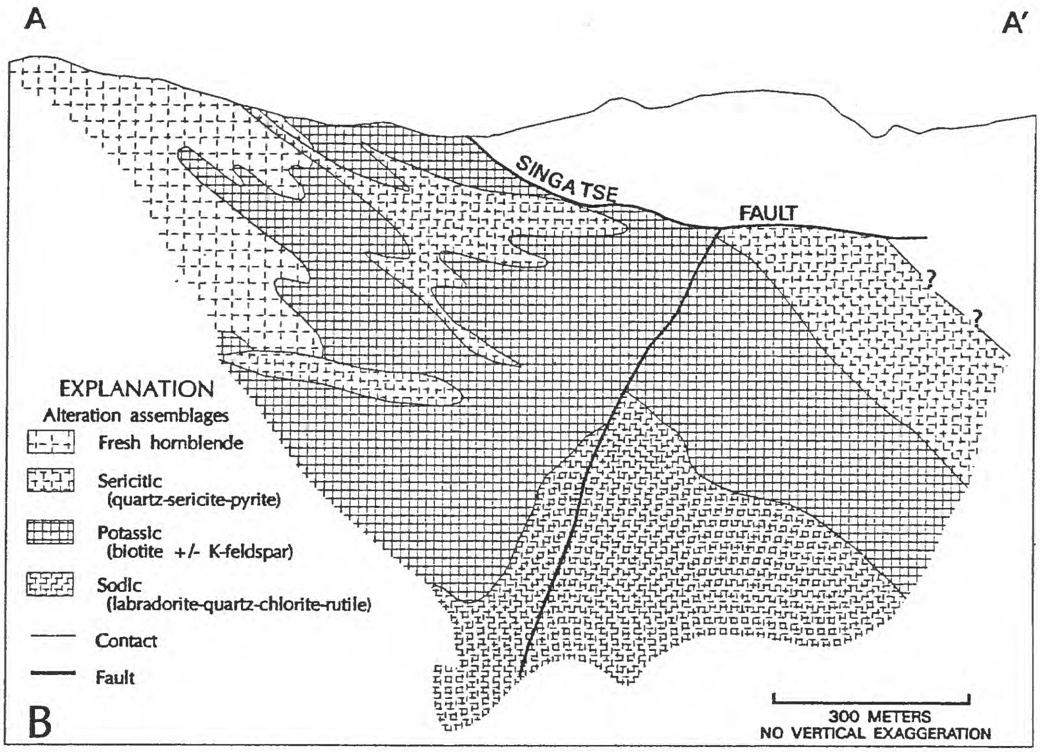


Figure 8. Cross sections through concealed Ann Mason porphyry copper deposit, Yerington district (modified from Dilles and Einaudi, 1992). Section runs south to north; see figure 5 for location. A, Jurassic geology. B, Alteration assemblages. C, Sulfide zones. D, Copper grade distribution. E, Molybdenum grade distribution.



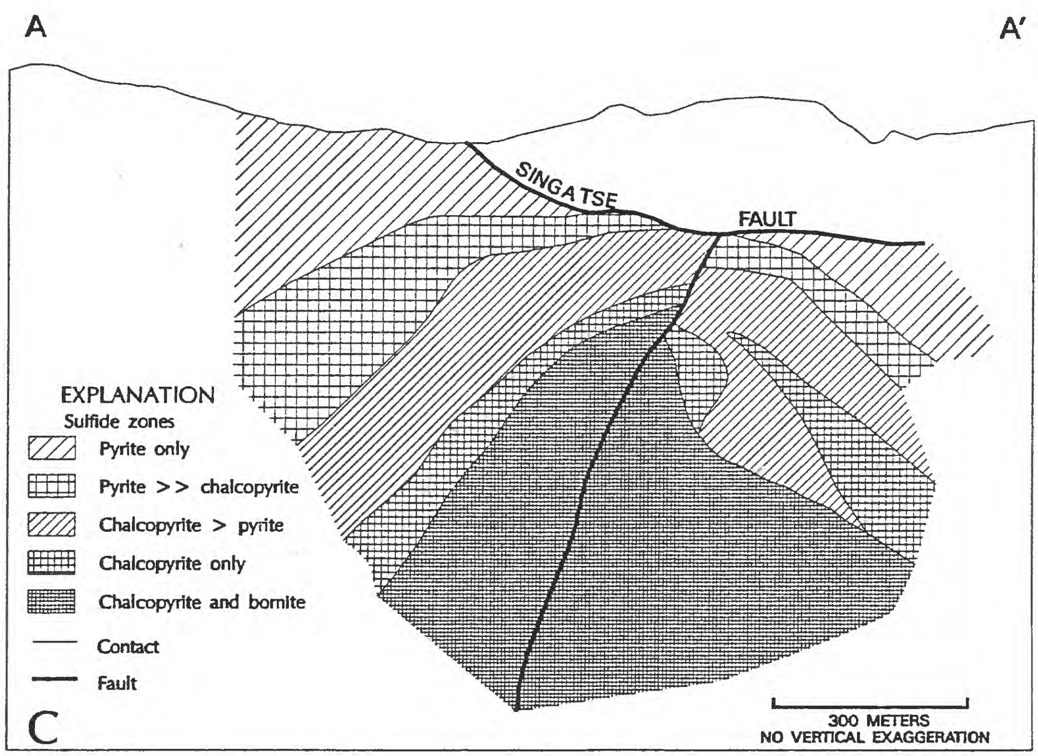


Figure 8. Continued.

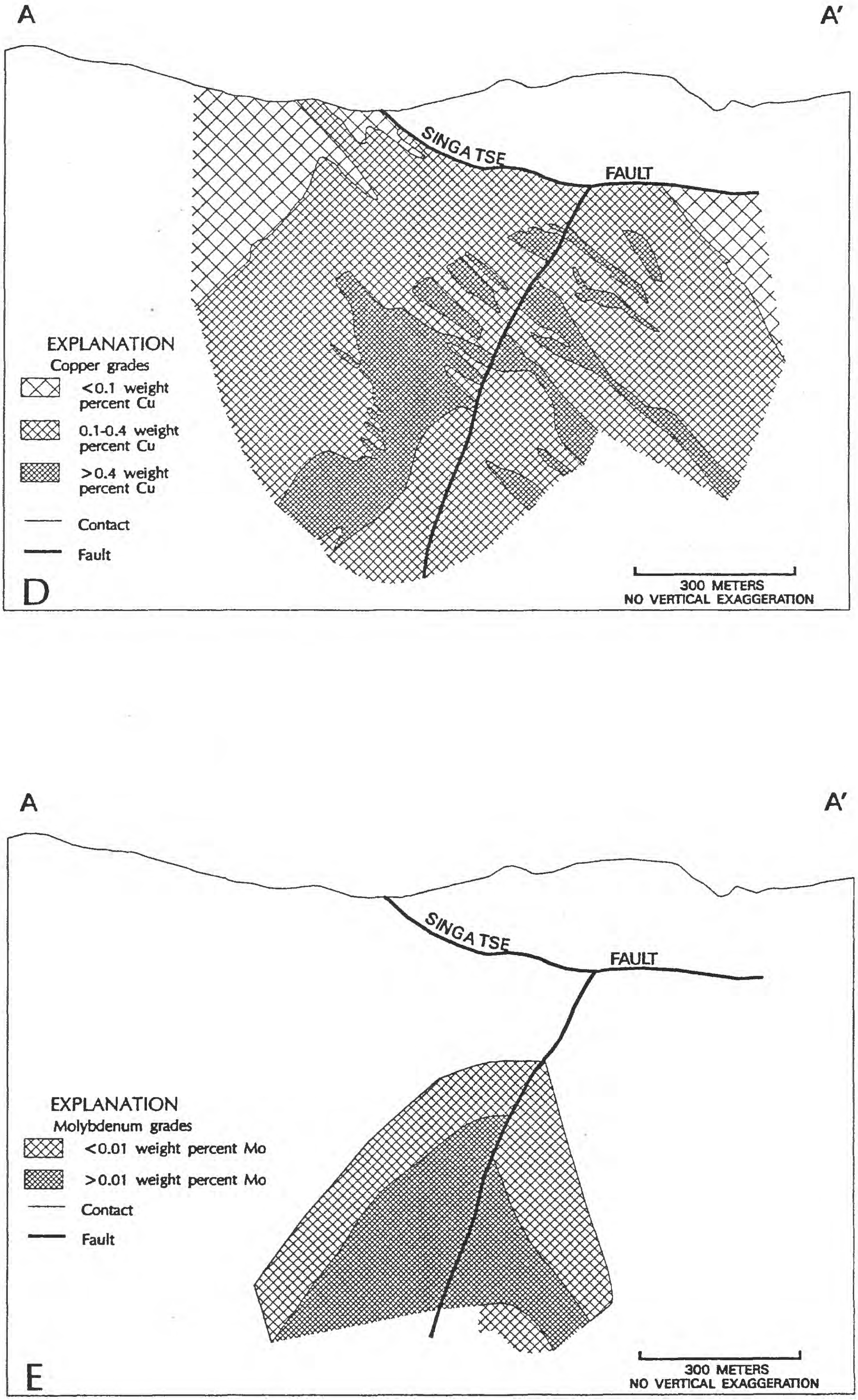


Figure 8. Continued.

Yerington batholith are located in a septum of Triassic and Jurassic volcanic and sedimentary rocks bordering the south margin of the batholith (fig. 5) and are believed to be genetically related to the Ann Mason hydrothermal system (J.H. Dilles, oral commun., 1991). These include deposits at the Bluestone, Mason Valley, Casting Copper, Douglas Hill, McConnell, and Western Nevada Mines, which together produced a combined 3.5 million tons of ore averaging 3 percent copper. When the area is reconstructed by removing the effects of late Tertiary faulting and tilting, a zoned pattern emerges. District-wide fine-grained grandite-diopside skarn forms a contact aureole, extending as much as 1,800 m from the batholith contacts. Both limestone and volcanic units were affected by this early skarn episode, which is believed to be related to the emplacement of the McLeod Hill quartz monzodiorite. Within this aureole the iron content of grandite increases away from the intrusive contact (Einaudi, 1982; Harris and Einaudi, 1982).

Following the formation of the grandite-diopside aureole, a metasomatic skarn episode produced two types of copper-bearing coarse-grained skarn deposits. Magnesium-rich salite-andradite skarns formed from high-temperature fluids (400°-600° C) along a fringe position where the earlier grandite-diopside skarn grades into dolomitized marble, generally 1-2 km from the batholith contact. Later, iron-rich andradite-epidote skarns formed from lower temperature fluids (120°-200° C) relatively close to the batholith contact. The metasomatic skarn deposits are believed to be related to the hydrothermal system set up by the emplacement of the Luhr Hill granite and related granite porphyry dikes (Einaudi, 1982; Harris and Einaudi, 1982).

Magnesium-rich copper skarn deposits include those at the Mason Valley, Western Nevada, Casting Copper, and McConnell Mines. These deposits are characterized by coarse-grained salite (Hd_{30-60}) and andradite (Ad_{50-75}) gangue, the presence of magnetite, talc, and tremolite, high total sulfide minerals (10-15 vol. pct.), high pyrite:chalcopyrite ratios ($\geq$1), and little or no hydrothermal breccia (Einaudi, 1977; Harris and Einaudi, 1982).

Iron-rich copper skarn deposits include those at the Bluestone and Douglas Hill Mines. These deposits are characterized by andradite (Ad_{50-75}) gangue (with some epidote at the Bluestone mine), low total sulfide minerals ($\leq$5 vol. pct.), low pyrite:chalcopyrite ratios ($\leq$0.1), the absence of magnetite and hematite, and abundant breccia, in places formed during several episodes (Harris and Einaudi, 1982). When reconstructed to Jurassic orientations, the Bluestone-Douglas Hill area appears closest to the center of copper mineralization, because the area contains the largest amount of disseminated sulfide minerals, the highest chalcopyrite:pyrite ratios, and the most pervasive conversion of limestone to skarn (Proffett, 1969).

The closest known source of mineralizing fluids would have been the Ann Mason hydrothermal system, some 3 to 4 km from the sites of copper skarn mineralization. The large mass of earlier McLeod Hill quartz monzodiorite effectively shielded the limestones from direct contact with the porphyry copper intrusive phase (Luhr Hill granite), which makes these deposits somewhat unique as Cu-skarn deposits related to porphyry copper hydrothermal systems. The extreme spatial separation between the skarn and porphyry deposits introduces significant uncertainties in detailed correlation of alteration-mineralization events between the intrusive and sedimentary rocks (Proffett, 1969; Harris and Einaudi, 1982).

Bear System

The Bear system (also referred to as the MacArthur-Bear-Lagomarsino-Airport system) is a single porphyry copper system that has been segmented into separate orebodies and tilted westward by late Tertiary normal faulting. Figures 9 and 10 show the system in its present

Water-quality data for selected wells in Puerco River study area--Continued

Well name: Private well at Pinta. Transect: Pinta

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MOLYBDENUM, TOTAL RECOVERABLE (UG/L AS MO)	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	SELENIUM, TOTAL (UG/L AS SE)	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	STRONTIUM, TOTAL RECOVERABLE (UG/L AS SR)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ALPHA, TOTAL (PCI/L)	ALPHA, TOTAL, COUNTING ERROR (PCI/L)	BETA, TOTAL (PCI/L)
DEC 1986										
05.........	70	33	1	<1	<1	850	90	42	8.0	<15

DATE	BETA, TOTAL, COUNTING ERROR (PCI/L)	LEAD 210 DISSOLVED (PCI/L)	LEAD 210 DISSOLVED COUNT ERROR (PCI/L)	RADIUM 226, DISSOLVED (PCI/L)	RADIUM 226 DISS. COUNTING ERROR (PCI/L)	RADIUM 228, TOTAL (PCI/L)	RADIUM 228, TOTAL, COUNTING ERROR (PCI/L)	THORIUM 230 DISSOLVED (PCI/L)	THORIUM 230 DISSOLVED COUNT ERROR (PCI/L)	URANIUM NATURAL TOTAL (UG/L AS U)
DEC 1986										
05.........	3.0	0.6	0.4	0	0.1	0.7	0.5	0	0.1	38

position and reconstructed to a time prior to late Tertiary faulting, respectively. The MacArthur segment is located northeast of Mason Pass in the Singatse Range (fig. 5) and contains 13 million tons of oxide ore averaging 0.4 percent copper (Heatwole, 1978). The Bear, Lagomarsino, and Airport segments are concealed within the Yerington batholith beneath Cenozoic volcanic and sedimentary rocks and unconsolidated basin fill in the vicinity of McLeod Hill (fig. 9), and represent 735 million tons of ore averaging 0.44 percent copper (Howard, 1980).

MacArthur porphyry copper deposit

At the MacArthur deposit, the Bear quartz monzonite is intruded by two types of granite porphyry dikes, biotite-rich and hornblende-rich. Because the deposit has been tilted westward on its side, its stratigraphic top is to the west. Albitized feldspar is most abundant in the eastern part of the property (lower part of system), biotized hornblende (potassic alteration assemblage) is present west of the albitized zones and a clay-sericite alteration assemblage is present in the western part of the property (upper part of system).

Four types of Cu-Fe oxides are found at the MacArthur deposit. These include (1) green copper oxides (chrysocolla with minor malachite and azurite), (2) black copper wad (possibly tenorite), (3) dark-brown iron oxides (largely geothite with minor Cu), and (4) light-brown iron oxides (mixtures of jarosite and geothite with negligible Cu) (Heatwole, 1972). In general, the Fe-bearing oxides are most abundant in the western part of the property, and the Cu-bearing oxides are most abundant in the eastern part of the property. This pattern represents an oxidized primary sulfide pattern; the Fe-bearing sulfide zone corresponds to the pyrite cap in the upper part of the system, whereas the Cu-bearing oxide zone corresponds to the main sulfide ore-bearing zones in the core and lower parts of the system. However, some of the Cu-oxide ore is clearly exotic and has been transported down a topographic gradient (the west part of the property is topographically higher than the east part) as evidenced by a east-northeast-trending enrichment zone of >0.4 percent Cu; this orientation is perpendicular to the northwest-trending granite porphyry dikes that were spatially and genetically related to the primary sulfide mineralization (Heatwole, 1972, 1978).

The Bear-Lagomarsino-Airport porphyry copper deposits

All three main phases of the Yerington batholith are present at the Bear-Lagomarsino-Airport deposits (fig. 9). As shown in figure 9, the Bear deposit is in the footwall of the Bear fault, whereas the Lagomarsino deposit is in the hanging wall and has been further segmented to create the Airport deposit. Normal-fault offset on the Bear fault is estimated to be approximately 1,230 m based on the offset of west-dipping Tertiary volcanic rocks, the McLeod Hill quartz monzodiorite-Bear quartz monzonite contact, and alteration and mineralized zones (Proffett, 1967). A middle to late Tertiary reconstruction of the system is portrayed in figures 10a-c.

Alteration and mineralization patterns are similar to other porphyry copper systems of the Yerington supersystem and are centered around late granite porphyry dikes (fig. 10a). Albitization, accompanied by tourmaline veinlets, was most prevalent in the roots of the system, whereas potassic alteration and associated copper sulfide mineralization formed at higher levels in the system (fig. 10b) (Proffett, 1967). The uppermost part of the system was affected by sericitic alteration accompanied by variable amounts of pyrite.

Within the zone of Cu-sulfide mineralization, sulfide minerals rarely exceed 2 volume

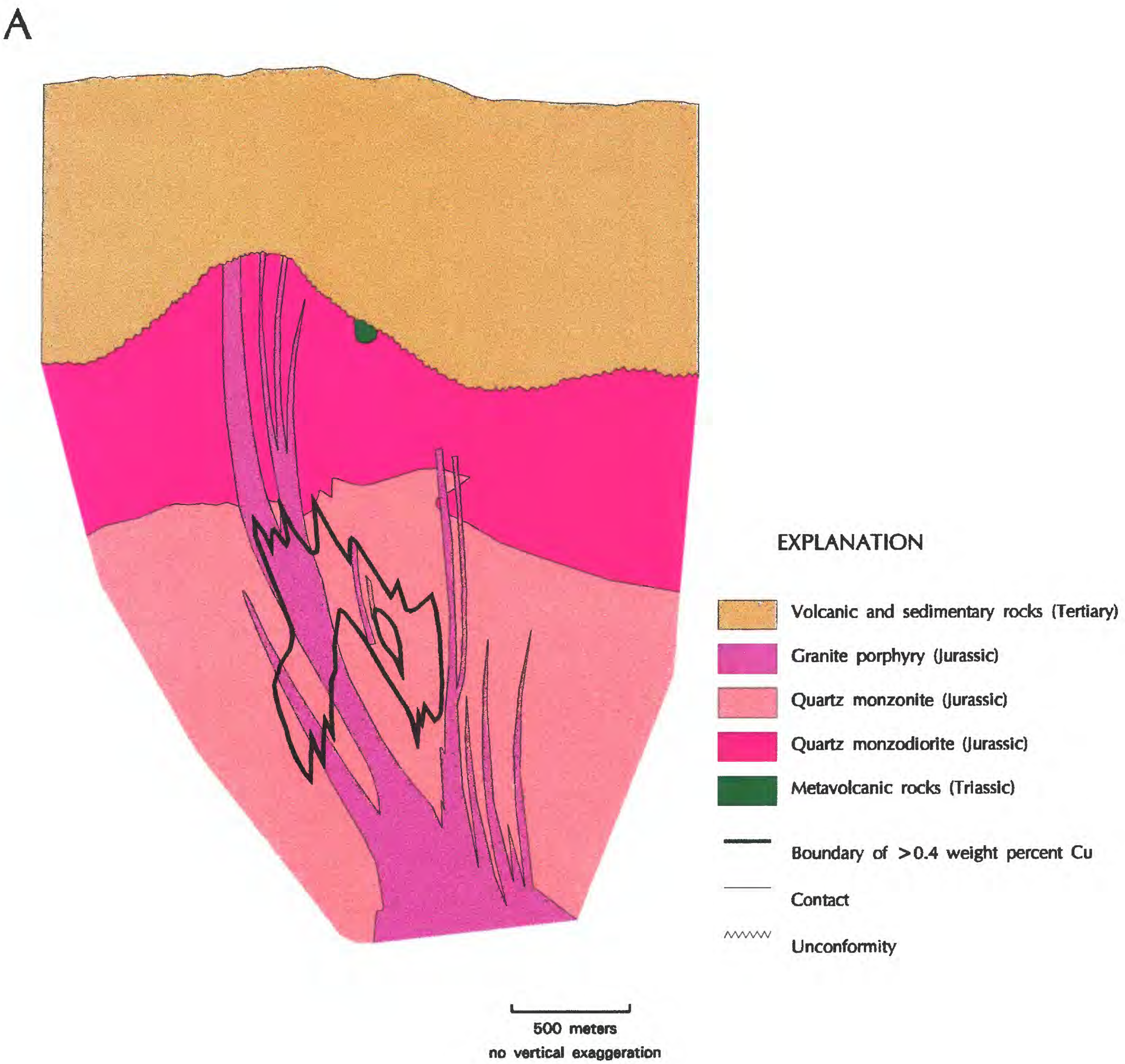


Figure 10. Schematic reconstructions of cross section shown in figure 9. Reconstructions show concealed porphyry-Cu deposit in Bear-Lagomarsino area, Yerington district, after late Tertiary faulting and tilting is removed (modified from Proffett, 1967). A, Geology. B, Alteration zones. C, Sulfide zones.

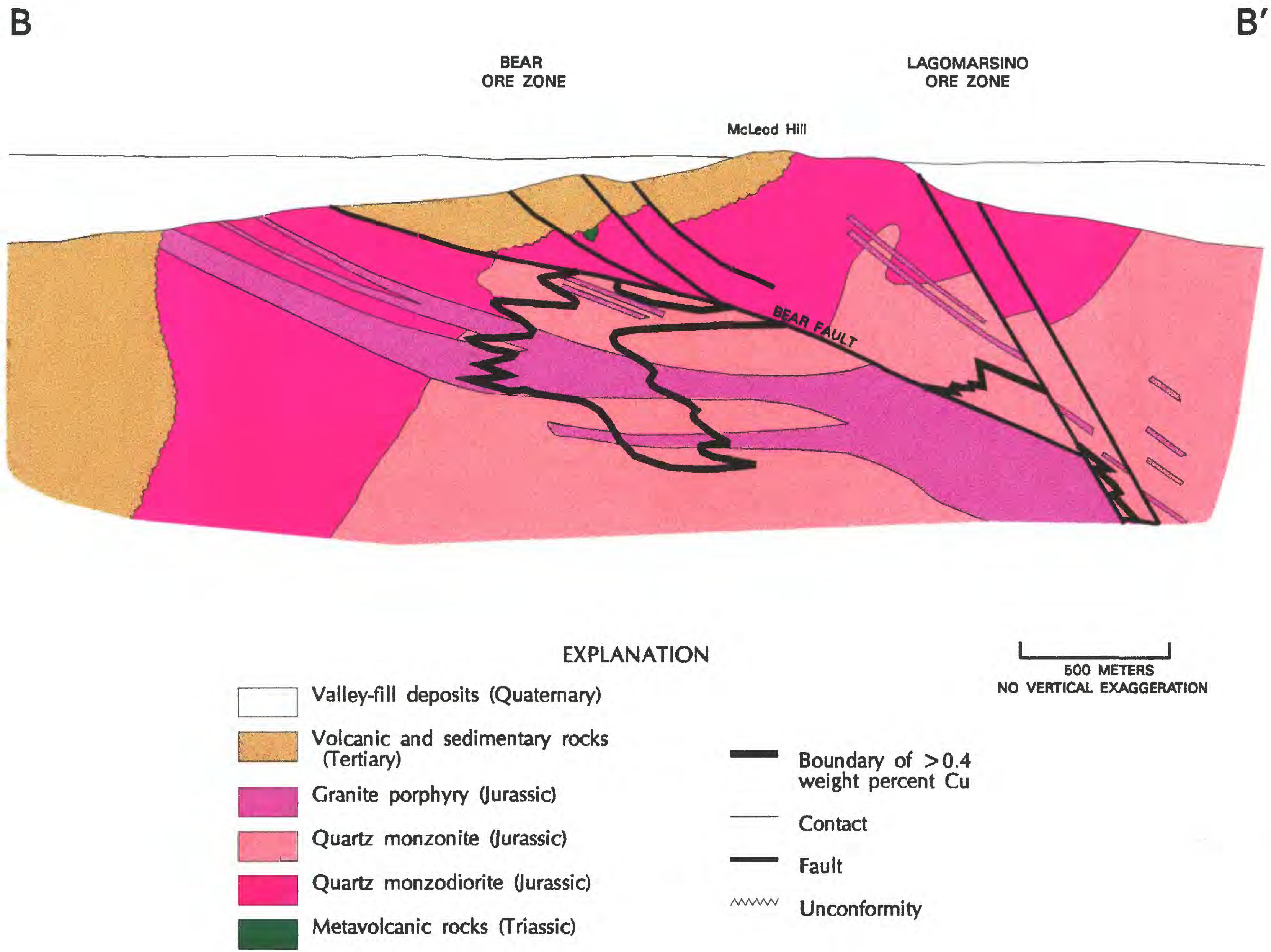


Figure 9. Cross section through Bear-Lagomarsino area, Yerington district, showing concealed porphyry-Cu deposits (modified from Proffett, 1967). Section runs west to east; see figure 5 for location. See figure 10 for reconstructed cross sections showing late Tertiary faulting and tilting removed.

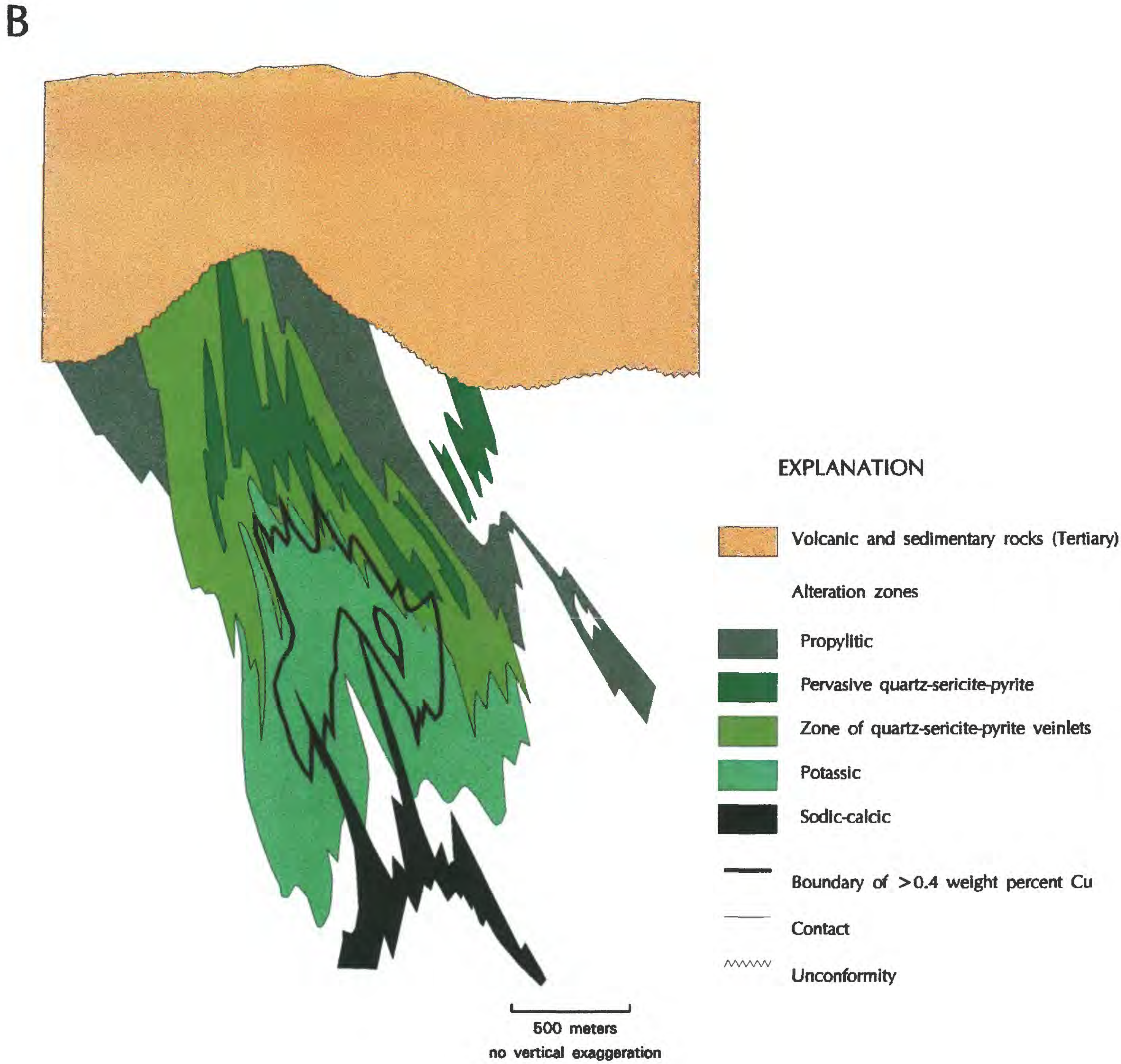


Figure 10. Continued.

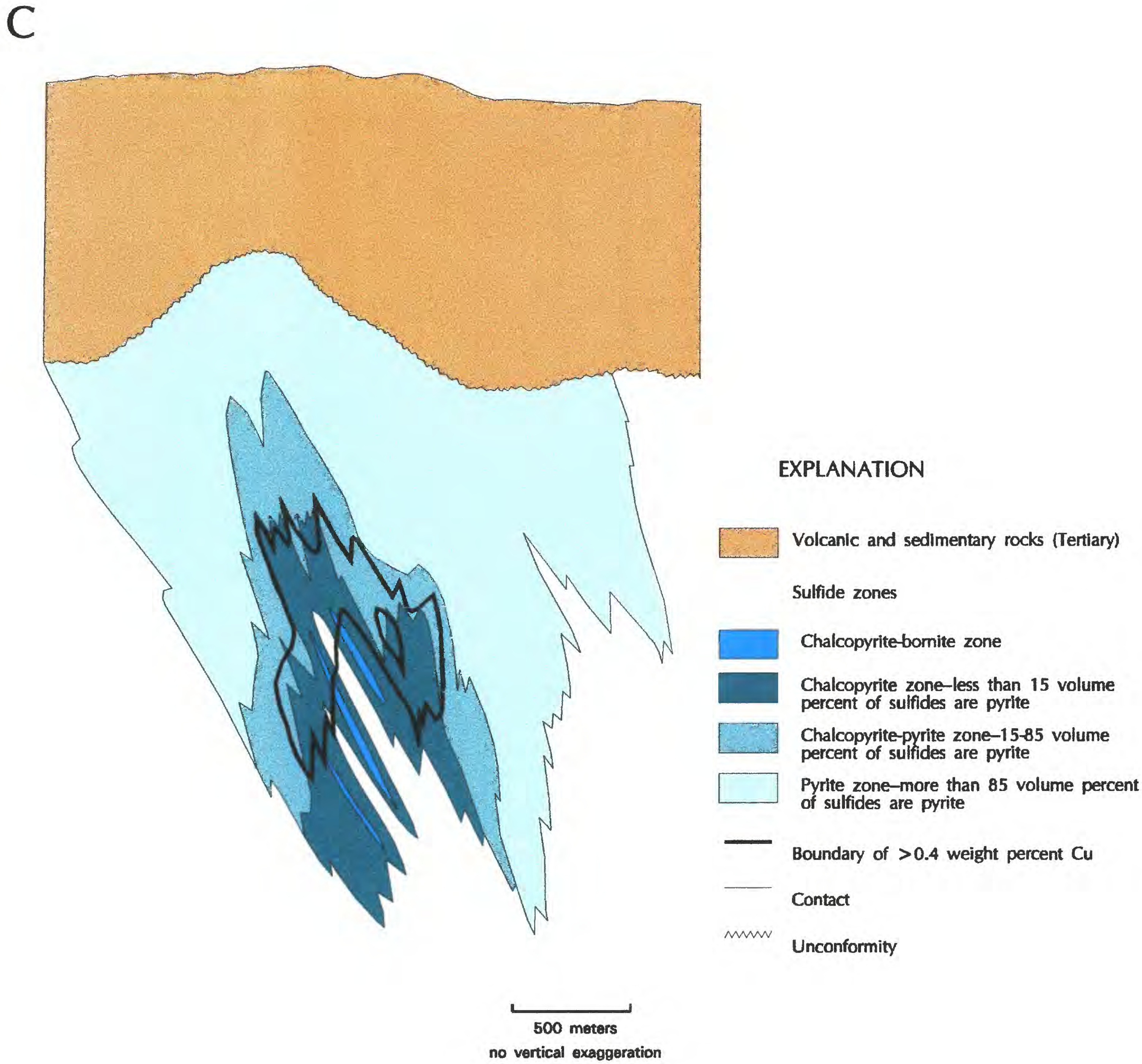


Figure 10. Continued.

percent and chalcopyrite:pyrite ratios decrease outward from the core (fig. 10c). As at Ann Mason, quartz veinlets are most abundant in areas of high chalcopyrite:pyrite ratios. Two types of veinlets are identified: A-type quartz+chalcopyrite±bornite veinlets, which display no alteration envelopes and B-type chalcopyrite+pyrite±molybdenite veinlets, which are more common and display weak sericitic alteration envelopes. Some remobilization of sulfide minerals is related to late "chloritization" (Proffett, 1967) and may correspond to the remobilization of sulfide minerals during late sodic alteration at the Yerington deposit (Carten, 1986).

In the northwest part of the Bear-Lagomarsino-Airport area, endoskarn and exoskarn zones were encountered in drill holes (Wilson, 1978). These zones are characterized by the presence of chlorite and actinolite, with minor amounts of epidote, calcite, scapolite, sphene, and apatite. Plagioclase is the only feldspar present. Locally, the chlorite-actinolite skarn contain cores of massive magnetite cut by veinlets of pyrite and chalcopyrite (Wilson, 1978).

Yerington Supersystem -- A Discussion

The depths of emplacement of the three porphyry copper deposits in the Yerington batholith have been estimated using a combination of paleogeologic and paleotopographic reconstructions, and pressure-temperature phase equilibria constraints (Proffett, 1967, 1969; Einaudi, 1971; Carten, 1986; Dilles, 1987). The porphyry copper mineralization in the Yerington deposit occurred at a paleodepth of approximately 1-2.5 km, whereas mineralization in the Bear and Ann Mason deposits occurred at paleodepths of 3-4.5 km. Proffett (1967) suggests that the greater depths of emplacement of the Bear and Ann Mason deposits may have resulted in less "telescoping" of mineralizing processes than took place in the Yerington deposit. This difference might explain the larger tonnage and lower grades associated with the Bear and Ann Mason deposits compared to the Yerington deposit (735 million tons of 0.44 percent Cu and 495 million tons of 0.40 percent Cu, respectively, versus 165 million tons of 0.60 percent Cu).

Gold is generally absent or only found in trace amounts in the porphyry copper deposits of the Yerington batholith. At the Yerington deposit, gold grades averaged less than 0.002 ppm (R.B. Carten, unpub. data, 1991). Molybdenum is present in all three porphyry copper deposits, although generally in less than by-product quantities. However, the Bear and Ann Mason deposits appear to contain significantly higher concentrations of molybdenum than the Yerington deposit. In the Yerington deposit, the average molybdenum grade in the zone of greater than 0.35 percent Cu was approximately 0.0005 percent (5 ppm), with a Cu:Mo ratio of 1,200 (R.B. Carten, unpub. data, 1991). In the Ann Mason deposit, the average molybdenum grade in the zone of greater than 0.30 percent Cu is 0.005 percent (50 ppm) with a Cu:Mo ratio of 80 (R.B. Carten, unpub. data, 1991). Furthermore, drill core intercepts in the Bear deposit indicate local concentrations of molybdenum (for example, 151 m of 0.030 percent Mo, 438 m of 0.020 percent Mo, 723 m of 0.011 percent Mo, 964 m of 0.009 percent Mo) (Anaconda, 1967), although overall grades and distributions of these zones are unknown to the authors. Wilson (1978) notes that molybdenite in the Bear deposit is closely associated with thin shears and quartz veins and is present as bands along vein margins and centers. The apparent high molybdenum content of the Bear and Ann Mason deposits relative to the Yerington deposit may be a function of their relative depths of emplacement, with molybdenum contents increasing with greater depths of emplacement.

The sodic and sodic-calcic alteration assemblages found at all three of the porphyry copper deposits in the Yerington batholith distinguish these deposits from porphyry copper deposits found in continental arc settings. The apparent absence of this type of alteration assemblage in porphyry copper deposits emplaced into Proterozoic continental crust (for example, the Arizona deposits) may be due to the lack of special high-salinity non-magmatic fluids which may be required for these alteration assemblages (Dilles, 1984; Dilles and others, in press) or to the lack of exposure of the deeper levels of the hydrothermal systems where these assemblages are commonly found.

Several Cenozoic porphyry copper deposits in the southwest Pacific exhibit sodic and sodic-calcic alteration assemblages similar to those found within the Yerington supersystem. At the Mamut deposit in Sabah, Malaysia, a Miocene adamellite porphyry stock associated with the porphyry copper deposit contains a tremolite-actinolite zone in which hornblende has been altered to tremolite-hastingsite-actinolite-chlorite. This zone is present interior to a biotite (potassic) alteration zone (Kosaka and Wakita, 1978). In the porphyry copper deposits in North Sulawesi, Indonesia, albite forms veins and pervasive replacement with sericite and magnetite and is most closely associated with the highest grade copper zones (Lowder and Dow, 1978). In the Koloula complex at Guadalcanal, Solomon Islands, an interior alkali feldspar (orthoclase to sodic oligoclase)-quartz-magnetite-actinolite±salite zone is surrounded by potassic and propylitic alteration zones (Chivas, 1978). An "amphibole-magnetite" alteration assemblage is noted as the earliest highest temperature assemblage at the Panguna porphyry copper deposit at Bougainville, Papua New Guinea (Ford, 1978).

Furthermore, some of the Jurassic porphyry copper deposits in British Columbia which were emplaced into a magmatic arc setting similar to the Triassic to Jurassic magmatic arc setting of this study display many similarities to the Yerington supersystem, particularly sodic and sodic-calcic (amphibole-stable) alteration assemblages (Sutherland-Brown, 1976; Carson and Jambor, 1974). It therefore appears that the sodic and sodic-calcic alteration assemblages associated with porphyry copper systems are more common in oceanic and continental-margin magmatic arc settings than in continental arc settings and may reflect the influence of sea water or sea-water-derived connate waters in the mineralizing process.

The Yerington batholith is within an east-west-trending graben that formed prior to 165 Ma (Dilles and Wright, 1988; Schweickert and others, in press b). The position of the north and south walls of the graben are represented by east-west-trending normal faults and quartz monzonite porphyry dikes that have been dated at 165-166.5 Ma (Dilles and Wright, 1988; Schweickert and others, in press b). It remains uncertain whether this graben formed prior to the emplacement of the Yerington batholith, influencing its emplacement, or formed after the emplacement of the batholith, downdropping and preserving the mineral systems within it, or both.

THE MEADOW LAKE SYSTEM

Introduction

The Meadow Lake mining district is located in Nevada County, California, in the northern Sierra Nevada, north of Interstate Highway 80 and the community of Cisco Grove (fig. 11). The district extends from Red Mountain on the south (3 km north of Cisco Grove) about 14 km to the north to English Mountain and Jackson Lake. The mines and prospects are in an approximately 3-km-wide curved band that is in part coincident with a septum of mostly

Mesozoic metamorphic rocks between a Jurassic and a Cretaceous pluton (fig. 11).

The distinctive gold- and copper-bearing quartz-tourmaline veins were discovered in 1863, in a remote area north of the main transportation route between San Francisco and the newly discovered Comstock Lode of Nevada. Whisker (1958) has described the rush to Meadow Lake as "the wildest stampede in California history." As the easily worked, free-gold-bearing, oxidized parts of the veins were exhausted, interest in the district waned. The town of Meadow Lake, consisting of several thousand persons in the late 1860s, was nearly abandoned by 1872. The refractory sulfide ores below the level of oxidation could not be profitably treated at the time; Lindgren (1893) has estimated that $200,000 was invested in the mining district, with returns of less than $75,000. There has been no major production from the district since the late 1800s, and there has been only sporadic interest since that time. Recent exploration work in the mining district has reportedly outlined 600,000 tons of ore with an average grade of 0.15 ounce gold per ton (Mining Record, 1991).

The geology and ore deposits of the Meadow Lake mining district has been described by a number of authors, including Bowman (1983), Gerlach (1963), Lindgren (1893), Logan (1924), and Whisker (1936, 1958).

Geology

Geologic units exposed in the Meadow Lake mining district consist of Paleozoic and Mesozoic metamorphic rocks, the Jurassic and Cretaceous plutons which intrude them, and an overlying group of Tertiary volcanic rocks and Quaternary alluvium (fig. 11).

The metamorphic rocks crop out either in roof pendants or in a curving 1- to 3-km-wide band which at its southern end is a septum between Jurassic and Cretaceous granodioritic plutons. The oldest rocks of the district are the Permian Reeve Formation, exposed to the south of the main district. The Reeve consists of argillite, slate, and volcaniclastic sandstone. Overlying the Reeve with low-angle unconformity is a thin Early Triassic volcanic unit which in turn is overlain by the Early to Middle Jurassic Sailor Canyon Formation. The Sailor Canyon consists of thin- to thick-bedded, dark-gray, locally limy and pyritic, volcaniclastic siltstone and fine- to medium-grained graywacke and minor marble. It strongly resembles the underlying Reeve Formation of this area (Davis, 1990). Lying disconformably above the Sailor Canyon is the Tuttle Lake Formation, which consists primarily of andesitic metavolcanic rocks, dioritic hypabyssal intrusive rocks, and mafic volcaniclastic sandstone and conglomerate (Harwood and others, in press). At English Mountain, fine-grained, thin-bedded tuff of the Tuttle Lake contains impressions of Early and Middle Jurassic pelecypods. Included with the Tuttle Lake Formation on figure 11 are Jurassic(?) diorite and microdiorite that may be subvolcanic intrusions related to Tuttle Lake volcanism. The pre-plutonic rocks are metamorphosed to greenschist grade except near the plutons, where they are hornblende hornfels facies.

The western part of the mining district is underlain by the granodiorite of French Lake, a light-gray, fine- to medium-grained, hypidiomorphic-granular rock consisting of plagioclase, quartz, biotite, hornblende, and potassium feldspar. The granodiorite of French Lake probably has a minimum age of 151 Ma (Garside and others, 1992), based on a K-Ar age determination of hornblende separated from a sample collected near Meadow Lake (H.F. Bonham, oral commun, 1990). U-Pb age determinations on zircon of 163-172(?) Ma (Wracher and others, 1991) on older(?) parts of a plutonic suite which may include the granodiorite of French Lake also suggest that a Jurassic age is reasonable for the granodiorite. East of the septum of metamorphic rocks

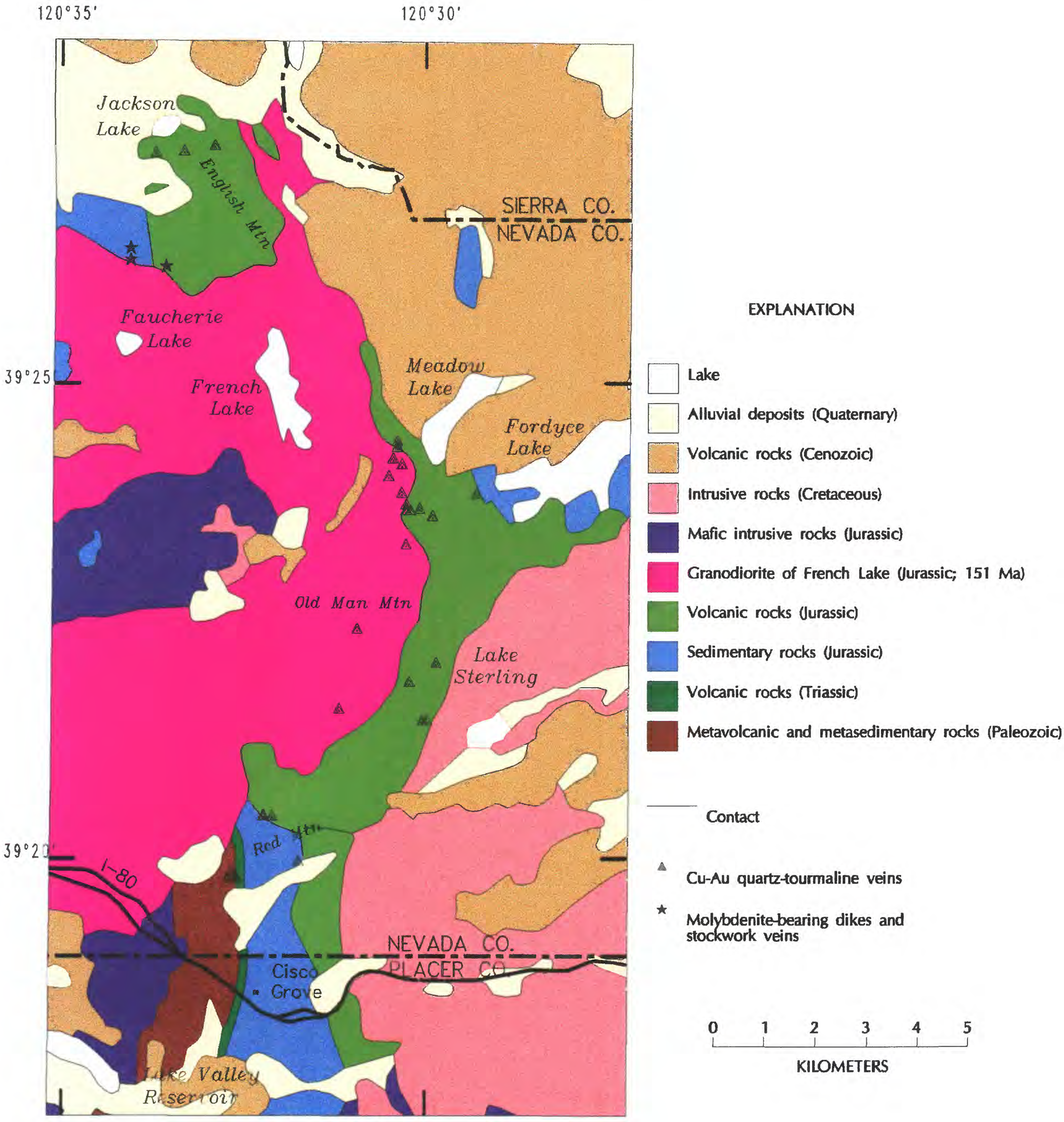


Figure 11. Generalized geologic map of the Meadow Lake district showing location of Cu-Au quartz-tourmaline veins and Mo-bearing dikes and stockwork veins (modified from Gerlach 1963; Bowman, 1983; Saucedo and Wagner, in press; Schweickert and others, in press a). See figure 1 for location.

and the mining district, a large pluton of porphyritic granodiorite is exposed. The granodiorite is a medium- to coarse-grained, light-colored unit consisting of plagioclase, quartz, potassium feldspar, biotite, and hornblende. Potassium feldspar phenocrysts are commonly pinkish colored, and typically dark, fine-grained, biotite-rich mafic inclusions are evenly distributed throughout the unit (Bowman, 1983). This pluton is most likely Cretaceous in age (probably 100 Ma, see Evernden and Kistler, 1970).

Tertiary volcanic rocks (Cenozoic volcanic rocks, fig. 11) lie with angular unconformity or nonconformity on the Mesozoic units. A group of quartz-bearing, rhyolitic ignimbrites is at the base of the Tertiary section. These pink to buff units contain at least one (hornblende-bearing) vitrophyric unit, both welded and unwelded tuffs, and rare lenses of well-rounded cobble conglomerate (Bowman, 1983). These ignimbrite units have not been correlated with the better described tuffs of northwestern Nevada, but the descriptions are reminiscent of several tuff units there. Deino (1985, fig. 8) has examined a section near the mining district, but did not correlate the ignimbrites with specific units exposed north of Reno. The interbedded conglomerate units may be lithologically similar to those between ignimbrite units in the Carson City area and described by Bingler (1978). A distinctive, nubbly or rectangular-shaped chip pattern on weathered tuff surfaces (Gerlach, 1963, p. 20) is similar to that recognized from Oligocene ignimbrites at the base of the Tertiary section north and east of Reno. However, a 34-Ma K-Ar age from an ignimbrite exposed near Donner Pass (Dalrymple, 1964) that is apparently correlative with tuffs in the mining district suggests that at least one unit is somewhat older than the tuffs of western Nevada.

Lying above the ignimbrites is a thick unit of andesite lahars, breccias, conglomerates, and associated epiclastic tuffaceous rocks (Bowman, 1983). These hornblende- and pyroxene-bearing andesitic rocks are part of a very extensive middle Miocene group of Andean-type arc stratovolcano deposits that are found along much of the northern Sierra.

Ore Deposits

Mineral deposits that are herein considered to be included in the Meadow Lake mining district are almost entirely gold-bearing tourmaline-quartz veins. These veins, hundreds to perhaps thousands of them, are generally northwest- to west-northwest-trending and steeply dipping (fig. 11). The veins vary in length from a few meters for the small, insignificant ones, to over 3,000 m for major veins systems (Bowman, 1983). The veins vary from a few millimeters to over 10 m in width and average perhaps 1-2 m. They are oxidized to gossan at the surface and commonly crop out as linear depressions (Bowman, 1983).

The gangue minerals in the veins are principally black tourmaline with usually subordinate quartz, and minor epidote (zoisite is reported by Gerlach, 1963), chlorite, and albite (Bowman, 1983). Minor amounts of apatite and muscovite are also reported (D.N. Bloom, written commun., 1991). Paragenetically late, coarsely crystalline calcite is present locally (Bowman, 1983; Gerlach, 1963). The black tourmaline is usually dense and fine grained, but is present rarely as needles lining vugs. The veins are locally brecciated and slickensided. In the Red Mountain area at the south end of the mining district, Bowman (1983) reports that veins consist of sulfide minerals in a gangue of alkali feldspar, biotite and (or) stilpnomelane, chlorite, and sparse tourmaline. Some skarn-hosted mineralized zones in the Sailor Canyon Formation are also present in this area (Southern Pacific Company, 1964).

Sulfide mineral content of veins ranges from a few to 20 volume percent (Whisker, 1936). The principal vein sulfide mineral is pyrite, constituting probably 95 volume percent of the ore according to Whisker (1936). Other hypogene ore minerals include chalcopyrite, arsenopyrite, pyrrhotite, magnetite, and sparse to rare sphalerite and galena (Bowman, 1983; Gerlach, 1963; Lindgren, 1893; D.N. Bloom, written commun., 1991; H.F. Bonham, Jr., written commun., 1990). In addition, Logan (1924) reported the presence of bornite. Free gold is present in the oxide zone of the veins, but its site or sites in sulfide ore have not usually been determined. Bowman (1983, p. 161) reports free gold in arsenopyrite as both minute exsolution(?) blebs, and as somewhat larger, cross-cutting blebs. Lindgren (1893) describes the gold as extremely fine and present in sulfide minerals; Gerlach (1963) reports that it appears to be associated with pyrite. In contrast to these descriptions, recent studies suggest that at least in the southern Excelsior vein system, gold is present in magnetite (D.N. Bloom, written commun., 1991). Historic production data suggests that the gold grade in ore shoots in the veins was about 0.25-0.5 ounces per ton (Bowman, 1983; Gerlach, 1963), and recent drilling has encountered veins with about 1 ounce per ton gold (D.N. Bloom, oral commun., 1991). Whisker (1936) thought that as much as 80 percent of the ore of the major claims was of pay grade (0.29-0.5 ounces gold per ton), and that the main control on ore shoots was just vein width. Lindgren (1893) reported that gas and fluid inclusions are plentiful in quartz, and multiphase fluid inclusions are reported to increase with increased gold content in the ore (Callahan Mining Co. study cited in D.N. Bloom, written commun., 1991).

The refractive nature of the sulfide ore stymied early miners, but recent developments in metallurgy allow its effective treatment (see Whisker, 1958). Several mining companies in the 1930s and again in the 1980s have attempted to develop ore reserves along some of the veins. Recently, exploration work in the mining district has outlined 600,000 tons with an average grade of 0.15 ounce gold per ton. The reserves are reported to be well suited to extraction using a narrow-cut surface mining technique (Mining Record, 1991).

In addition to the quartz-tourmaline veins, copper-molybdenum-tungsten mineralized zones are present in hornfels and quartzite of the Sailor Canyon Formation on the south flank of English Mountain at the north end of the mining district. Veins, stockworks, and associated skarn-related mineralization took place in the Sailor Canyon Formation near a granitic stock; leucocratic granitic dikes are present in the mineralized zone. Ore minerals reported include chalcopyrite, molybdenite, scheelite-powellite, magnetite, pyrite, pyrrhotite, and bornite. In addition to quartz, gangue minerals include epidote and garnet (Wilson, 1981; H.F. Bonham, Jr., written commun., 1990). Garnet is also reported to be associated with sulfide minerals in skarn-hosted mineralized zones from the Red Mountain area at the south end of the mining district (Southern Pacific Company, 1964).

Alteration

The walls of the tourmaline-quartz veins are commonly indistinct (Lindgren, 1893; Bowman, 1983, p. 147), and most wallrock alteration consisted of replacements and veinlets formed adjacent to the main veins. These alteration envelopes consist of the main vein-forming minerals. Bowman (1983) reports that in the walls of veins, alteration proceeded from outside toward the vein through zones of silicification, albitization, chloritization, epidotization, and tourmalinization.

Age of Mineralization

In the Meadow Lake mining district, the quartz-tourmaline veins cut the granodiorite of French Lake (Jurassic quartz diorite of Bowman, 1983). This pluton has a minimum age of 151 Ma (see the section "Geology"). The veins are cut off by a Cretaceous (probably 100 Ma; Evernden and Kistler, 1970) granodiorite; they are both cut by and cut pegmatite dikes, and are cut by a metamorphosed (or altered) pyroxene andesite dike (Bowman, 1983, p.172). Bowman related the vein mineralization to hydrothermal fluids generated during and immediately following consolidation of the Late Jurassic pluton. However, his evidence is not conclusive, and the veins could be related to the nearby Cretaceous pluton, as could the dike rocks which are both younger and older than the veins. The presence of black tourmaline-bearing aplite and pegmatite dikes within and probably associated with the Cretaceous pluton (Gerlach, 1963) suggests either remobilization of tourmaline or a Cretaceous age for the quartz-tourmaline veins.

Mineralized zones in fine-grained clastic rocks of the Sailor Canyon Formation adjacent to the northern margin of the pluton are interpreted to be related to the Late Jurassic granodiorite of French Lake (fig. 11). Copper- and molybdenum-bearing skarn at the Molly Mine (sec. 12, T.18 N., R. 12 E.) is present immediately adjacent to the pluton, and late-stage(?) quartz veinlets cut both the pluton and Sailor Canyon Formation. A nearby massive, vein-like replacement deposit of pyrrhotite+magnetite+chalcopyrite is also interpreted as a metasomatic replacement deposit associated with the French Lake pluton.

Geochemistry

The following elements are commonly anomalous in ore and mineralized vein samples: gold, silver, copper, lead, zinc, cobalt, boron, molybdenum, arsenic (appendixes 2 and 3, this report; Bowman, 1983). Whisker (1958) reported anomalous concentrations of nickel as well, although this was not confirmed by Bowman or our study. The presence of most of these anomalous elements, can be deduced from the ore minerals. High gold concentrations appear to be associated with high concentrations of copper and, according to Bowman (1983), with cobalt also. Silver concentrations are apparently highest in copper-rich ores. Although sparse to rare galena and sphalerite have been reported from ore samples, lead and zinc are rarely slightly to moderately anomalous.

Origin of Mineral Deposits

The quartz-tourmaline veins of the Meadow Lake mining district and similar veins elsewhere in western Nevada (see description of Cu-Au quartz-tourmaline veins in the section "Mineral Deposit Types") should be considered as high temperature or hypothermal. Lindgren (1933, p. 770) lists copper-tourmaline deposits as one type of hypothermal veins and gives the Meadow Lake veins as one example. Hypothermal mineral deposits were originally defined as being formed at temperatures of 300-500 °C and very high pressure. Later studies suggest shallower formation depths for many high temperature deposits, including tourmaline veins (see Buddington's (1935) xenothermal category). The upper temperature limit of hypothermal deposits is now considered to be at least 600 °C (Jensen and Bateman, 1981, p. 105).

Tourmaline is present in contact metasomatic deposits, and the presence of black tourmaline (schorl) is specifically noted in hypothermal mineral deposits by Park and

MacDiarmid (1964, p. 268). Similarly, magnetite is commonly associated with such deposits, and some of the quartz-magnetite-tourmaline deposits (for example, on Peavine Peak, at the Bessemer Mine in the Delaware mining district, and on Fort Sage Mountain in the State Line Peak mining district 17 km north of the study area) are skarn-like replacement deposits and apparently a variant of, or part of a continuum, with the gold- and copper-bearing quartz-tourmaline veins. Fluid-inclusion and experimental petrology studies on hydrothermal tourmaline that formed in the Larderello geothermal field suggest that most formed at 400° to 600°C (Cavarretta and Puxeddu, 1990). Also, at some Cu-Au quartz-tourmaline veins in the study area, wallrock alteration zones and non-vein deposits are definitely skarn-like, such as at the Red Metals Mine in the Peavine mining district, where abundant epidote is present with sparse garnet. Sericite is present as a wallrock alteration product adjacent to some quartz-tourmaline veins; this is compatible with its association with certain hypothermal veins, as described by Park and MacDiarmid (1964, p. 269). The presence of molybdenite in a few of the veins is also suggestive of at least moderately high temperature. The generally inconspicuous wallrock alteration zones suggest that the physical conditions of vein formation were not too different from those during crystallization of the plutonic wallrocks.

The quartz-tourmaline veins have some remarkable similarities (but some differences as well) to porphyry copper/molybdenum deposits and related skarns, as noted by Bowman (1983). Similar veins are described from a porphyry copper environment at the Lights Creek stock near Taylorsville, California (Putman, 1975), 100 km north of the Meadow Lake mining district and outside the study area. Although there is no evidence of any porphyry-style mineral deposit in the vicinity of many of the quartz-tourmaline veins in the study area, the vein mineralization can be viewed as a related type, developed in and adjacent to mainly granodioritic plutons. Possibly the veins represent somewhat weaker mineralization, without the development of the large hydrothermal cells necessary for porphyry mineralization. Bowman (1983) suggests that vein deposits like those at Meadow Lake may be the lowermost part of porphyry copper systems, or the manifestation of a deeply emplaced mineralized pluton which might have formed a porphyry copper deposit if it had come to rest at a higher, subvolcanic level. However, tourmaline is present in high-level breccias at some porphyry copper deposits. Although it may represent intense pneumatolytic activity, it is not necessarily indicative of deep emplacement.

THE PINE NUT SYSTEM

The Pine Nut mineral system is located in the Gardnerville mining district in the southern Pine Nut Mountains (fig. 12). The mineral system is here defined as the Pine Nut porphyry molybdenum deposit (Roxlo and Ranta, 1982) and all related tungsten skarn deposits, including deposits at the Alpine, Cherokee, Pioneer, and Divide Mines (Moore, 1969; Stager and Tingley, 1988).

Pine Nut Porphyry Molybdenum Deposit

The Pine Nut molybdenum deposit was discovered by the Climax Molybdenum Co. in 1963. The evaluation of the deposit involved mapping, geochemical sampling (rock chip, stream sediment, water, soil, and tree), geophysics (magnetics, IP, SP, gravity, and CSAMT), and drilling. Estimated reserves are 60 million tons of ore averaging 0.14 percent MoS_2 (using a 0.10 percent MoS_2 cutoff) or 200 million tons of ore averaging 0.10 percent MoS_2 (using a 0.05

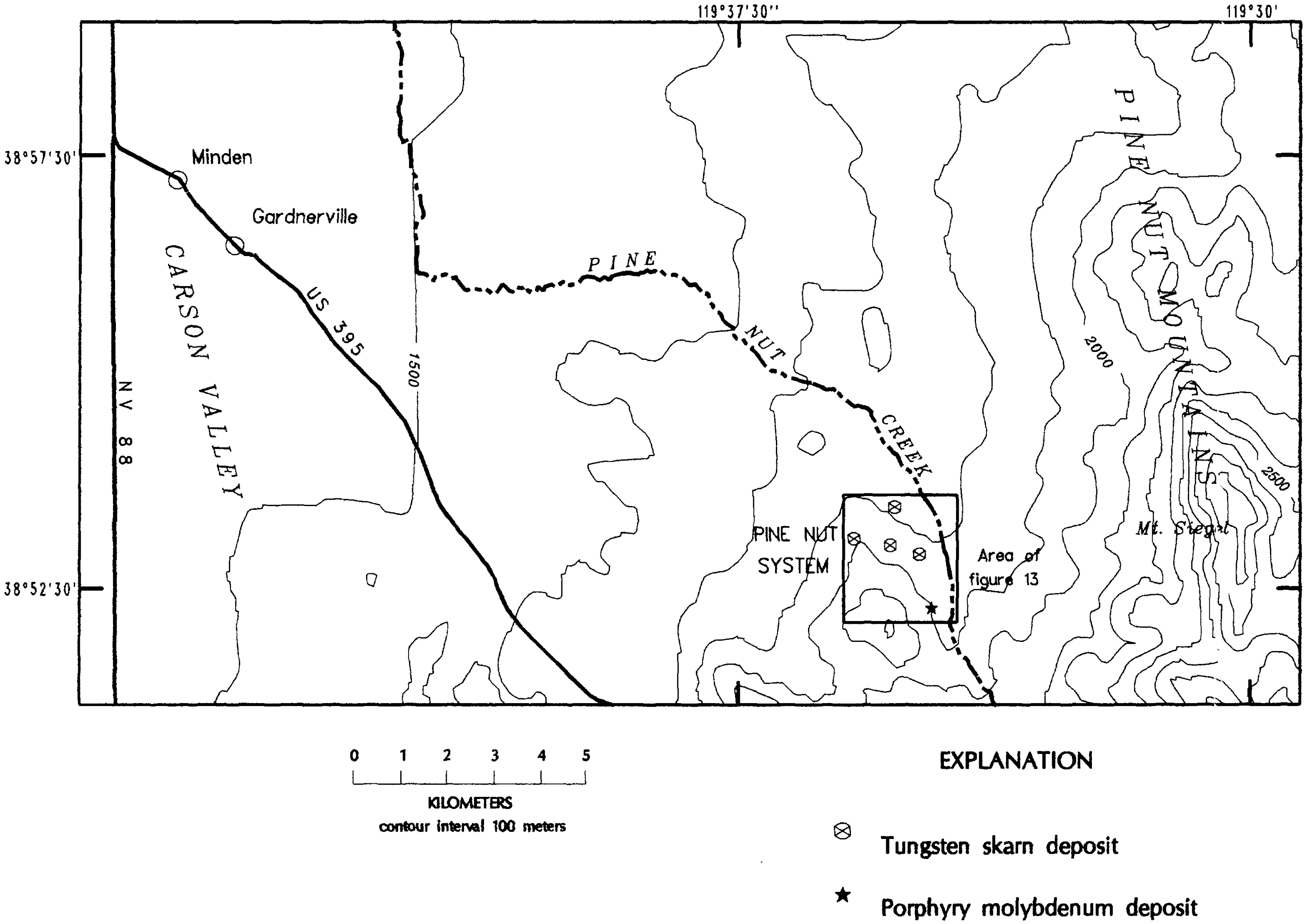


Figure 12. Index map of Gardnerville district showing location of the Pine Nut mineral system and area of figure 13. See figure 1 for location. See figures 14 and 15 for cross sections through Pine Nut porphyry molybdenum deposit.

percent MoS_2 cutoff) (Roxlo and Ranta, 1982).

The geology of the area consists of mixed Triassic metavolcanic and carbonate units of the Oreana Peak Formation of Noble (1962, 1963) (fig. 13) that were folded about a N. 20° W.-trending axis to form the Ruby Hill anticline (Noble, 1962). The folded sequence was intruded by a biotite quartz monzonite stock(s), which locally domed the anticlinal axis in the vicinity of the Alpine Mine and was responsible for porphyry molybdenum and tungsten skarn mineralization. The age of the stock and associated mineral deposits is uncertain. Roxlo and Ranta (1982) indicate that the quartz monzonite stock is probably related to the Mount Siegel quartz monzonite unit which is Middle Jurassic and part of the Shamrock batholith (Dilles and Wright, 1988). However, the Mount Siegel quartz monzonite unit is generally hornblende-rich (John and others, 1994) whereas the quartz monzonite at the Pine Nut deposit is biotite rich (Roxlo and Ranta, 1982). Other nearby plutons in the Pine Nut Mountains are Early Cretaceous or younger age (Noble, 1962; Noble and others, 1973). With the exception of the Middle to Late Jurassic porphyry molybdenum system in the Cucomungo area of Esmeralda County, Nevada (Briner, 1980), all dated porphyry molybdenum deposits in the western Great Basin are Cretaceous or Tertiary in age (Schilling, 1968; Cox and others, 1991).

Small exposures of the quartz monzonite stock and associated dikes and apophyses are found in the vicinity of the Alpine, Cherokee, and Divide Mines (fig. 13). Exposures at the Alpine Mine represent the uppermost part of what is known as the south stock (Roxlo and Ranta, 1982). East-west and north-south cross sections through the south stock are shown in figures 14 and 15, respectively. Dikes near the Cherokee and Divide Mines are texturally and compositionally similar to the south stock. The south stock ranges from biotite quartz monzonite to biotite granite in composition. A border phase, generally 3 m wide, consists of gray fine- to medium-grained porphyritic granite with abundant finely crystalline biotite and scattered phenocrysts (as long as 1 mm) of potassium feldspar and quartz. The interior phase is a light-gray, medium-grained equigranular quartz monzonite with varied amounts of biotite and rare phenocrysts of quartz and potassium feldspar. Aplite dikes (generally less than 1 cm wide) and apophyses of the stock are most common within 15 m of the intrusive contact (Roxlo and Ranta, 1982).

Hydrothermal alteration was most intense in and adjacent to the south stock. A zone of pervasive quartz-sericite-pyrite alteration and stockwork quartz veining formed in the metavolcanic and carbonate units above the stock. Quartz+potassium-feldspar veins with potassium feldspar alteration envelopes form a zone at the top of the stock and partially in the overlying country rock, in general, beneath the quartz-sericite-pyrite alteration zone. The potassium feldspar envelopes coalesce to form pervasive potassic alteration zones in areas of high vein density (Roxlo and Ranta, 1982).

A zone of stockwork quartz+molybdenite veins caps and partially overlaps the apical zone of the south stock, such that 75 percent of the molybdenum is in country rock and 25 percent is in the quartz monzonite stock (figs. 14, 15). Quartz+molybdenite veins average 1 mm in width and typically cut aplite dikes and apophyses of the stock. The deposit, using a 0.05 percent MoS_2 cutoff, is umbrella shaped with a flat, thin top and steeply dipping west and south limbs (figs. 14, 15). In plan view, the deposit is about 675 m in diameter and the 0.10 percent MoS_2 zone is donut shaped. The "donut hole" may be due to a combination of erosion, oxidation, and leaching of near-surface molybdenum, or to original nonuniform MoS_2 deposition, with higher grade zones along the limbs rather than the top (Roxlo and Ranta, 1982).

Soil geochemistry outlined an area of anomalous molybdenum (>10 ppm) 615 by 370 m

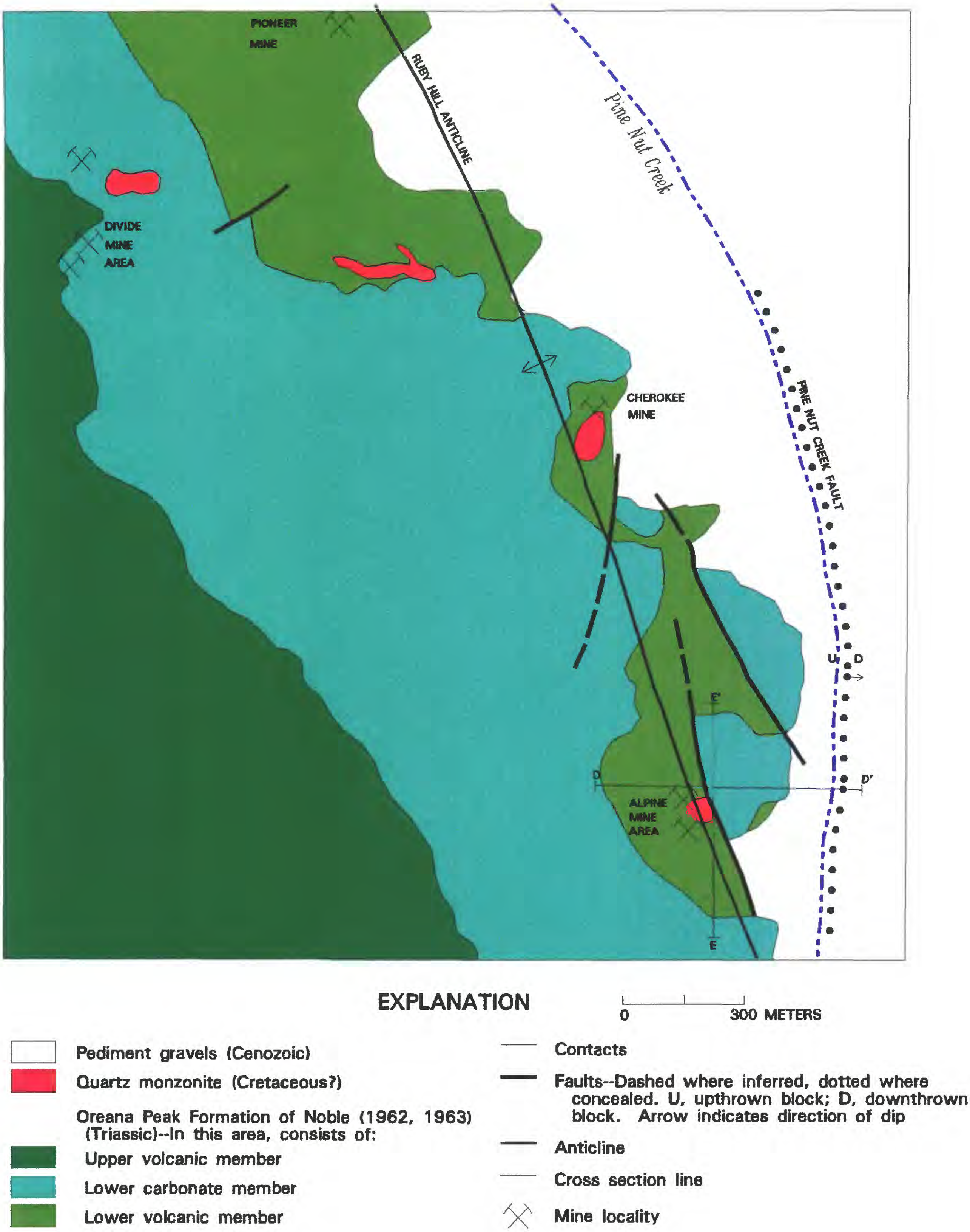


Figure 13. Geologic map of area around Pine Nut mineral system, Gardnerville district (modified from DeLong, 1977; Roxlo and Ranta, 1982; Stager and Tingley, 1988). See figure 12 for location. Also shown are locations of cross sections shown in subsequent figures (D-D', see fig. 14; E-E' see fig. 15).

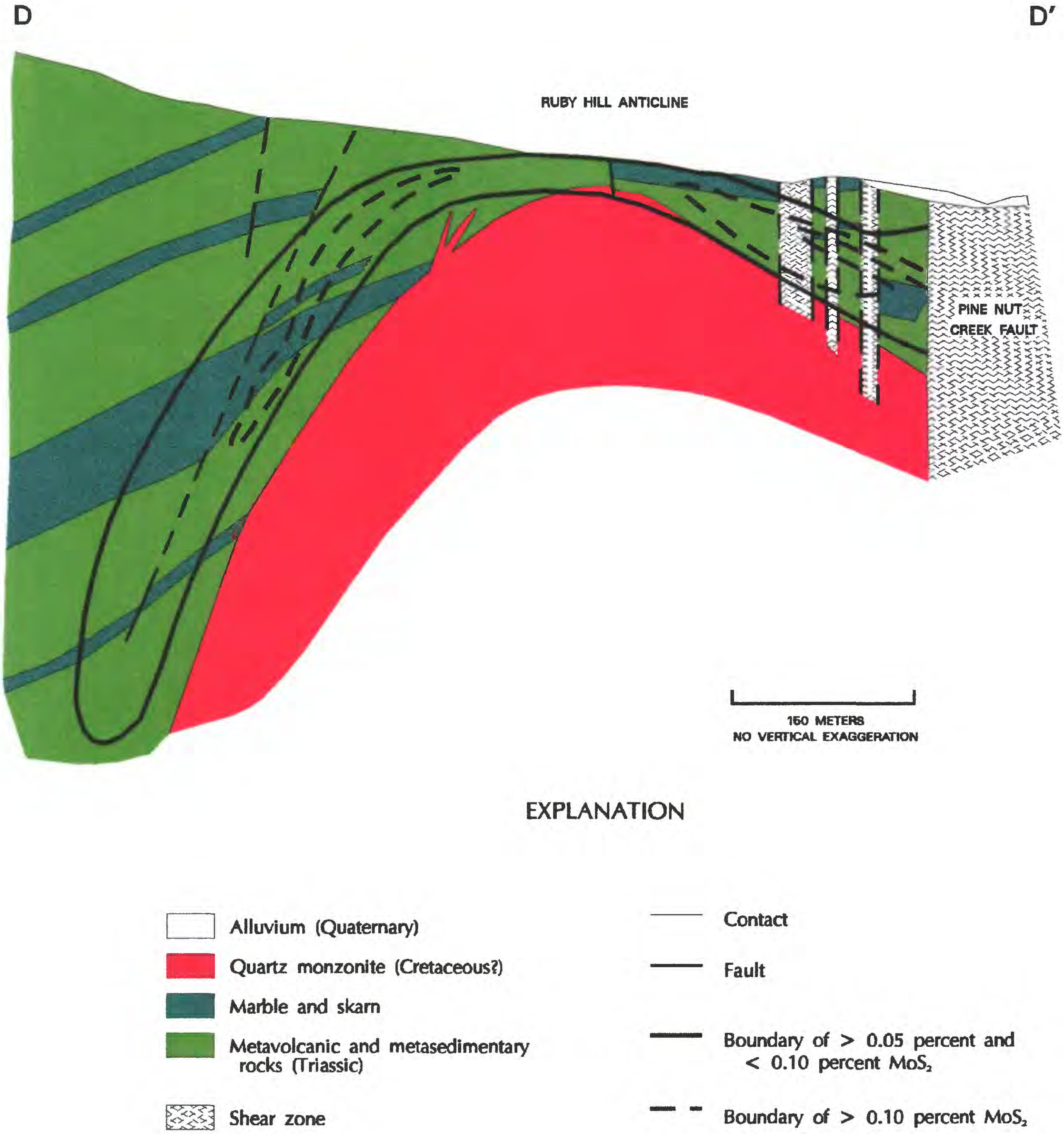


Figure 14. East-west cross section through Pine Nut porphyry molybdenum deposit, Gardnerville district, showing geology and geometry of ore shell (modified from Roxlo and Ranta, 1982). See figure 13 for location.

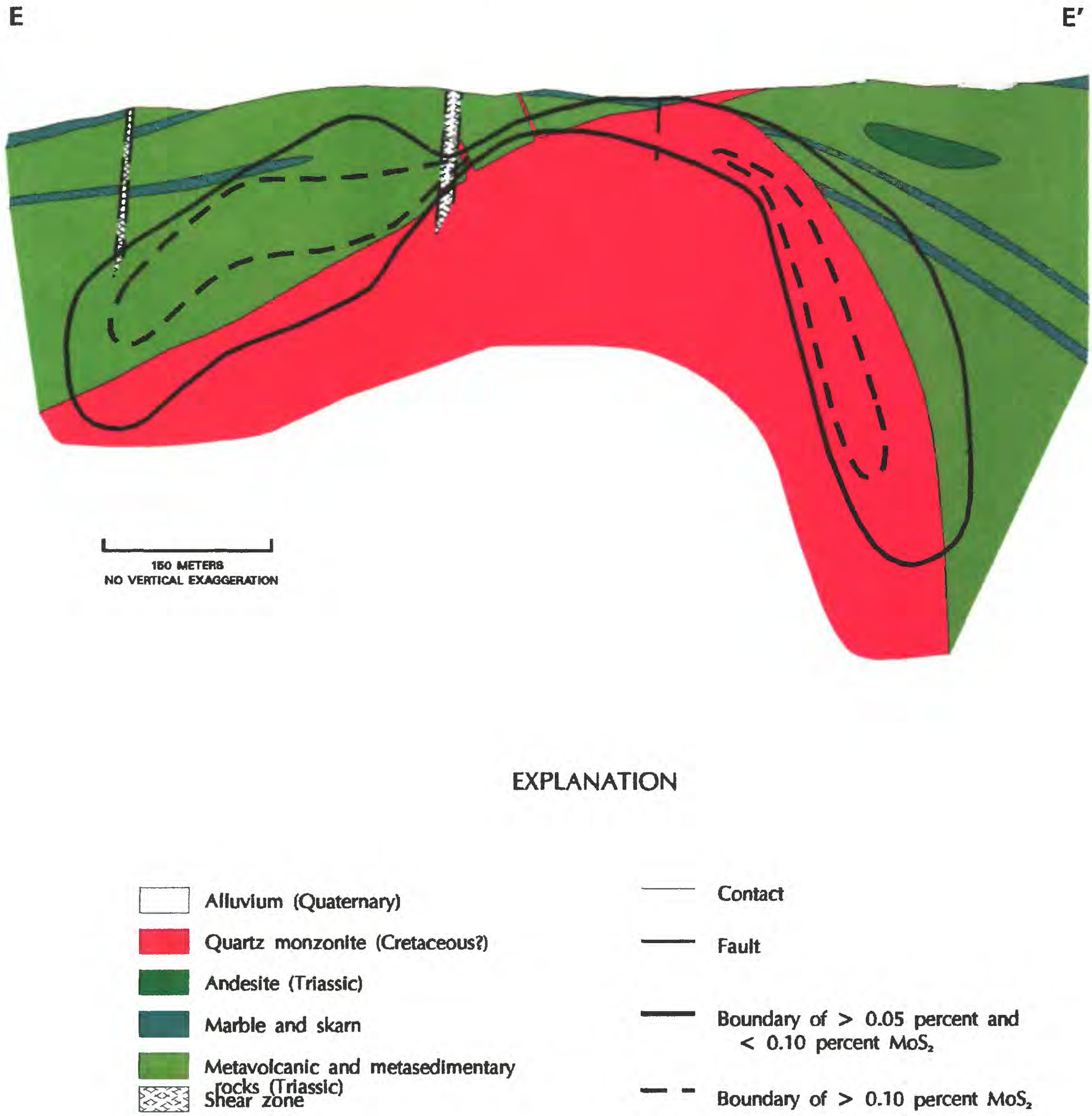


Figure 15. North-south cross section through Pine Nut porphyry molybdenum deposit, Gardnerville district, showing geology and geometry of ore shell (modified from Roxlo and Ranta, 1982). See figure 13 for location.

and centered over the quartz monzonite stock (Roxlo and Ranta, 1982). Copper is also anomalous in this zone. Rock-chip geochemistry indicates that Be, Bi, Sn, W, Zn, and Ag are spatially related to the mineralized stock (Roxlo and Ranta, 1982).

As shown in figure 14, the east part of the deposit has been displaced by the Pine Nut Creek fault (fig. 13). Furthermore, the orientation of the ore shell (figs. 14, 15) suggests that the deposit has not been tilted, in contrast to the porphyry deposits in the Yerington mining district 30 km away (see section on "Yerington Supersystem"). However, even Tertiary volcanic rocks west of the Pine Nut Creek fault show little evidence of tilt (R. Schweickert, oral commun., 1991). Thus, the only conclusion that can be reached at this time is that mineralization predated the late Tertiary(?) Pine Nut Creek fault.

Tungsten Skarn Deposits

Numerous tungsten skarn deposits are located in the Gardnerville mining district. They are the reason the area was formerly known as the Tungsten Hills. These skarns are all genetically related to the same quartz monzonite stock(s) and dikes that produced porphyry molybdenum mineralization at the Pine Nut deposit. The largest of the tungsten skarn deposits saw periodic production during the periods 1937-1944 and 1951-1956 and include deposits at the Alpine, Divide, Cherokee, and Pioneer Mines (fig. 13).

The Alpine Mine was by far the largest producer of tungsten in the Gardnerville district with a total production of 12,938 units of WO_3 (Stager and Tingley, 1988). At the Alpine Mine, scheelite is in garnetiferous skarn that partly replaces a 2 m thick bed of dolomite that is present within the lower volcanic member of the Oreana Peak Formation (Noble, 1962) (fig. 13). Ore grades were as high as 1.5 percent WO_3 in 0.5-1 m thick sections. No tungsten ore was encountered below the 60 m (200 ft.) level. Powellite ($CaMoO_4$) is found with scheelite with increasing frequency at deep levels, and at the 120 m (400 ft) level powellite is abundant and associated with finely crystalline molybdenite (Stager and Tingley, 1988). The zonation of scheelite to powellite to molybdenite with increasing depth is consistent with a genetic relationship between tungsten skarn and porphyry molybdenum mineralization.

Tungsten skarn at the Divide Mine produced a total of 1,979 units of WO_3 (Stager and Tingley, 1988). Skarn deposits here are hosted by the lower carbonate member of the Oreana Peak Formation (Noble, 1962), which is intruded by felsic dikes and quartz monzodiorite plugs. Tungsten ore is present in beds of calcite- and pyroxene-rich wollastonite 2.5-3 m thick. Scheelite is found principally as pods, as much as 1.5 m long and 0.6 m thick, in wollastonite zones (Stager and Tingley, 1988).

The tungsten skarns at the Cherokee and Pioneer Mines are hosted by thin carbonate beds within the lower volcanic member of the Oreana Peak Formation (Noble, 1962) as at the Alpine Mine (fig. 13). Combined production equal 519 units of WO_3 (Stager and Tingley, 1988). Scheelite is present as small grains distributed erratically throughout garnetiferous skarn zones which average 0.1 to 1 percent WO_3 (Stager and Tingley, 1988).

THE LUCKY BOY AND PAMLICO MINING DISTRICTS: A COMPARATIVE STUDY

by

Daniel R. Shawe, Holly J. Stein, Jeff L. Doebrich, and Robert O. Rye

Introduction

The Lucky Boy and Pamlico precious metal mining districts are located in Mineral County, Nevada, in the southern Wassuk Range and Garfield Hills, respectively (fig. 16). They are positioned on opposite sides of the proposed Pine Nut fault, which is thought to be a fundamental structural boundary separating the Pine Nut lithotectonic terrane on the west from the Sand Springs and Pamlico lithotectonic terranes to the east (Oldow, 1984). A lead-isotope study of the two mining districts was conducted in order to clarify the significance of the fault as a major tectonic discontinuity. A geologic map of the Lucky Boy mining district prepared by Shawe and a geologic map of the Pamlico mining district (modified from Archbold and Paul, 1970, and Oldow, 1985) were used as frameworks for the study. Geochemical and sulfur isotopic characteristics of the mining districts were also investigated. D.R. Shawe and J.L. Doebrich collected samples of mineralized rocks from both mining districts for geochemical and isotopic studies. H.J. Stein performed Pb-isotope analyses and R.O. Rye performed S-isotope analyses on galenas.

Geology

Lucky Boy mining district

In the Lucky Boy mining district, Triassic(?) limestone was metamorphosed widely to marble and calc-silicate mineral assemblages and argillite was locally metamorphosed to schist, as a result of intrusion by late Mesozoic granite, granodiorite, and diorite (pl. 1). A plate of Permian and (or) Mesozoic andesite has been thrust over these rocks. The andesite was intruded by a Cretaceous (77-80 Ma; Evernden and Kistler, 1970; Robinson and Kistler, 1986) granodioritic pluton, probably after emplacement of the thrust plate. Tertiary andesite and latite were emplaced in the south part of the mining district, and unconsolidated late Cenozoic alluvial deposits are widespread. Subsidiary thrust faults formed locally beneath the upper andesite plate. A few north-striking faults have small displacement. The Triassic(?) sedimentary rocks have been folded into northeast-trending isoclinal folds; local shear foliations in granite and granodiorite parallel the fold axes.

The thrust faults and northeast-trending folds and shear foliation observed in the Lucky Boy mining district are more characteristic of structural features found in the Pamlico terrane and not the Pine Nut terrane as defined by Oldow (1984). Oldow (1984) describes the Pine Nut terrane west of the Pine Nut fault as having a single phase of tight to isoclinal folds with north-northwest-striking axial planes and no major thrust faults. The Pamlico terrane is described as exhibiting polyphase folding (northeast-, north-northwest-, and west-northwest-trending axial planes) and thrust imbrication in response to northwest-southeast shortening (Oldow, 1984). Consequently, the boundary between the Pine Nut and Pamlico lithotectonic terranes may be west of the Lucky Boy mining district rather than east.

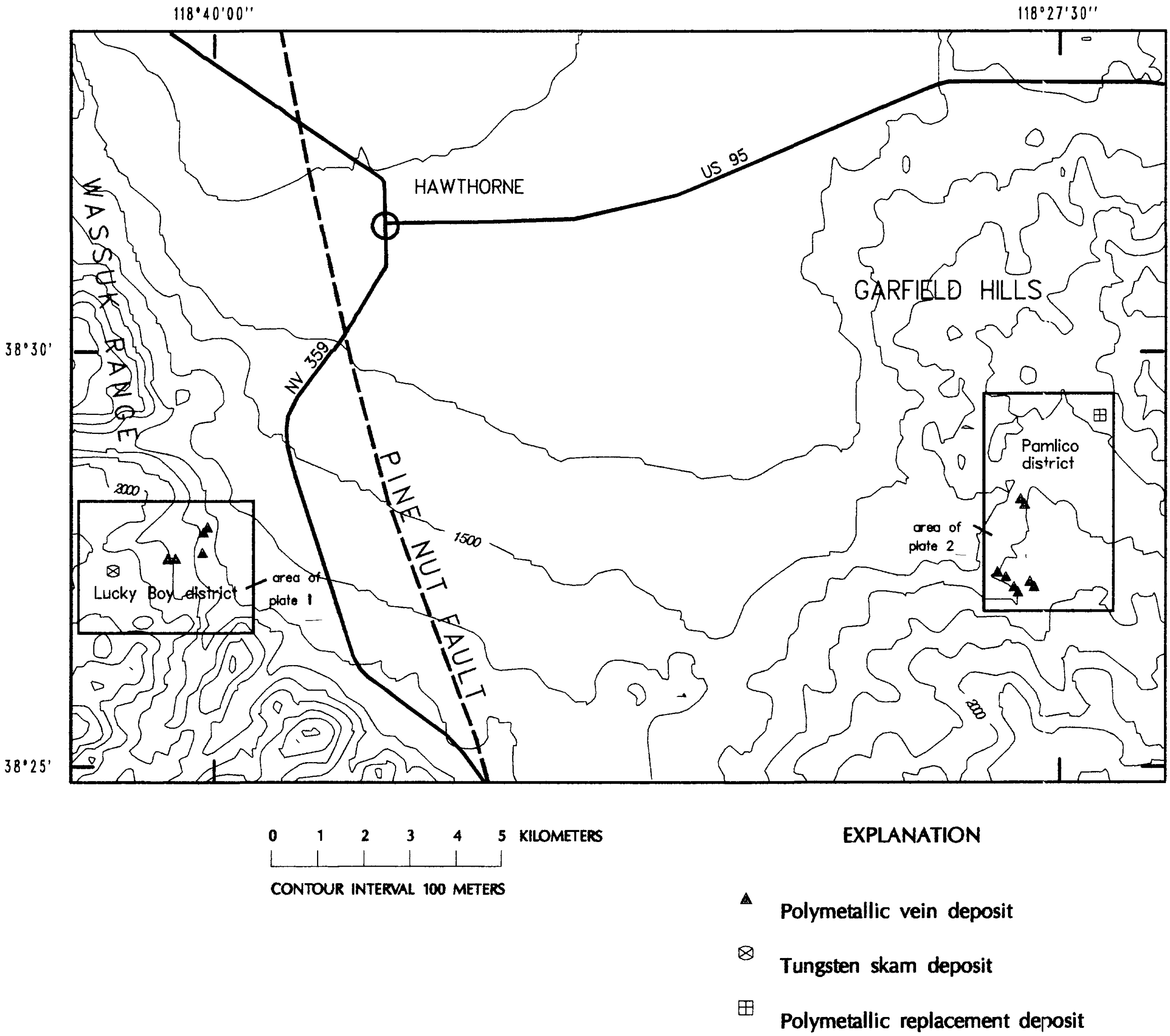


Figure 16. Index map showing location of Lucky Boy and Pamlico mining districts and areas of plates 1 and 2. See figure 1 for location.

Pamlico mining district

The Pamlico mining district and environs are underlain by a sequence of late Paleozoic and Mesozoic volcanic and sedimentary units that were intruded by late Mesozoic igneous rocks and subsequently overlain by Tertiary volcanic rocks (pl. 2; Archbold and Paul, 1970; Oldow, 1985). Permian to Triassic latite tuff, agglomerate, and rhyolite porphyry comprise the oldest unit in the mining district. This unit is comformably overlain by the Pamlico Formation of Oldow (1978), a sequence of Triassic volcanic rocks, volcanogenic sedimentary rocks, andesitic agglomerate, and limestone (locally metamorphosed to marble). The volcanosedimentary sequence was intruded by a Cretaceous quartz monzonite pluton, and Tertiary tuff and rhyolite flows cover a minor part of the mining district. Northwest-trending folds and faults dominate the mining district.

Mineral Deposits

Lucky Boy mining district

Mineral deposits in the Lucky Boy mining district consist of quartz veins localized along a prominent linear zone of east-striking shears. The veins are several centimeters to as much as 2.5 m wide (Ross, 1961, table 6.3), lenticular, locally brecciated, and commonly iron stained. The quartz veins contain pockets of argentiferous galena and argentiferous tetrahedrite. Ross (1961, table 6.3) also reported the presence of subordinate sphalerite, argentite, pyrargyrite, and pyrite. Secondary minerals are malachite, azurite, linarite, and brochantite. In places barite constitutes a major gangue mineral. Ankerite, ferroan dolomite, or calcite are present in quartz locally. The veins mostly strike east and dip steeply south in a narrow east-trending zone through the central part of the mining district (pl. 1). They are found in Mesozoic (Late Cretaceous?) granite and granodiorite and in Triassic limestone and its metamorphosed equivalents. Minor tungsten has been produced from skarn-like deposits in the mining district (Stager and Tingley, 1988, p. 116).

The east-trending mineralized vein system in the Lucky Boy mining district may extend eastward beneath shallow alluvial fill of the Hawthorne basin. Gravity data analyzed by D.A. Ponce (see Schweickert and others, in press b) indicate that the intermontane basin east of the Wassuk Range at this latitude contains no more than about 1,000 m of unconsolidated alluvium. The mountain front at the Lucky Boy mining district is a gently warped surface, sloping valleyward; it is not a faulted mountain front as is typical of Basin-and-Range mountains in the province. This geomorphic character of the range front at the mining district suggests that bedrock may continue eastward as a gently sloping surface beneath shallow alluvium, raising the possibility that the east-striking vein system of the mining district may underlie shallow alluvium there.

A soil-gas survey by J.H. McCarthy, Jr. (see McCarthy and others, in press) conducted along a north-south traverse about 1 km east of the mountain front indicated anomalies on the eastward projection of the principal Lucky Boy mineralized trend. According to McCarthy the organic (alkane) gases detected are known to indicate buried sulfide deposits in some other localities. The area east of the main Lucky Boy mineralized trend therefore appears to be worth further evaluation for the possible presence of mineral deposits buried beneath shallow alluvium.

Pamlico mining district

The Pamlico mining district contains four types of mineral deposits: (1) gold-bearing quartz veins in the main Pamlico mines, (2) gold-bearing limonitic quartz deposits at the La Panta mines, (3) copper-bearing skarn northeast of the La Panta mines, and (4) gold- and silver-bearing quartz veins in the area of the Central Mine (pl. 2; Archbold and Paul, 1970, p. 8-11).

Gold-bearing quartz veins in the main Pamlico Mines consist of white quartz, commonly iron stained and brecciated, and locally showing cockscomb structure, that contains small amounts of galena, tetrahedrite, pyrite, chalcopyrite, and sphalerite. Free gold was found as coarse nuggets and wires (Hill, 1915, p. 156-157). Argentiferous galena is the most abundant sulfide mineral. The veins have northwest orientations, commonly with shallow dips as low as 15° and are localized mostly along faults and shear zones. The veins are in Permian and (or) Mesozoic rhyolites and latitic tuffs (pl. 2).

The La Panta deposits (pl. 2) are strongly oxidized, limonite-rich jasperoid replacements in Triassic limestone. Free gold was found in iron-rich ores; minor sulfide minerals are present in unoxidized (unweathered) rocks (Archbold and Paul, 1970, p. 10).

Copper minerals are found along the contact between late Mesozoic quartz monzonite and Triassic limestone northeast of the La Panta mines. Skarn contains calc-silicate minerals and secondary copper minerals. Lincoln (1923, p. 145) reported high-grade gold pockets at the locality.

Gold- and silver-bearing quartz veins are present in Triassic(?) shales, siltstones, and volcanic rocks about 1.5 km north of the main Pamlico Mines in the Central Mines area (pl. 2). Iron-stained, brecciated white quartz forms thin lenticular veins in north-trending, east-dipping faults. The quartz contains pockets of argentiferous galena and minor free gold.

Geochemistry and Isotopes

The geochemical character of vein samples from the Lucky Boy and Pamlico mining districts are compared in table 2. Table 2 shows that veins in the Lucky Boy mining district contain more lead, silver, and antimony, and less arsenic than do veins in the Pamlico mining district. This is consistent with the difference in ore mineralogy, i.e., the presence of argentite, and pyrargyrite, and the greater abundance of galena in veins from the Lucky Boy mining district.

A tabulation of lead isotope data from the two mining districts is presented in table 3. The mining districts contain distinctive but similar lead isotopic characteristics, both of sialic crustal affinity. Galenas from the Lucky Boy mining district have higher $^{206}Pb/^{204}Pb$ than galenas from the Pamlico mining district. Within each mining district, the very tight grouping of $^{206}Pb/^{204}Pb$ suggests derivation of lead from a fluid with a homogeneous lead isotopic composition on a mining district scale. In the Lucky Boy mining district, one galena (LB-8) has a $^{206}Pb/^{204}Pb$ ratio slightly higher than the tightly grouped $^{206}Pb/^{204}Pb$ ratios of the other samples, and it is the only analyzed sample collected from outside the main east-west linear trend of the mining district (pl. 1). A preliminary interpretation of the lead isotope data for the Lucky Boy and Pamlico mining districts supports, but does not confirm, the suggestion that the mining districts are located within separate and distinctive tectonic terranes separated by the Pine Nut fault.

A tabulation of sulfur isotope data from the two mining districts is presented in table 4.

Table 2.--Chemical compositions and descriptions of samples from the Lucky Boy (LB) and Pamlico(PAM) districts.

(Values in parts per million (ppm); analyses by J.M. Motooka, R.T. Hopkins, and B.H. Roushey; Au by flame atomic absorption; Ag, As, and Sb by induced coupled plasma-atomic emission spectroscopy; Cu, Pb, and Zn by semiquantitative emission spectroscopy; sample localities shown on plates 1 and 2)

Sample No.	Au	Ag	Cu	Pb	Zn	As	Sb
LB- 1	1.35	1200	7000	>20000	7000	<0.6	1100
3	<0.07	120	300	15000	200	7.2	190
4A	0.05	790	1500	>20000	200	7.6	910
4B	0.05	>1300	3000	>20000	700	9.7	1900
5	<0.05	180	700	2000	<200	3.2	120
6	4.60	390	1000	>20000	500	24	580
8	<0.05	41	150	15000	<200	<0.6	<0.6
9A	0.40	19	70	>20000	<200	<0.6	<0.6
PAM-1	4.20	43	700	1500	1500	300	190
2	0.15	260	7000	10000	1500	130	590
3	<0.05	28	300	7000	500	300	170
4	0.10	110	3000	2000	700	250	470
5	0.20	3.9	100	500	1500	6.8	<0.6
6	0.45	120	500	2000	500	140	150
7	0.15	100	500	5000	300	52	180
8	0.10	5.5	20	700	300	22	12
10	0.20	37	30	20000	2000	530	<0.6

Descriptions of samples:

LB- 1 - Silicified, brecciated and pulverized rock with galena; mine dump.
3 - Brecciated quartz vein material with sulfide minerals; mine dump.
4A - Quartz vein material with sulfide minerals and ferrodolomite(?); mine dump.
4B - Barite vein material with sulfide minerals; mine dump.
5 - Siliceous vein material with iron oxides, sulfide minerals; mine dump.
6 - Quartz vein material with sulfide minerals; mine dump.
8 - Drusy and sheared quartz vein material with sulfide minerals; mine dump.
9A - White quartz veinlets and siliceous rock with sulfide minerals; mine dump.

PAM- 1 - Quartz vein material with sulfide minerals; mine dump.
2 - Do.
3 - Do.
4 - Do.
5 - Do.
6 - Do.
7 - Brecciated quartz vein material with sulfide minerals; mine dump.
8 - Quartz vein material with sulfide minerals; mine dump.
9 - Quartz vein material with galena; mine dump.
10 - Brecciated quartz vein material with galena; mine dump.

Table 3.--Lead isotope compositions of galenas from the Lucky Boy (LB) and Pamlico (PAM) districts. Sample localities are shown on plates1 and 2. Sample descriptions are in table 2.

Sample No.		$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
LB-	1	19.056	15.654	38.779
	3	19.048	15.649	38.758
	4A	19.053	15.647	38.750
	4B	19.067	15.669	38.824
	5	19.050	15.643	38.739
	6	19.063	15.658	38.790
	8	19.102	15.668	38.841
	9A	19.063	15.673	38.836
PAM-	1A	18.884	15.638	38.622
	2	18.947	15.647	38.681
	3	18.981	15.643	38.677
	4	18.889	15.634	38.606
	5	18.881	15.643	38.637
	6	18.932	15.687	38.786
	7	18.901	15.637	38.623
	8	18.947	15.637	38.656
	9	18.961	15.661	38.720
	10	18.964	15.661	38.727

Table 4.--Sulfur isotope compositions of galenas from the Lucky Boy (LB) and Pamlico (PAM) districts. Sample localities are shown on plates 1 and 2. Sample descriptions are in table 2.

Sample No.		$\delta^{34}S$ per mil
LB-	4B	-10.6
	5	-10.7
	6	-9.5
	9A	-10.1
PAM-	5	-1.8
	9	-5.1
	10	-1.3

Although more information is needed on the chemical environment during mineral deposition in the two mining districts, the $\delta^{34}S$ data is consistent with the derivation of sulfur from two dissimilar sources, and probably a reflection of the host rocks in each mining district. The considerably more negative $\delta^{34}S$ values for galenas from the Lucky Boy mining district support the derivation of some sulfur from a non-igneous source, such as the surrounding Triassic(?) metasedimentary rocks. The slightly negative $\delta^{34}S$ values for galenas from the Pamlico mining district are consistent with derivation of sulfur from an igneous source, possibly the volcanic host rocks.

Summary and Conclusions

The Lucky Boy and Pamlico mining district exhibit differences in geology, vein geochemistry, and isotopic character of galena. Though the mining districts are underlain by rocks of similar age, the character and derivation of the Triassic host rocks in each mining district are different. Triassic metasedimentary rocks dominate in the Lucky Boy mining district, whereas Triassic volcanic and possibly plutonic rocks dominate in the Pamlico mining district. These differences are reflected in the difference in $\delta^{34}S$ values from galenas collected from both mining districts. Structural features observed in the Lucky Boy mining district (thrust faults and northeast-trending fold axes) are more characteristic of the terrane east of the Pine Nut fault (Pamlico terrane). This suggests that if a major lithotectonic terrane boundary (Pine Nut fault) exits, it may be present west of the Lucky Boy mining district, rather than east.

Deposits in both mining districts are of the gold-bearing polymetallic vein type. However, ore mineralogy and vein geochemistry differ between mining districts. Veins at the Lucky Boy mining district contain significantly more silver, lead, and antimony, and less arsenic than veins in the Pamlico mining district. These geochemical differences are reflected in differences in ore mineralogy. An analysis of lead isotope characteristics of galena from each mining district indicates that the lead in each mining district was derived from a fluid with a homogenous lead isotopic composition on a mining district scale. Furthermore, the source of the lead in both mining districts is inferred to be sialic crust. However, a comparison of lead isotope values between mining districts is inconclusive as to whether or not the mining districts are in distinctive lithotectonic terranes separated by the Pine Nut fault.

SUMMARY AND CONCLUSIONS

Mineral deposits and mineral systems hosted in rocks of the Triassic to Jurassic magmatic arc of western Nevada and eastern California represent a record of metallogenic evolution that goes beyond the evolution of the Triassic to Jurassic arc itself. A documentation of styles of mineralization over time has led to a correlation of specific metallogenic episodes with specific geologic and tectonic events (fig. 3).

Just as the character and style of mineralization is a reflection of coeval geologic and tectonic processes, the absence of a particular deposit type is a reflection of the same. For example, the apparent absence of volcanogenic massive sulfide (VMS) deposits from the magmatic arc exposed in the study area is the consequence of a combination of geologic factors. The shallow-marine to subaerial volcanic environments that dominated the arc, as in most continental-margin magmatic arcs, were not conducive to the formation and preservation of VMS deposits. Furthermore, the scarcity of proximal volcanic facies within rock sequences deposited in deep restricted basinal settings (for example, the Gardnerville and Sailor Canyon Formations) makes these units unfavorable hosts for Besshi-type VMS deposits. Finally, the absence of identified submarine felsic volcanic centers diminishes the potential for the occurrence of Kuroko-type VMS deposits.

Of the Triassic- to Jurassic-hosted mineral deposits and mineral systems that are present in the area, those of the so-called Yerington supersystem have historically been the most economically significant. Mineralization in the Yerington supersystem was associated with the emplacement and evolution of the Middle Jurassic Yerington batholith during a period of intra-arc extension (fig. 3). At least three separate mineralizing systems, the Yerington, Bear, and Ann Mason systems, produced porphyry copper and associated copper and iron skarn, and polymetallic vein deposits that currently represent a reserve of greater than 1.2 billion tons of ore averaging 0.40 percent Cu.

There is evidence for a Middle to Late Jurassic episode of Mo-W mineralization associated with the granite of Desert Creek in the Risue Canyon area of the Wellington Hills and with the granodiorite of French Lake in the Meadow Lake mining districts, as described above. This Mo-W mineralization episode may correspond to the final magmatic stages in the evolution of the Triassic to Jurassic magmatic arc (fig. 3).

The evolution from Cu-Fe porphyry-skarn mineralization to Mo-W porphyry-skarn mineralization is consistent with a magmatic arc that was thickening and maturing through time in response to successive plutonic events. Most economic porphyry molybdenum deposits were emplaced into sialic continental crust, although some important prospects have been found in <u>older</u> island arcs (for example, Indonesia, Sillitoe, 1980; Japan, Ishihara, 1978). No economic porphyry molybdenum deposits have been found in <u>young</u> island arcs (Westra and Keith, 1981). However, an alternative explanation for the Mo-W occurrences associated with the Middle to Late Jurassic stocks must take into consideration the depth of erosion in these areas. The exposed Mo-W occurrences may be eroded remnants of porphyry copper systems and represent the exposed roots of such systems. The presence of Cu-Au quartz-tourmaline veins in the French Lake pluton in the Meadow Lake mining district may indicate just such a situation there (Bowman, 1983; also see above.)

The undisputed W-Mo association with the Cretaceous Sierra Nevada batholith is a function of depth of emplacement as well as depth of erosion of the exposed batholith. The exposed Sierra Nevada batholith was emplaced at considerably greater depth (~7 km) than the Yerington batholith (<2.5 km) and represents the roots of the Sierran magmatic arc that overprinted the Triassic to Jurassic magmatic arc. Low-F porphyry molybdenum, tungsten skarn, and Au-Cu quartz-tourmaline vein deposits are closely associated with plutons of the Sierra Nevada batholith.

In the study area, late Tertiary magmatism produced several hydrothermal systems that affected mostly Tertiary volcanic areas but locally also altered and mineralized Triassic to Jurassic arc rocks. Epithermal Au-Ag veins are the most common and economically significant deposit type of this period and include deposits and occurrences in the Comstock, Ramsey, and Peavine mining districts as well as other scattered localities. Some of these deposits are postulated to represent the upper levels of concealed porphyry copper systems (Wallace, 1979; Hudson, 1983).

REFERENCES CITED

Ague, J.J., and Brimhall, G. 1988, Magmatic arc asymmetry and distribution of anomalous plutonic belts in the batholiths of California: Effects of assimilation, crustal thickness, and depth of crystallization: Geological Society of America Bulletin, v. 100, p. 912-927.

Alabaster, T., and Pearce, J.A., 1985, The interrelationship between magmatic and ore-forming hydrothermal processes in the Oman Ophiolite: Economic Geology, v. 80, no. 1, p. 1-16.

Albers, J.P., and Bain, J.H., 1985, Regional setting and new information on some critical geologic features of the west Shasta district, California: Economic Geology, v. 80, p. 2072-2091.

Albers, J.P., and Robertson, J.F., 1961, Geology and ore deposits of East Shasta copper-zinc district, Shasta, California: U.S. Geological Survey Professional Paper 338, 107 p.

Anaconda, 1967, Drill core assay summary for the Bear deposit: Anaconda Company Report, Reference No. 38402, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming.

Archbold, N. L., 1966, Industrial mineral deposits of Mineral County, Nevada: Nevada Bureau of Mines Report 14, 32 p.

___1969, Industrial mineral deposits, *in* Moore, J.G., Geology and mineral deposits of Lyon, Douglas, and Ormsby Counties, Nevada: Nevada Bureau of Mines Bulletin 75, p. 31-41.

Archbold, N.L., and Paul, R.R., 1970, Geology and mineral deposits of the Pamlico mining district, Mineral County, Nevada: Nevada Bureau of Mines and Geology Bulletin 74, 12 p., 5 sheets.

Armstrong, A.K., Chaffee, M.A., and Scott, D.F., 1983, Mineral resource potential map of the Pyramid Roadless Area, El Dorado County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1616-A, 5 p., scale 1:62,500.

Ashley, R.P., 1982, Occurrence model for enargite-gold deposits, *in* Erickson, L.R., ed., Characteristics of mineral deposit occurrences: U.S. Geological Survey Open-File Report 82-795, p. 126-129.

Ashley, R.P., Goetz, A.F.H., Rowan, L.C., and Abrams, M.J., 1979, Detection and mapping of hydrothermally altered rocks in the vicinity of the Comstock Lode, Virginia City, Nevada: U.S. Geological Survey Open-File Report OF-79-960, 41 p.

Bagby, W.C., and Ashley, R.P., 1990, The Comstock Lode precious-metal district, Washoe County, Nevada, *in* Shawe, D.R., and Ashley, R.P. eds., Geology and resources of gold in the United States: U.S. Geological Survey Bulletin 1875, p. H21-H31.

Barton, M.D., 1990, Cretaceous magmatism, metamorphism, and metallogeny in the east-central Great Basin, *in* Anderson, J.L., ed, The nature and origin of Cordilleran magmatism: Geological Society of America Memoir 174, p. 283-302

Barton, M.D., Battles, D.A., Bebout, G.E., Capo, R.C., Christensen, J.N., Davis, S.R., Hanson, R.B., Michelson, C.J., and Trim, H.E., 1988, Mesozoic contact metamorphism in the western United States, *in* Ernst, W.G., ed., Metamorphism and crustal evolution of the western United States, Rubey Volume VII, p. 110-178.

Battles, D.A., 1991, Hydrothermal alteration in the tilted Shamrock batholith, Yerington district, Nevada: *in* Raines, G.L., eds., Geology and ore deposits of the Great Basin symposium proceedings, Geological Society of Nevada, p. 351-354.

Becker, G.F., 1882, Geology of the Comstock Lode and the Washoe district: U.S. Geological Survey Monograph 3, 422 p.

Bell, J.W., and Garside, L.J., 1987, Geologic map of the Verdi quadrangle, Nevada: Nevada Bureau of Mines and Geology Map 4G, scale 1:24,000.

Berger, B.R., 1975, Summary and evaluation of the Waterhole prospect; Conoco Waterhole Projects: Nevada Bureau of Mines and Geology unpublished mining district files, no. 203, item 6, 11p.

Bingler, E.C., 1977, Geologic map of the New Empire quadrangle: Nevada Bureau of Mines and Geology Map 59, scale 1:24,000.

___1978, Abandonment of the name Hartford Hill Rhyolite Tuff and adaption of new formation names for middle Tertiary ash-flow tuffs in the Carson City-Silver City area, Nevada: U.S. Geological Survey Bulletin 1457-D, 19 p.

Binyon, E.O., 1946, Exploration of the Blue Metal corundum property, Douglas County, Nevada: U.S. Bureau of Mines Report of Investigations 3895, 7 p.

Bonham, H.F., 1969, Geology and mineral deposits of Washoe and Storey Counties, Nevada, with a section on Industrial rock and mineral deposits by K.G. Papke: Nevada Bureau of Mines and Geology Bulletin 70, 107 p., 2 maps, scale 1:250,000.

Bonham, H.F., Jr., 1976, Gold-producing districts of Nevada: Nevada Bureau of Mines and Geology Map 32, scale, 1:1,000,000.

___1980, Silver-producing districts of Nevada: Nevada Bureau of Mines and Geology Map 33, scale, 1:1,000,000.

___1986, Bulk-mineable precious-metal deposits and prospects in Nevada: Nevada Bureau of Mines and Geology Map 91, scale, 1:1,000,000.

___1988, Models for volcanic-hosted epithermal precious metal deposits, *in* Schafer, R.W., Cooper, J.J., and Vikre, P.G., Bulk mineable precious metal deposits of the western United States, Symposium Proceedings: Reno, Geological Society of Nevada, p. 259-271.

Bonham, H.F., Jr., and Giles, D.L., 1983, Epithermal gold-silver deposits: Geothermal Resources Council Special Report 13, p. 257-262.

Bowman, J.K., 1983, Geology and mineralization of the Meadow Lake mining district, Nevada County, California: Hayward, Calif., California State University M.S. thesis, 268 p.

Brem, G.F., 1984, Geologic map of the Sweetwater Roadless Area, Mono County, California, and Lyon and Douglas Counties, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1535-B, scale 1:62,500.

Brem, G.F., Chaffee, M.A., Plouff, D., Lambeth, R.H., Campbell, H.W., Scott, D.F., and Spear, J.M., 1983, Mineral potential map of the Sweetwater Roadless Area, Mono County, California, and Lyon and Douglas Counties, Nevada: U.S. Geological Survey, MF-1535-A, 26 p., scale 1:62,500.

Briner, W.D., 1980, Geology of part of the Cucomungo area, Esmeralda County, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 78 p.

Buchanan, L.J., 1981, Precious metal deposits associated with volcanic environments in the southwest, *in* Dickinson, W.R., and Payne W.D., Relations of tectonics to ore deposits in the southern Cordillera: Arizona Geological Society Digest, v. 14, p. 237-262.

Buddington, A.F., 1935, High temperature mineral associations at shallow to moderate depths: Economic Geology, v. 30, p. 205-222.

Butler, A.P., Jr., 1945, Dayton iron deposits, Lyon County, Nevada: U.S. Geological Survey Open-File Report OF-45-2, 9 p.

Carson, D.J.T., and Jambor, J.L., 1974, Mineralogy, zonal relationships and economic significance of hydrothermal alteration of porphyry copper deposits, Babine Lake area, British Columbia: Canadian Institute of Mining and Metallurgy Bulletin, v. 67, p. 1-24.

Carten, R.B, 1986, Sodium-calcium metasomatism: Chemical, temporal, and spatial relationships at Yerington, Nevada, porphyry copper deposit: Economic Geology, v. 81, no. 6, p. 1495-1519.

Castor, S.B., 1972, Geology of the central Pine Nut and northern Buckskin Ranges, Nevada: A study of Mesozoic intrusive activity: Reno, Nev., University of Nevada, Ph.D. dissertation, 270 p.

Cavarretta, G., and Puxeddu, M., 1990, Schorl-dravite-ferridravite tourmalines deposited by hydrothermal magmatic fluids during early evolution of the Larderello geothermal field, Italy: Economic Geology, v. 85, p. 1236-1251.

Chivas, A.R., 1978, Porphyry copper mineralization at the Koloula igneous complex, Guadalcanal, Solomon Islands: Economic Geology, v. 73, p. 645-677.

Clark, W.B., 1970, Gold districts of California: California Division of Mines and Geology Bulletin 193, 186 p., scale 1:1,000,000.

___1977, Mines and mineral resources of Alpine County, California: California Division of Mines and Geology County Report 8, 48 p.

Coats, R.R., and Stephens, E.C., 1968, Mountain City copper mine, Elko County, Nevada, *in* Ridge, J.D., ed., Ore deposits in the United States, 1933-1967 (Graton-Sales Volume) , v. 2: New York, N.Y., American Institute of Mining, Metallurgical, and Petroleum Engineers, p. 1074-1101.

Conoco, Inc., 1982, Pumpkin Hollow copper prospect, Yerington, Nevada: Conoco, Inc. Company report, Reference No. 36009.06, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 9 p.

Cox, D.P., 1986a, Descriptive model of Zn-Pb skarn deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 90.

___1986b, Descriptive model of Fe skarn deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 94.

___1986c, Descriptive model of Besshi massive sulfide, in Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 136.

___1986d, Descriptive model of volcanic-hosted magnetite, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 172.

Cox, D.P., Ludington, S., Sherlock, M.G., Singer, D.A., Berger, B.R., and Tingley, J.V., 1991, Mineralization patterns in time and space in the Great Basin of Nevada: Geology and Ore Deposits of the Great Basin Symposium Proceedings, Reno, Nev., Geological Society of Nevada, p. 193-198.

Dalrymple, G. B., 1964, Cenozoic chronology of the Sierra Nevada, California: University of California Publications in Geological Sciences, v. 47, 41 p.

Davis, D.A., 1990, The Paleozoic-Mesozoic unconformity of the northern Sierra Nevada, California and its significance: Reno, Nevada, University of Nevada, M.S. thesis, 319 p.

Dawson, K.M., and Sangster, D.F., 1984, Skarn zinc-lead-silver, *in* Eckstrand, O.R., ed., Canadian mineral deposit types: a geological synopsis: Geological Survey of Canada, Economic Geology Report 36, p. 56.

Deino, A.L., 1985, Stratigraphy, chemistry, K-Ar dating, and paleomagnetism of the Nine Hill tuff, California-Nevada, and Miocene/Oligocene ash-flow tuffs of Seven Lakes Mountain, California-Nevada. Improved calibration methods and error estimates for potassium-40-argon-40 dating of young rocks: Berkeley, Calif., University of California, Ph.D. dissertation, 457 p.

DeLong, J.E., 1977, Molybdenum distribution in soils and trees at the Pine Nut molybdenum deposit, Douglas County, Nevada: Lake Tahoe, Nev., Paper presented at Pacific Southwest Minerals Industry Conference, March 23, 1977, 6 p.

Dilles, J.H., 1984, The petrology and geochemistry of the Yerington batholith and the Ann-Mason porphyry copper deposit, western Nevada: Palo Alto, Calif., Stanford University Ph.D. dissertation, 389 p.

___1987, Petrology of the Yerington batholith, Nevada: Evidence for evolution of porphyry copper ore fluids: Economic Geology, v. 82, p. 1750-1789.

Dilles, J.H., and Einaudi, M.T., 1992, Wall-rock alteration and hydrothermal flow paths about the Ann-Mason porphyry copper deposit, Nevada - A 6-km vertical reconstruction: Economic Geology, v. 8, no. 87, p. 1963-2001.

Dilles, J.H., Solomon, G.C., Taylor, H.P., Jr., Einaudi, M.T., in press, Oxygen and hydrogen isotope characteristics of hydrothermal alteration at the Ann-Mason porphyry copper deposit, Yerington, Nevada: Economic Geology.

Dilles, J.H., and Wendell, D., 1982, The geology and gold mineralization of the central Buckskin Range, Douglas County, Nevada: Anaconda Company Report, Reference No. 39707.20, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 27 p.

Dilles, J.H., and Wright, J.E., 1988, The chronology of early Mesozoic arc magmatism in the Yerington district of western Nevada and its regional implications: Geological Society of America Bulletin, v. 100, p. 644-652.

Dixon, R.L., 1971, The geology and ore deposits of the Red Canyon Mining District, Douglas Co., Nevada: Reno, Nev., University of Nevada, M.S. thesis, 88 p.

Dodge, F.C.W., and Fillo, P.V., 1967, Mineral resources of the Desolation Primitive Area of the Sierra Nevada, California: U.S. Geological Survey Bulletin 1261-A, 27 p., geologic map, scale 1:62,500.

Doe, B.R., Delevaux, M.H., and Albers, J.P., 1985, The plumbotectonics of the West Shasta mining district, eastern Klamath Mountains, California: Economic Geology, v. 80, p. 2136-2148.

Durham, D.L. and Felmlee, J.K., 1982, National Uranium Resource Evaluation, Walker Lake Quadrangle, California and Nevada (prepared for the U.S. Department of Energy, Grand Junction Office, Under Contract No. ED-A113-78GJ01686 with the U.S. Geological Survey, Golden, Colorado): U.S. Department of Energy, Report No. PGJ/F-010 (82), 43 p., 13 plates.

Einaudi, M.T., 1971, Skarn and porphyry copper type targets in the Bluestone-Mason Valley Mine area, Yerington district, Lyon county, Nevada: Anaconda Company Report, Reference No. 39411.03, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 21 p.

___1975, The Lyon skarns, Lyon County, Nevada - A summary of preliminary conclusions: Anaconda Company Report, Reference No. 39411.09, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 15 p.

___1977, Petrogenesis of the copper-bearing skarn at the Mason Valley mine, Yerington district, Nevada: Economic Geology, v. 72, p. 769-795.

___1982, Description of skarns associated with porphyry copper plutons, southwestern North America, in Titley, S.R., ed., Advances *in* Geology of the Porphyry Copper Deposits, Southwestern North America: Tucson, University of Arizona Press, p. 139-183.

Einaudi, M.T., and Burt, D.M., 1982, Introduction--terminology, classification and composition of skarn deposits: Economic Geology, v. 77, no. 4, p. 745-754.

Einaudi, M.T., Meinert, L.D., and Newberry, R.J., 1981, Skarn deposits, *in* Skinner, B.J., ed. Economic Geology Seventy-Fifth Anniversary Volume, p. 317-391.

Ekren, E.B., and Byers, F.M., Jr., 1985, Geologic map of the Gabbs Mountain, Mount Ferguson, Luning, and Sunrise Flat quadrangles, Mineral and Nye Counties, Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I-1577, scale 1:48,000.

Evernden, J.F. and Kistler, R.W., 1970, Chronology of emplacement of Mesozoic batholithic complexes in California and western Nevada: U.S. Geological Survey Professional Paper 623, 43 p.

Fisher, G.R., 1989, Geologic map of the Mount Tallac roof pendant, El Dorado County, California: U.S. Geological Survey miscellaneous Field Studies Map MF-1943, scale 1:24,000.

Ford, J.H., 1978, A chemical study of alteration at the Panguna porphyry copper deposit, Bougainville, Papau New Guinea: Economic Geology, v. 73, p. 703-720.

Gans, P.B., Mahood, G.A., Schermer, E., 1989, Synextensional magmatism in the Basin and Range Province: A case study from the eastern Great Basin: Geological Society of America Special Paper 233, 53 p.

Garside, L.J., 1973, Radioactive mineral occurrences in Nevada: Nevada Bureau of Mines and Geology Bulletin 81, 121 p., 1 map.

___1979, Geologic map of the Camp Douglas quadrangle, Nevada: Nevada Bureau of Mines and Geology Map 63, scale 1:24,000.

___in press, Peavine sequence and related rocks of western Nevada and eastern California, *in* Schweickert, R.A., Stewart, J.H., Dilles, J.H., Garside, L.J., Greene, R.C., Harwood, D.S., John, D.A., Hardyman, R.F., Ponce, D., Proffett, J.H., Senterfit, R.M., and Silberling, N.J., Triassic to Jurassic magmatic arc of western Nevada and eastern California--Chapter A, Geology and Geophysics: U.S. Geological Survey Bulletin.

Garside, L. J., Bonham, H.F., Jr., and McKee, E.H., 1992, Potassium-argon ages of plutonic rocks and associated vein and alteration minerals, northeast Sierra Nevada, California and Nevada: Isochron/West, no. 58, p. 13-15.

Garside, L. J., Bonham, H.F., Jr., Tingley, J.V., and McKee, E.H., 1993, Potassium-argon ages of igneous rocks and alteration minerals associated with mineral deposits, western and southern Nevada and eastern California: Isochron/West v. 59, p. 17-23.

Garside, L.J., and Silberman, M.L., 1978, New K-Ar ages of volcanic and plutonic rocks from the Camp Douglas quadrangle, Mineral County, Nevada: Isochron/West, no. 22, p. 29-32.

Geehan, R.W., 1949, Investigation of the Dayton iron deposit, Lyon and Storey Counties, Nevada: U.S. Bureau of Mines Report of Investigations 4561, 34 p.

Geissman, J.W., Van der Voo, R., and Howard, K.L., Jr., 1982, A paleomagnetic study of the structural deformation in the Yerington district, Nevada: American Journal of Science, v. 282, p. 1042-1109.

Gerlach, K.H., 1963, The economic geology of the Meadow Lake mining district, Nevada County, California: Berkeley, Calif., University of California, M.S. thesis, 40 p.

Gianella, V.P., 1936, Geology of the Silver City district and the southern portion of the Comstock Lode, Nevada: Nevada University Bulletin, v. 30, no. 9, p.

Gibson, P.C., 1987, Geology of the Buckskin mine, Douglas County, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 93 p.

Giles, D.L., and Nelson, C.E., 1983, Principal features of epithermal lode gold deposits of the Circum-Pacific Rim: Transactions of the third Circum-Pacific energy and minerals resource conference, Honolulu, Hawaii, August 22-28, 1982. American Association of Petroleum Geologists, Circum-Pacific Series ??

Greene, R.C., Stewart, J.H., John, D.A., Hardyman, R.F., Silberling, N.J., and Sorensen, M.L., 1991, Geologic map of the Reno 1° by 2° quadrangle, Nevada and California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2154-A, scale 1:250,000.

Gross, G.A., 1984, Skarn iron, *in* Eckstrand, O.R., ed., Canadian mineral deposit types: a geological synopsis: Geological Survey of Canada, Economic Geology Report 36, p. 57.

Gustafson, D.L., 1971, Progress report on the Ann-Mason Pass project, Yerington district, Lyon County, Nevada: Anaconda Company Report, Reference No. 39008.05, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 13 p.

Hall, R.B., 1982, Model for hydrothermal alunite deposits: *in* Erickson, R.L., ed., Characteristics of mineral deposit occurrences: U.S. Geological Survey Open-File Report 82-795, p. 130-135.

Harder, E.C., 1910, Iron ores near Dayton, Nevada: U.S. Geological Survey Bulletin 430, p. 240-246.

Hardyman, R.F., and Oldow, J.S., 1991, Tertiary tectonic framework and Cenozoic history of the central Walker Lane, Nevada: *in* Raines, G.L., eds., Geology and ore deposits of the Great Basin symposium proceedings, Geological Society of Nevada, p. 279-302.

Harris, D.P., and Pan, G., 1990, Subdividing geologic areas by relative exceptionalness and additional information: Methods and case study: Economic Geology, v. 85, p. 1072-1083.

___1991, Consistent geologic areas for epithermal gold-silver deposits in the Walker Lake quadrangle, Nevada and California: Delineated by quantitative methods: Economic Geology, v. 86, p. 142-165.

Harris, N.B., 1991, Geology and geochemistry of the New Boston-Blue Ribbon prospect, Mineral County, Nevada - A skarn associated with a calc-alkaline porphyry molybdenum system, *in* Raines, G.L., eds., Geology and ore deposits of the Great Basin symposium proceedings, Geological Society of Nevada, p. 443-460.

Harris, N.B., and Einaudi, M.T., 1982, Skarn deposits in the Yerington district, Nevada: Metasomatic skarn evolution near Ludwig: Economic Geology, v. 77, p.887-898.

Harwood, D.S., Federspiel, F.E., Cather, E.E., and Scott, D.F., 1982a, Mineral resource potential map of the Granite Chief Wilderness Study Area, Placer County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1273-C, 4p., scale 1:62,500.

Harwood, D.S., Fisher, G.R., and Waugh, B.J., 1995, Geologic map of the Duncan Peak and southern part of the Cisco Grove 7-½' quadrangles, Placer and Nevada counties, California: U.S. Geological Survey Miscellaneous Investigations Map I-2341, scale 1:24,000.

Harwood, D.S., Griscom, A., Federspiel, F.E., Leszcykowski, A.M., and Spicker, F.A., 1982b, Mineral resource potential map of the North Fork of the American River Wilderness Study Area (RARE II No. 5-262), Placer

County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1177-C, 7 p., scale 1:62,500.

Harwood, D.S., Schweickert, R.A., and Fisher, G.R., in press, Mesozoic stratigraphy - northeastern Sierra Nevada, *in* Schweickert, R.A., Stewart, J.H., Dilles, J.H., Garside, L.J., Greene, R.C., Harwood, D.S., John, D.A., Hardyman, R.F., Ponce, D., Proffett, J., Senterfit, M., and Silberling, N.J., Triassic to Jurassic magmatic arc of western Nevada and eastern California--Chapter A, Geology and Geophysics: U.S. Geological Survey Bulletin.

Hayba, D.O., Bethke, P.M., Heald, P., Foley, N.K., 1985, Geologic, mineralogic, and geochemical characteristics of volcanic-hosted epithermal precious-metal deposits, *in* Berger, B.R., and Bethke, P.M., eds., Geology and geochemistry of epithermal systems: Reviews in Economic Geology, v. 2, p. 129-162.

Heald, P., Foley, N.K., and Hayba, D.O., 1987, Comparative anatomy of volcanic-hosted epithermal deposits: Acid-sulfate and adularia-sericite types: Economic Geology, v. 82, p. 1-26.

Heatwole, D.A., 1972, Progress report and drilling proposal, MacArthur claims, Lyon county, Nevada: Anaconda Company Report, Reference No. 39702.05, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 16 p.

___1973, Geology of the Standard Slag Mine, Pine Nut/Buckskin Range project, Lyon County, Nevada: Anaconda Company Report, Reference No. 40318.12, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 26 p.

___1978, Controls of oxide copper mineralization, MacArthur property, Lyon County, Nevada: Arizona Geological Society Digest: v. 11, p. 59-66.

Heyl, A.V., and Bozion, C.N., 1964, Oxidized zinc districts in California and Nevada: U.S. Geological Survey Mineral Investigations Resource Map MR-39, 6p., scale 1:750,000, 2 sheets.

Hill, J.M., 1911, Notes on the economic geology of the Ramsey, Talapoosa, and White Horse mining districts, in Lyon and Washoe Counties, Nevada: U.S. Geological Survey Bulletin 470, p. 99-108.

___1915, Some mining districts in northeastern California and northwestern Nevada: U.S. Geological Survey Bulletin 594, p. 153-155.

Horton, R.C., 1962, Iron ore occurrences in Nevada: Nevada Bureau of Mines and Geology Map 5, scale 1:1,000,000.

Howard, K.L., 1973, Progress report - Ann-Mason Pass project: Reinterpretation of Ann-Mason grade and pattern: Anaconda Company Report, Reference No. 39008, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 7 p.

___1974, Progress report, western Nevada massive sulfide project: Anaconda Company Report, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 6 p.

___1980, Anaconda Company Memorandum to J.C. Wilson, March 14, 1980, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming.

Howard, K.L., Jr., 1976, Geology of the Yerington Mine, Lyon County, Nevada [abs.]: Economic Geology, v.71, p. 700.

Hudson, D.M., 1977, Geology and alteration of the Wedekind and part of the Peavine districts, Washoe County, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 102 p.

___1983, Alteration and geochemical characteristics of the upper parts of selected porphyry systems, western Nevada: Reno, Nev., University of Nevada, Ph.D. dissertation, 94 p.

Hudson, D. M., and Smith, D. B., 1991, Geochemical signature of the Comstock district, Storey County, Nevada [abs.]: Fifteenth International Geochemical Symposium [Association of Exploration Geochemists], Reno, Nevada, 1991.

Hurley, B.W., Johnson, C.L., Cupp, G.M., Mayerson, D.L., Dodd, P.A., and Berg, J.C., 1982, National Uranium Resource Evaluation, Reno 1° by 2° quadrangle, Nevada and California: Grand Junction, Colorado, Bendix Field Engineering Corporation, Report PGJ/F-037(82), 51 p., map scale 1:250,000, 14 sheets.

Ishihara, S., 1978, Metallogenesis in the Japanese island-arc system: Geological Society of London Journal, v. 135, no. 4., p. 389-406.

James, O.B., 1971, Origin and emplacement of the ultramafic rocks of the Emigrant Gap area, California: Journal of Petrology, V. 12, p. 532-560.

Jenkins, O.P., 1948, Copper in California: California Division of Mines Bulletin 144, 429 p., 61 plates.

Jensen, M. L., and Bateman, A. M., 1981, Economic mineral deposits (third edition): New York, John Wiley and Sons, 593 p.

John, D.A., 1983, Map showing distribution, ages, and petrographic characteristics of Mesozoic plutonic rocks in the Walker Lake 1° by 2° quadrangle, California and Nevada: U.S. Geological Survey MF-1382-B, scale 1:250,000.

John, D.A., Armin, R.A., Plouff, D., Chaffee, M.A., Federspiel, F.E., Scott, D.F., and Cather, E.E., 1983a, Mineral resource potential of the east part of the Raymond Peak roadless area, Alpine County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1365-C, scale 1:62,000.

John, D.A., Armin, R.A., Plouff, D., Chaffee, M.A., Scott, D.F., Federspiel, F.E., Peters, T.J., Cather, E.E., and Campbell, H.W., 1983b, Mineral resource potential map of the Freel and Dardanelles Roadless Areas, Alpine and El Dorado Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1322-C, 6 p., scale 1:62,500.

John, D.A., Chaffee, M.A., and Stebbins, S.A., 1983c, Mineral resource potential map of the Lincoln Creek Roadless Area, Douglas County, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1545, scale 1:62,500.

John, D.A., Schweickert, R.A., and Robinson, A.C., 1994, Granitic rocks in the Triassic-Jurassic magmatic arc of western Nevada and eastern California: U.S. Geological Survey Open-File Report 94-148, 61 p.

John, D.A., Stewart, J.H., Kilburn, J.E, Silberling, N.J., and Rowan, L.C., 1993, Geology and mineral resources of the Reno 1° by 2° quadrangle, Nevada and California: U.S. Geological Survey Bulletin 2019, 65 p.

Johnson, R.C., 1977, Geological investigation and ore reserve estimation of the Copper Chief (Ruby Hill) mine, Douglas County, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 32 p.

Johnson, M.C., and Rutherford, M.J., 1989, Experimental calibration of the aluminum-in-hornblende geobarometer with application to Long Valley caldera (California) volcanic rocks: Geology, v. 17, p. 837-841.

Jones, J.C., 1920, Ludwig Mine [Lyon County, Nevada], *in* Stone, J.W., ed., Gypsum deposits of the United States: U.S. Geological Survey Bulletin 697, p. 153-155.

Jones, R.B., 1983, Lead deposits and occurrences in Nevada: Nevada Bureau of Mines and Geology Map 78, scale, 1:1,000,000.

___1984, Zinc deposits and occurrences in Nevada: Nevada Bureau of Mines and Geology Map 85, scale, 1:1,000,000.

Kaare, A. and Barries, A.H., 1948, A preliminary examination of the Guy Walt's zinc property: unpublished report, Nevada Bureau of Mines and Geology mining district files, Peavine district, item 5, 11 p.

Kelly, D.S., and Robinson, P.T., 1990, Development of a brine-dominated hydrothermal system at temperatures of 400-500° C in the upper level plutonic sequence, Troodos ophiolite, Cyprus: Geochimica et Cosmochimica Acta, v. 54, p. 653-661.

Kemp, W.R., 1982, Petrochemical affiliations of volcanogenic massive sulfide deposits of the Foothills Cu-Zn belt, Sierra Nevada, California: Reno, Nev., University of Nevada, Ph.D. thesis, 458 p.

Kerrick, D.M., Crawford, K.E., Randazzo, A.F., 1973, Metamorphism of calcareous rocks in 3 roof pendants in the Sierra Nevada, California: Journal of Petrology, v. 14, p. 303-325.

Kilbreath, S., and Leger, A., 1978, Progress report of the Walker Mine project: Unpublished report for Conoco, Inc., Minerals Department, Reno, Nevada, 29 p.

Kilbreath, S.P., 1979, Walker Mine report: Unpublished report for Conoco, Inc., Minerals Department, Reno, Nevada, 50 p.

Klinger, F.L., 1952, Andalusite-corundum mineralization near Hawthorne, Nevada: Madison, Wis., University of Wisconsin, M.S. thesis, 31 p.

Knopf, A., 1918, Geology and ore deposits of the Yerington district, Nevada, U.S. Geological Survey Professional Paper 114, 68 p.

Kosaka, H., and Wakita, K., 1978, Some geologic features of the Mamut porphyry copper deposit, Sabah, Malaysia: Economic Geology, v. 73, p. 878-890.

Laraya, R.G., 1973, Aeromagnetics in the search for porphyry copper deposits, Mineral Co., Nevada: Palo Alto, Calif., Stanford University, Ph.D. dissertation, 94 p.

Lawrence, E.F., 1969, Geological and geophysical investigations of the mineral deposits of the Calico area, Mineral County, Nevada: Riverside, Calif., University of California, Ph.D. dissertation, 112 p.

Lemaire, D.B., 1954, The metallurgy of the Divide [mine] tungsten ore: Reno, Nev., University of Nevada, M.S. thesis, 37p.

Lincoln, F.C., 1923, Mining districts and mineral resources of Nevada: Nevada Newsletter Publishing Company, Reno, 295 p.

Lindgren, W., 1893, The auriferous veins of the Meadow Lake district, California: American Journal of Science, v. 46, p. 201-206.

___1933, Mineral deposits (fourth edition): New York, McGraw-Hill Book Co., Inc., 930 p.

Logan, C.A., 1924, Meadow Lake mining district: California Division of Mines Report 20 of the State Mineralogist, no. 4, p. 355-362.

Lowder G.G., and Dow, J.A.S., 1978, Geology and exploration of porphyry copper deposits in North Sulawesi, Indonesia: Economic Geology, v. 73, p. 628-644.

Matson, E.J., 1952, MacArthur copper deposit, Lyon County, Nevada: U.S.Bureau of Mines, Reports of Investigations 4906, 47 p.

Mattinen, P.R., and Bennett, G.H., 1986, The Green Mountain massive sulfide deposit. Besshi-style mineralization within the California Foothills copper-zinc belt: Journal of Geochemical Exploration, v. 25, p. 185-200.

McCarthy, J.H., Jr., Turner, R.L., Erdman, J.A., and Sawatzky, D.L., in press, Triassic to Jurassic magmatic arc of western Nevada and eastern California--Chapter C, Geochemical studies: U.S. Geological Survey Bulletin.

McKee, E.H., Chaffee, M.A., Federspiel, F.E., McHugh, E.L., Cather, E.E., Scott, D.F., Rumsey, C.M, 1982, Mineral resource potential of the Mokelumne Wilderness and Caples Creek, Tragedy-Elephants Back, and Raymond Peak Roadless Areas, Central Sierra Nevada, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1201-D, scale 1:62,500.

Meinert, L.D., 1984, Mineralogy and petrology of iron skarns in western British Colombia, Canada: Economic Geology, v. 79, p. 869-882.

Michell, W.D., 1945, Oxidation in a molybdenite deposit, Nye County, Nevada: Economic Geology, v. 40, p. 112.

Mining Record, 1991, Mining operations begin at San Luis gold property: Mining Record, January 16, 1991, p. 1.

Moore, J.G., 1969, Geology and mineral resources of Lyon, Douglas, and Ormsby Counties, Nevada: Nevada Bureau of Mines and Geology, Bulletin 75, 45 p.

Morris, H.T., 1986, Descriptive model of polymetallic replacement deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 99-100.

Mosier, D.L., Singer, D.A., and Berger, B.B., 1986, Descriptive model of Comstock epithermal veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 150.

Mukasa, S.B., and Ludden, J.N., 1987, Uranium-lead isotopic ages of plagiogranites from the Troodos ophiolite, Cyprus, and their tectonic significance: Geology, v. 15, p. 825-828.

Muller, S.W., and Ferguson, H.G., 1936, Triassic and Lower Jurassic formations of west central Nevada: Geological Society of America Bulletin, v. 47, p. 241-252.

___1939, Mesozoic stratigraphy of the Hawthorne and Tonapah quadrangles, Nevada: Geological Society of America Bulletin, v. 50, p. 1573-1624.

Newberry, R.J., and Einaudi, M.T., 1981, Tectonic and geochemical setting of tungsten skarn mineralization in the Cordillera: Arizona Geological Society Digest, v. XIV, p. 99-111.

Noble, D.C., 1962, Mesozoic geology of the southern Pine Nut Range, Douglas County, Nevada: Palo Alto, Calif., Stanford University, Ph.D. dissertation, 200 p.

___1963, Mesozoic geology of the southern Pine Nut range, Douglas County, Nevada: Dissertation Abstracts, v. 23, no. 11, p. 4319.

Noble, D.C., McKee, E.H., and Schweickert, R.A., 1973, K-Ar ages on post Early Jurassic granodiorite from the southern Pine Nut Range, western Nevada: Isochron/West, no. 7, p. 3-4.

Ohmoto, H., and Takahashi, T., 1983, Geologic setting of the Kuroko deposits, Japan - Part III. Submarine calderas and Kuroko genesis: Economic Geology Monograph 5, p. 39-54.

Oldow, J.S., 1978, Triassic Pamlico Formation: an allochthonous sequence of volcanogenic-carbonate rocks in west-central Nevada, *in* Howell, D.G., and McDougall, K.A., eds, Mesozoic paleogeography of the western United States, Pacific Coast Paleogeography Symposium 2: Society of Economic Paleontologists and Mineralogists, Pacific Section, p. 223-235.

___1984, Evolution of a late Mesozoic back-arc fold and thrust belt, western Great Basin, U.S.A: Tectonophysics, v. 102, p. 245-274.

___1985, Preliminary geologic map of the Pamlico quadrangle, Mineral County, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1485, scale 1:24,000.

Oriel, W.M., 1977, 1976 Annual progress report, Buckskin copper prospect, Douglas and Lyon counties: Nevada Bureau of Mines and Geology, unpublished mining district files, no. 35, item 15.

Overton, T.D., 1948, Mineral resources of Douglas, Ormsby, and Washoe Counties, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 91 p.

Palmer, A.R., 1983, The decade of North American geology 1983 geologic time scale: Geology, v. 11, no. 9, p. 503-504.

Papke, K.G, 1984, Barite in Nevada: Nevada Bureau of Mines and Geology Bulletin 98, 125 p., 2 maps.

___1987, Gypsum deposits of Nevada: Nevada Bureau of Mines and Geology Bulletin 103, 26 p., 2 maps.

Park, C.F., Jr., and MacDiarmid, R.A., 1964, Ore deposits: San Francisco, W.H. Freeman and Co., 475 p.

Pincock, Allen, and Holt, 1977, Feasibility Study of Pumpkin Hollow deposits: Reference No. 36105.03, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming.

Ponsler, H.E., 1977, The geology and mineral deposits of the Garfield district, Mineral County, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 73 p.

Price, J.G., 1977, Geologic history of alteration and mineralization at the Yerington porphyry copper deposit, Nevada: Berkeley, Calif., University of California, Ph.D. dissertation, 168 p.

Proffett, J.M., Jr., 1967, Progress report on the Bear-Lagomarsino area, Yerington district, Lyon County, Nevada: Anaconda Company Report, Reference No. 38409.01, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 31 p.

___1969, Report on the geology of the Yerington district: Anaconda Company Report, Reference No. 36903, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 2 volumes.

___1977, Cenozoic geology of the Yerington district, Nevada, and implications for the nature and origin of basin and range faulting: Geological Society of America Bulletin, v. 88, p. 247-266.

Proffett, J.M., Jr., and Dilles, J.H., 1984, Geologic map of the Yerington district, Nevada: Nevada Bureau of Mines and Geology Map 77, scale 1:24,000.

___in press, Early Mesozoic sedimentary and volcanic rocks of the Yerington region, Nevada, *in* Schweickert, R.A., Stewart, J.H., Dilles, J.H., Garside, L.J., Greene, R.C., Harwood, D.S., John, D.A., Hardyman, R.F., Ponce, D., Proffett, J., Senterfit, M., and Silberling, N.J., Triassic to Jurassic magmatic arc of western Nevada and eastern California--Chapter A, Geology and geophysics: U.S. Geological Survey Bulletin.

Putman, G.W., 1975, Base metal distribution in granitic rocks II: three-dimensional variation in the Lights Creek stock, California: Economic Geology, v. 70, p. 1225-1241.

Quade, J., Tingley, J.V., and Garside, L.J., 1990a, Mineral resource inventory of the BLM Carson City district, Nevada: Appendix A--Mines, prospects, and occurrences: Nevada Bureau of Mines and Geology Open-File Report 90-2, 177 p.

___1990b, Mineral resource inventory of the BLM Carson City district: Appendix B--sample descriptions; Appendix C--sample analyses: Nevada Bureau of Mines and Geology Open-File Report 90-3, 227 p.

Reeves, R.G., 1964, Iron, *in* Mineral and water resources of Nevada: Nevada Bureau of Mines Bulletin 65, p. 101-112.

Reeves, R.G., and Kral, V.E., 1955, Iron ore deposits of Nevada--Part A: Geology and iron ore deposits of the Buena Vista Hills, Churchill and Pershing Counties, Nevada: Nevada Bureau of Mines and Geology Bulletin 53a, p. 1-32.

Reeves, R.G., Shawe, F.R. and Kral, V.E., 1958, Iron ore deposits of Nevada: Part B--Iron ore deposits of west-central Nevada: Nevada Bureau of Mines and Geology, Bull. 53b, 78 p.

Robinson, A.C., 1985, Whole-rock strontium isotopic ages of Mesozoic plutons in the West Walker area, east-central California: Geological Society of America Abstracts with Programs, v. 17, p. 404.

Robinson, A.C., and Kistler, R.W., 1986, Maps showing isotopic dating in the Walker Lake 1° by 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-N.

Ross, D.C., 1961, Geology and mineral deposits of Mineral County, Nevada: Nevada Bureau of Mines and Geology Bulletin 58, 98 p., 2 maps, scale 1:250,000.

Roxlo, K., and Ranta, D.E, 1982, Pine Nut project, 1982 progress report, Douglas County, Nevada: Climax Molybdenum Company Report, 50 p.

Roylance, J.G., Jr., 1966, The Dayton iron deposits, Lyon and Storey Counties, Nevada, *in* A.I.M.E. Pacific Southwest Mineral Industry Conference Papers: Nevada Bureau of Mines and Geology, Report 13, p. 125-141.

Russell, B.J., 1984, Mesozoic geology of the Jackson Mountains, northwestern Nevada: Geological Society of America Bulletin, v. 95, p. 313-323.

Sampson, R.J., and Tucker, W.B., 1940, Mineral resources of Mono County, California: California Journal of Mines and Geology, v. 36, p. 117-156.

Satkoski, J.J., Lambeth, R.H., White, W.W., III, and Dunn, M.D., 1985, Field inventory of mineral resources and compilation of exploration data, Walker River Indian Reservation, Nevada: U.S. Bureau of Mines Report BIA No. 21-II, volume I, 271 p.

Sato, T., 1974, Distribution and setting of the Kuroko deposits: Society of Mining Geologists, Japan, Special Issue 6, p. 1-10.

Saucedo, G.J., and Wagner, D.L., in press, Geologic map of the Chico quadrangle, California: California Division of Mines and Geology Regional Geologic Map Series Map No. 7A, scale 1:250,000.

Sawatzky, D.L., and Raines, G.L., in press, Evaluation of Cenozoic basins and ranges for selected mineral deposit types with the weights of evidence method--Chapter D, Triassic to Jurassic magmatic arc of western Nevada and eastern California: U.S. Geological Survey Bulletin.

Sawkins, F.J., 1990, Integrated tectonic-genetic model for volcanic-hosted massive sulfide deposits: Geology, v. 18, p. 1061-1064.

Schilling, J.H., 1968, Molybdenum resources of Nevada: Nevada Bureau of Mines and Geology Open-File Report 79-3, 189 p.

Schryver, R. F., 1961, Geology of the Mound House area, Ormsby and Lyon Counties, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 47 p.

Schweickert, R.A., 1972, Shallow-level intrusions in the eastern Sierra Nevada, California: Palo Alto, Calif., Stanford University, Ph.D. dissertation, 85 p.

___1976, Shallow-level plutonic complexes in the eastern Sierra Nevada and their tectonic implications: Geological Society of America Special Paper 176, 58p.

Schweickert, R.A., Harwood, D.S., Girty, G.H., and Hanson, R.E., in press a, Geologic map of the Emigrant Gap 15-minute Quadrangle, Sierra, Nevada, and Placer Counties, California: U.S. Geological Survey Geologic Quadrangle Map, 8 ms p., scale 1:62,500.

Schweickert, R.A., Stewart, J.H., Dilles, J.H., Garside, L.J., Greene, R.C., Harwood, D.S., John, D.A., Hardyman, R.F., Ponce, D., Proffett, J., Senterfit, M., and Silberling, N.J., in press b, Triassic to Jurassic magmatic arc of western Nevada and eastern California--Chapter A, Geology and geophysics: U.S. Geological Survey Bulletin.

Seedorff, C.E., 1991, Magmatism, extension, and ore deposits of Eocene to Holocene age in the Great Basin -- Mutual effects and preliminary proposed genetic relationships, *in* Raines, G.L., eds., Geology and ore deposits of the Great Basin symposium proceedings, Geological Society of Nevada, p. 133-178.

Shawe, F.R., Reeves, R.G., and Kral, V.E., 1962, Iron ore deposits of Nevada, part C, Iron ore deposits of northern Nevada: Nevada Bureau of Mines and Geology Bulletin 53c, 125 p.

Sherlock, M.G., 1989, Metallogenic map of volcanogenic massive-sulfide deposits in pre-Tertiary island-arc and ocean-basin environments in Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1853-E, 17 p.

Sidder, G.B., 1986, Mineral deposits of the Reno 1° x 2° Quadrangle, Nevada, with a comprehensive bibliography: U.S. Geological Survey Open-File Report OF-86-407, 53 p.

Sillitoe, R.H., 1980, Types of porphyry molybdenum deposits: Mining Magazine, June 1980, p. 550-553.

Sillitoe, R.H., 1993, Epithermal models: genetic types, geometric controls and shallow features, *in* Kirkham, R.V., Sinclair, W.D., Thorpe, R.I., and Duke, J.M., eds., Mineral Deposit Modeling: Geological Association of Canada, Special Paper 40, p. 403-417.

Singer, D.A., 1983a, Descriptive model of Cyprus massive sulfide, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 131.

___1983b, Descriptive model of Kuroko massive sulfide, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 189.

Smith, M.R., 1981, Geology and Mineralization of the southeastern Gillis Range, Mineral County, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 103p.

___1984, Pumpkin Hollow property: Transcript of tape from field trip no. 10: Skarn Deposits, March 22-24, 1984, Exploration for Ore Deposits of the North American Cordillera: Association of Exploration Geochemists Symposium, Reno, Nevada.

Sorensen, M.L., Plouff, D., and Turner, R.L., 1987, Mineral resources of the South Jackson Mountains Wilderness Study Area, Humboldt County, Nevada: U.S. Geological Survey Bulletin 1726-B, 14 p.

Southern Pacific Company, 1964, Minerals for industry, summary of geological survey of 1955-1961: Northern California, v. 2, 207 p.

Souviron, A., 1976, Progress report on the Ann-Mason project: Anaconda Company Report, Reference No. 39008.01, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 13 p.

Spence, C.D., and deRosen-Spence, A.F., 1975, The place of sulfide mineralization in the volcanic sequence at Noranda, Quebec: Economic Geology v. 70, no. 1, p. 90-101.

Staatz, M.H., and Bauer, H.L., Jr., 1953, Uranium in the East Walker River area, Lyon County, Nevada: U.S. Geological Survey Bulletin 988-C, p. 29-43.

Stager, H.K., and Tingley, J.V., 1988, Tungsten deposits in Nevada: Nevada Bureau of Mines and Geology Bulletin 105, 256 p.

Stewart, J. H., 1980, Geology of Nevada: Nevada Bureau of Mines and Geology Special Publication 4, 136 p.

___1988, Tectonics of the Walker Lane Belt, western Great Basin: Mesozoic and Cenozoic deformation in a zone of shear, *in* Ernst, W.G., ed., Metamorphism and crustal evolution of the western United States, Ruby volume 7: Englewood Cliffs, New Jersey, Prentice Hall, p. 683-713.

___in press, An overview of Mesozoic stratigraphy of west-central Nevada and eastern California, *in* Schweickert, R.A., Stewart, J.H., Dilles, J.H., Garside, L.J., Greene, R.C., Harwood, D.S., John, D.A., Hardyman, R.F., Ponce, D., Proffett, J., Senterfit, M., and Silberling, N.J., Triassic to Jurassic magmatic arc of western Nevada and eastern California--Chapter A, Geology and Geophysics: U.S. Geological Survey Bulletin.

Stewart, J.H., Brem, G.H., and Dohrenwend, J.C., 1989, Geologic map of the Desert Peak quadrangle, Lyon and Douglas Counties, Nevada, and Mono County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2050, scale 1:62,500

Stewart, J.H., and Carlson, J.E., 1976, Cenozoic Rocks of Nevada: Nevada Bureau of Mines and Geology Map 52, scale 1:1,000,000.

Stewart, J.H., Carlson, J.E., and Johannessen, D.C., 1982, Geologic map of the Walker Lake 1° by 2° quadrangle, California and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1382-A, scale, 1:250,000.

Stewart, J.H., Chaffee, M.A., Dohrenewnd, D.A., John, D.A., Kistler, R.W., Kleinhampl, F.J., Menzie, W.D., Plouff, D., Rowan, L.C., and Silberling, N.J., 1984, The Conterminous U.S. Mineral Appraisal Program; Background information to accompany folio of geologic, geochemical and mineral resource map of the Walker Lake 1 x 2 Quadrangle, California and Nevada: U.S. Geological Survey Circular 927, 22 p. [maps are MF-1382-A through MF-1382-V].

Stewart, J.H., and Reynolds, M.W., 1987, Geologic map of the Pine Grove Hills quadrangle, Lyon County, Nevada: U.S. Geological Survey Open-File Report OF-87-658, 7 p., scale 1:62,500.

Stewart, J.H., Reynolds, M.W., and Johannesen, D.C., 1981, Geologic map of the Mount Grant quadrangle, Lyon and Mineral Counties, Nevada, Surficial geology by J.C. Dohrenwend: U.S. Geological Survey Miscellaneous Field Studies Map MF-1278.

Storey, L.O., 1978, Geology and mineralization of the Lights Creek stock, Plumas County, California, *in* Jenny, J.P., and Hauck, H.R., eds, Proceedings of the porphyry copper symposium, Tucson, Arizona, March 18-20, 1976: Arizona Geological Society Digest, v. 11, p. 49-58.

Sutherland-Brown, A., ed., 1976, Porphyry deposits of the Canadian Cordillera: Canadian Journal of Earth Science Special Volume 15, 515 p.

Tafuri, W.J., 1973, A geochemical study of the barite deposits of Mineral County, Nevada: Reno, Nev., University of Nevada, M.S. thesis, 69 p.

Templeton, J.H., and Hanson, R.E., 1991, Volcanology and stratigraphic evolution of a Jurassic island-arc sequence, northern Sierra Nevada, California: Geological Society of America Abstracts with Programs, v. 23, no. 2, p.103.

Tingley, J.V., 1990, Mineral resource inventory of the BLM Carson City district: Nevada Bureau of Mines and Geology Open-File report 90-1, 259 p.

Titley, S.R., 1982, Geologic setting of porphyry copper deposits, southeastern Arizona, *in* Titley, S.R., ed., Advances in geology of the porphyry copper deposits, southwestern North America: Tucson, University of Arizona Press, p. 37-58.

U.S. Steel Corporation, 1972, Lyon copper-iron skarn deposits: U.S. Steel Corporation company report, reference no. 36009.03, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 5 p.

Vikre, P.G., 1989, Fluid-mineral relations in the Comstock Lode: Economic Geology, v. 84, p. 1574-1613.

Vikre, P.G., McKee, E.H., and Silberman, M.L., 1988, Chronology of Miocene hydrothermal and igneous events in the western Virginia Range, Washoe, Storey, and Lyon Counties, Nevada: Economic Geology, v. 83, p. 864-874.

Wagner, D.L., Jennings, C.W., Bedrossian, T.L., and Bortugno, E.J., 1981, Geologic map of the Sacramento quadrangle, California: California Division of Mines and Geology Regional Geologic Map Series Map No. 1A, scale 1:250,000.

Wallace, A.B., 1979, Possible signatures of porphyry-copper deposits in middle to late Tertiary volcanic rocks of western Nevada: Nevada Bureau of Mines and geology Report 33, p. 69-76.

Wernicke, B.P., Christiansen, R.L., England, P.C., Sonder, L.J., 1987, Tectonomagmatic evolution of Cenozoic extension in the North American Cordillera, *in* Coward, M.P., Dewey, J.F., and Hancock, P.L., eds., Continental Extensional Tectonics, Geological Society of London Special Publication No. 28, p. 203-221.

Westra, G., and Kieth, S.B., 1981, Classification and genesis of stockwork molybdenum deposits: Economic Geology, v. 76, p. 844-873.

Whisker, A.L., 1936, The gold-bearing veins of the Meadow Lake district, Nevada County: California Journal of Mines and Geology, v. 32, p. 189-204.

___1958, Can modern metallurgical methods revitalize the Meadow Lake area?: Engineering and Mining Journal, v. 159, no. 5, p. 104-105.

Wilson, G.E., 1978, Data exchange with Phelps Dodge on the Bear-Lagomarsino area: Anaconda Company Report, Reference No. 38409.08, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 27 p.

___1981, Shumate (English Mountain) Mo-Cu submittal, Nevada County, California: Anaconda Company Report, Anaconda Geological Document Collection, American Heritage Center, University of Wyoming, 6 p.

Wilson, J.R., 1963, Geology of the Yerington Mine [Lyon County, Nevada]: Mining Congress Journal, v. 49, p. 30-34.

Wracher, M. D., Girty, G. H., and Wardlaw, M. S., 1991, Deformation in the Shoo Fly Complex and the role of a Middle Jurassic plutonic complex, northern Sierra Nevada, California: Geological Society of America Abstracts with Programs, v. 23, no. 2, p. 111.

Wright, W.A., 1976, Mo distribution, Lyon property, Lyon County, Nevada: Anaconda Company Report, Reference No. 336009.07, Anaconda Geological Documents Collection, International Archive of Economic Geology, American Heritage Center, University of Wyoming, 8 p.

Appendix 1.--Mineral Deposit Data

Inventory of mineral deposits hosted in Triassic to Jurassic rocks of the study area. Localities are sorted by mining district and deposit type. The MRDS number is a reference number in the USGS Mineral Resource Data System data base. Further information on MRDS localities may be obtained from a USGS Mineral Resource Surveys' office.

MRDS No.	SITE NAME	MINING DISTRICT	DEPOSIT TYPE
W017642	ALPINE	ALPINE	W skarn
M004730	ALPINE FAIRVIEW	ALPINE	polymetallic vein, undivided
M022172	CAL-PINE	ALPINE	Au vein, undivided
M035925	EAST SECTION 11 PROSPECT	ALPINE	Au vein, undivided
N000362	GENOA CLAIMS	ALPINE	Au vein, undivided
M035927	SECTION 21 PROSPECT	ALPINE	Au vein, undivided
N000347	MINNESOTA MINE	BUCKSKIN	Fe skarn
M035884	BLUE METAL PROSPECT	BUCKSKIN	aluminosilicate
N000432	TOP PROSPECT	BUCKSKIN	aluminosilicate
N000130	B.C. CLAIMS	BUCKSKIN	polymetallic vein, undivided
M035885	BUCKSKIN MINE	BUCKSKIN	polymetallic vein, undivided
N000348	AQUA CLAIM	BUCKSKIN	Au vein, undivided
N000349	BAR CLAIMS	BUCKSKIN	Au vein, undivided
N000397	HIGH-LINE MINING CLAIMS	BUCKSKIN	Au vein, undivided
N000344	SECTION 11 SHAFTS AND PROSPECTS	BUCKSKIN	Au vein, undivided
N000346	SECTION 12 SHAFTS AND PROSPECTS	BUCKSKIN	Au vein, undivided
N000431	AFTERTHOUGHT PROSPECT	CALICO HILLS	Fe skarn
N000429	CALICO DEPOSIT	CALICO HILLS	Fe skarn
M035004	HOTTENTOT/BADGER PROSPECTS	CALICO HILLS	Fe skarn
D011086	CARSON MINE	CARSON CITY	W skarn
M231084	NORTH CARSON	CARSON CITY	polymetallic vein, undivided
N000316	UNNAMED PROSPECT PITS	CARSON CITY	polymetallic vein, undivided
N000414	UNNAMED	CARSON CITY	Cu-Au quartz-tourmaline vein
N000423	UNNAMED	CARSON CITY	Cu-Au quartz-tourmaline vein
N000415	UNNAMED	CARSON CITY	Cu-Au quartz-tourmaline vein
M232533	ADAMS MINE	CARSON CITY	sedimentary gypsum
M231182	RUTH MINE	CHURCHILL	W skarn
M231180	SECTION 15 TUNGSTEN MINE	CHURCHILL	W skarn
M231181	SECTION 9 TUNGSTEN PROSPECT	CHURCHILL	W skarn
N000351	SECTION 10 GOLD PROSPECT	CHURCHILL	Au vein, undivided
N000392	GOODMAN	COMSTOCK	Au-Ag adularia-sericite vein
N000175	FLORIDA SHAFT	COMSTOCK	Au-Ag adularia-sericite vein
M231239	OEST MINE	COMSTOCK	Au-Ag adularia-sericite vein
N000177	SECTIONS 27/28 SHAFT AND ADIT	COMSTOCK	Au-Ag adularia-sericite vein
N000168	UNNAMED SHAFT	COMSTOCK	Au-Ag adularia-sericite vein
N000127	UNNAMED PROSPECT	DELAWARE	unknown
D011076	ALEX ESKE MINE	DELAWARE	W skarn
D011337	CAPITOL MINE	DELAWARE	W skarn
D001250	MCTARNAHAN HILL	DELAWARE	W skarn
D011104	WAR BOND MINE	DELAWARE	W skarn
M231059	VALLEY VIEW	DELAWARE	Cu skarn
N000309	NE SECTION 22 SHAFTS AND ADIT	DELAWARE	barite vein
N000406	PRISON HILL	DELAWARE	barite vein
M231046	AJAX-NEVADA	DELAWARE	polymetallic vein, undivided
N000315	BIDWELL MINE	DELAWARE	polymetallic vein, undivided
M231049	BUNKER HILL MINE	DELAWARE	polymetallic vein, undivided
M231052	EDISON-NEVADA	DELAWARE	polymetallic vein, undivided
N000313	SECTION 31 SHAFT	DELAWARE	polymetallic vein, undivided
N000312	SECTION 31 SHAFT AND ADIT	DELAWARE	polymetallic vein, undivided
N000416	UNNAMED	DELAWARE	polymetallic vein, undivided
N000126	UNNAMED MINE	DELAWARE	polymetallic vein, undivided
N000314	SECTION 28 SHAFT	DELAWARE	Au vein, undivided
N000310	SE SECTION 22 SHAFTS AND ADITS	DELAWARE	Au vein, undivided
N000311	UNNAMED SHAFT	DELAWARE	Au vein, undivided
M231066	SPOT-LUCKY BIRD GROUPS	DELAWARE	U-bearing vein or pegmatite
M231048	BESSEMER MINE	DELAWARE	volcanic-hosted magnetite
M231044	UNITED MINING CO. MINE	DELAWARE	Cu-Au quartz-tourmaline vein
N000128	UNNAMED OCCURRENCE	DELAWARE	Cu-Au quartz-tourmaline vein
N000129	UTOPIAN MINE	DELAWARE	Cu-Au quartz-tourmaline vein
M035647	DRY GULCH CLAIMS	FITTING	W skarn
M035010	GENTRY MINE	FITTING	W skarn
D001273	LUCKY FOUR	FITTING	W skarn
N000144	UNNAMED ADIT	FITTING	W skarn
M035016	COPPER HILL	FITTING	Cu skarn
M035682	BLACK BUTTE PROSPECT	FITTING	Fe skarn
M035681	BLACK HORSE PROSPECT	FITTING	Fe skarn
M233154	GILLIS PROSPECT	FITTING	Fe skarn
M035639	IRON CROWN PROSPECT	FITTING	Fe skarn
M233162	QACME COPPER MINE	FITTING	polymetallic replacement
N000194	SILVER BELL MINE	FITTING	polymetallic replacement
N000197	UNKNOWN	FITTING	polymetallic replacement
M035657	BISMARK MINE	FITTING	aluminosilicate
M233161	BISMARK PROSPECT	FITTING	aluminosilicate
M035082	DOVER MINE	FITTING	aluminosilicate
W007484	GREEN TALC MINE	FITTING	aluminosilicate
M035658	KENJAYS CLAIMS	FITTING	aluminosilicate
M035661	BARIUM MINING CO. PROSPECT	FITTING	barite vein
N000382	GRAVITY MINE	FITTING	barite vein
M035019	NE SECTION 32 PROSPECT	FITTING	barite vein
M035659	UNNAMED BARITE PROSPECTS	FITTING	barite vein
N000190	UNNAMED PROSPECT	FITTING	barite vein
N000192	BUCKLEY MINE	FITTING	polymetallic vein, undivided
N000146	CANYON CLAIMS	FITTING	polymetallic vein, undivided
N000152	COL CLAIMS	FITTING	polymetallic vein, undivided
N000376	LAKEVIEW LEAD SILVER	FITTING	polymetallic vein, undivided

MRDS No.	SITE NAME	MINING DISTRICT	DEPOSIT TYPE
M035643	LOS AMIGOS MINING CO	FITTING	polymetallic vein, undivided
N000389	MAKO MINE	FITTING	polymetallic vein, undivided
N000191	MALAPAIS CLAIMS	FITTING	polymetallic vein, undivided
M035662	MONTREAL MINE	FITTING	polymetallic vein, undivided
M035664	P.M. CLAIMS	FITTING	polymetallic vein, undivided
N000149	RED HILL CLAIMS	FITTING	polymetallic vein, undivided
M035683	SILVER QUEEN MINE	FITTING	polymetallic vein, undivided
N000360	UNAMED INCLINES	FITTING	polymetallic vein, undivided
N000410	UNKNOWN	FITTING	polymetallic vein, undivided
N000193	UNNAMED ADITS AND SHAFT	FITTING	polymetallic vein, undivided
N000150	UNNAMED MINE	FITTING	polymetallic vein, undivided
M035667	UNNAMED PROSPECTS	FITTING	polymetallic vein, undivided
N000189	AMERICAN GOLD CLAIMS (NORTH)	FITTING	Au vein, undivided
M035666	LAST CHANCE PROSPECT	FITTING	Au vein, undivided
N000147	POLSTON SUN CLAIM #2	FITTING	Au vein, undivided
N000145	RUSTY CANYON CLAIMS	FITTING	Au vein, undivided
M035023	SE CENTRAL SEC 28 PROSPECT	FITTING	Au vein, undivided
M234088	SILVER KING MINE	FITTING	Au vein, undivided
M035963	BLUE BOTTLE CLAIMS	FITTING	U-bearing vein or pegmatite
N000151	H.C. CLAIMS	FITTING	U-bearing vein or pegmatite
M035641	NAME UNKNOWN	FITTING	U-bearing vein or pegmatite
M035965	LUCKY ANN	FITTING	U-bearing vein or pegmatite
M231081	COMSTOCK EUREKA	FRED'S MOUNTAIN	polymetallic vein, undivided
N000124	COPPER GULCH # 2 CLAIM	FRED'S MOUNTAIN	polymetallic vein, undivided
M231074	UNNAMED COPPER	FRED'S MOUNTAIN	polymetallic vein, undivided
N000122	UNNAMED PROSPECT	FRED'S MOUNTAIN	polymetallic vein, undivided
N000121	UNNAMED PROSPECT	FRED'S MOUNTAIN	polymetallic vein, undivided
N000403	FRED'S MOUNTAIN	FRED'S MOUNTAIN	Au vein, undivided
M231143	ELLEN B	GALENA	W skarn
M231144	GALENA HILL MINE	GALENA	polymetallic vein, undivided
M231145	ROCKY HILL MINE	GALENA	Cu-Au quartz-tourmaline vein
M035916	CHEROKEE MINE	GARDNERVILLE	W skarn
M035917	DIVIDE MINE	GARDNERVILLE	W skarn
N000182	LAND N	GARDNERVILLE	W skarn
M035919	PIONEER MINE	GARDNERVILLE	W skarn
N000413	SE SECTION 23 MINE	GARDNERVILLE	W skarn
D001198	ALPINE MINE/PINE NUT DEPOSIT	GARDNERVILLE	W skarn/porphyry Mo
M035908	DANITE MINE	GARDNERVILLE	polymetallic vein, undivided
M035913	DUVAL PROSPECTS	GARDNERVILLE	polymetallic vein, undivided
M035920	MONARCH MINE	GARDNERVILLE	polymetallic vein, undivided
M035910	OLLIE LODE	GARDNERVILLE	polymetallic vein, undivided
M035915	PREACHERS MINE	GARDNERVILLE	polymetallic vein, undivided
M035914	RUBY HILL MINE	GARDNERVILLE	polymetallic vein, undivided
N000187	SUPRISE MINE	GARDNERVILLE	polymetallic vein, undivided
M035909	VETA GRANDE MINE AND MILL	GARDNERVILLE	polymetallic vein, undivided
M035922	BENTLEY PROSPECTS	GARDNERVILLE	Au vein, undivided
N000186	GOLD PROSPECT 4	GARDNERVILLE	Au vein, undivided
M035921	SECTIONS 2 AND 3 PROSPECTS	GARDNERVILLE	Au vein, undivided
D001276	BATAAN	GARFIELD	Cu skarn
M035309	WESTERN CLAIM	GARFIELD	barite vein
M233185	ACME GROUP	GARFIELD	polymetallic vein, undivided
M233204	ASHBY GOLD MINE	GARFIELD	polymetallic vein, undivided
M035318	BIG DEAL CLAIMS 1-26	GARFIELD	polymetallic vein, undivided
N000301	BIG DEAL CLAIM #5	GARFIELD	polymetallic vein, undivided
W016419	GARFIELD MINE	GARFIELD	polymetallic vein, undivided
M035305	LAZY MAN MINE	GARFIELD	polymetallic vein, undivided
M035315	LOMAN MINE	GARFIELD	polymetallic vein, undivided
M035255	MABLE MINE	GARFIELD	polymetallic vein, undivided
M233189	MINDORA MINE	GARFIELD	polymetallic vein, undivided
M035322	WAMSLEY MINE	GARFIELD	polymetallic vein, undivided
M035311	SOUTH EXTENSION OF LAZY MAN MINE	GARFIELD	Au vein, undivided
M035656	DEEP PROSPECTS	HAWTHORNE	aluminosilicate
M035652	CRYSTAL MINE	HAWTHORNE	barite vein
N000358	GARY CLAIMS (EAST)	HAWTHORNE	barite vein
M035655	UNNAMED BARITE DEPOSIT	HAWTHORNE	barite vein
N000357	GARY CLAIMS (WEST)	HAWTHORNE	polymetallic vein, undivided
M035653	KING DAVID PROSPECT	HAWTHORNE	polymetallic vein, undivided
N000308	SECTION 12 GOLD PROSPECTS	HAWTHORNE	polymetallic vein, undivided
N000307	SECTION 12 SHAFT	HAWTHORNE	polymetallic vein, undivided
N000411	UNKNOWN	HAWTHORNE	polymetallic vein, undivided
M233194	BISMARK 1	HAWTHORNE	Au vein, undivided
M035105	LEMR PROSPECT	HAWTHORNE	Au vein, undivided
N000422	UNKNOWN	JUMBO	Cu-Au quartz-tourmaline vein
N000166	SECTION 13 SHAFT AND PROSPECTS	LUCKY BOY	W skarn
M035114	LUCKY BOY MINES	LUCKY BOY	polymetallic vein, undivided
M233199	LUCKY BOY MINE EAST	LUCKY BOY	polymetallic vein, undivided
D011038	LUCKY BOY MINE NORTH	LUCKY BOY	polymetallic vein, undivided
M035113	MOUNTAIN KING CLAIM	LUCKY BOY	polymetallic vein, undivided
M233205	BABCOCK LEAD PROSPECT	LUCKY BOY	Au vein, undivided
M024214	GROUSE RIDGE	MEADOW LAKE	unknown
M030171	MOLLY MINE	MEADOW LAKE	porphyry Mo
M011977	CARLISLE	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M012012	ORO GRANDE	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M011999	TOLA GROUP	MEADOW LAKE	Cu-Au quartz-tourmaline vein
N000103	TONY MOLY 2 MINE	MEADOW LAKE	Cu-Au quartz-tourmaline vein

MRDS No.	SITE NAME	MINING DISTRICT	DEPOSIT TYPE
M024313	UNNAMED	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M011995	UNNAMED PROSPECT	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M022060	CALEDONIA	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012002	CALIFORNIA	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012003	CONFIDENCE	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012004	FRACTION	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012005	FREEMAN GROUP	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011992	GEO. WASHINGTON	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012007	GREEN EMIGRANT	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012013	GREY EAGLE	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012009	MOSCOW	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M024314	OF WHAT NOS 1 & 2	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012011	PACIFIC	MEADOW LAKE	Cu-Au quartz-tourmaline vein
W000362	PROSPECT	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012014	SUNNY SOUTH	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011990	UNNAMED	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M011987	SIGNAL PEAK	MEADOW LAKE	volcanic-hosted magnetite
C011980	BELLA QTZ	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M011994	ENGLISH MOUNTAIN	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C012001	EXCELSIOR MINE	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M030170	EXCELSIOR MINE # 2	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011970	HIGH GRADE GP	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011983	JOHANNA QTZ.	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011989	LUCKY JOE	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011993	MARGUERITE CONS	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M030169	RED MOUNTAIN	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011981	SYLVANITE GP.	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011967	UNNAMED	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011985	UNNAMED	MEADOW LAKE	Cu-Au quartz-tourmaline vein
C011986	UNNAMED	MEADOW LAKE	Cu-Au quartz-tourmaline vein
M035933	A AND C MINE	MOUNTAIN HOUSE	W skarn
M035879	HIGH JACKS	MOUNTAIN HOUSE	W skarn
M035931	SECTION8 PROSPECTS	MOUNTAIN HOUSE	polymetallic vein, undivided
M035932	SECTION 7 PROSPECTS	MOUNTAIN HOUSE	polymetallic vein, undivided
N000179	UNNAMED ADIT	MOUNTAIN HOUSE	polymetallic vein, undivided
N000132	UNNAMED MINE	MOUNTAIN HOUSE	polymetallic vein, undivided
N000133	UNNAMED MINE AND PROSPECTS	MOUNTAIN HOUSE	polymetallic vein, undivided
N000138	UNNAMED MINE AND PROSPECTS	MOUNTAIN HOUSE	Au vein, undivided
M035930	WILLARD - MCDONALD MINE	MOUNTAIN HOUSE	Au vein, undivided
M035880	TRIANGLE GROUP	MOUNTAIN HOUSE	U-bearing vein or pegmatite
D011039	HOWARD MINE	MOUNTAIN VIEW	W skarn
M035046	BEACH MINE/BLACK MOUNTAIN PROSPECT	MOUNTAIN VIEW	porphyry Cu
N000430	MICROWAVE PROSPECT	MOUNTAIN VIEW	porphyry Cu
M233241	BIG TWENTY MINE	MOUNTAIN VIEW	polymetallic vein, undivided
N000338	LITTLE JOHN CLAIMS	MOUNTAIN VIEW	polymetallic vein, undivided
M035059	NORTHERN LIGHTS MINE	MOUNTAIN VIEW	polymetallic vein, undivided
N000327	NW SECTION 31 COPPER-GOLD PROSPECT	MOUNTAIN VIEW	polymetallic vein, undivided
N000353	UNKNOWN	MOUNTAIN VIEW	polymetallic vein, undivided
N000378	EVA A NO. 1	MOUNTAIN VIEW	Au vein, undivided
M035040	GRANITE	MOUNTAIN VIEW	Au vein, undivided
M233242	MOUNTAIN VIEW MINE	MOUNTAIN VIEW	Au vein, undivided
N000326	SER MINES PROSPECT	MOUNTAIN VIEW	Au vein, undivided
N000352	UNKNOWN	MOUNTAIN VIEW	Au vein, undivided
N000321	SECTION 14 ADIT	MT. GRANT	polymetallic vein, undivided
N000319	SECTION 14 INCLINES AND ADIT	MT. GRANT	polymetallic vein, undivided
N000318	SECTION 24 SHAFT	MT. GRANT	polymetallic vein, undivided
M035091	STAR PROSPECT	MT. GRANT	polymetallic vein, undivided
M035099	W SECTION 19 PROSPECT	MT. GRANT	polymetallic vein, undivided
M233191	BIG INDIAN MINE	MT. GRANT	Au vein, undivided
M233190	EUREKA PROPERTY	MT. GRANT	Au vein, undivided
M035092	NW SECTION 2 PROSPECT	MT. GRANT	Au vein, undivided
N000322	SECTION 14 PROSPECTS	MT. GRANT	Au vein, undivided
N000320	SECTION 2 ADITS AND PROSPECTS	MT. GRANT	Au vein, undivided
N000323	SECTION 6 PROSPECTS AND ADIT	MT. GRANT	Au vein, undivided
M233193	STAR PROSPECT	MT. GRANT	Au vein, undivided
M035095	W SECTION 18 PROSPECT	MT. GRANT	Au vein, undivided
N000156	DERBY MINE	OLINGHOUSE	W skarn
M233196	GYPSY CLAIM	PAMLICO	W skarn
M035358	SILVER STAR MINE	PAMLICO	W vein
M035277	LA PANTA MINE	PAMLICO	polymetallic replacement
N000300	EARLY DAWN CLAIM	PAMLICO	polymetallic vein, undivided
N000198	GOLD BAR CLAIM	PAMLICO	polymetallic vein, undivided
M035297	GOLD BAR MINE	PAMLICO	polymetallic vein, undivided
M233200	GOOD HOPE MINE	PAMLICO	polymetallic vein, undivided
M035283	CENTRAL MINES AREA	PAMLICO	polymetallic vein, undivided
M035292	MAIN PAMLICO MINES	PAMLICO	polymetallic vein, undivided
M233209	UNIDENTIFIED OCCURRENCE	PAMLICO	polymetallic vein, undivided
N000199	UNKNOWN	PAMLICO	Au vein, undivided
C010296	ANGELO MISSION	PATTERSON	Au-Ag adularia-sericite vein
M035954	C AND B CLAIMS	PATTERSON	U-bearing vein or pegmatite
N000421	GUY WALT'S ZINC PROPERTY	PEAVINE	Zn skarn
M231170	RED METALS MINE	PEAVINE	Cu skarn/Cu-Au quartz-tourmaline vein
N000115	UNNAMED OCCURRENCE	PEAVINE	Cu skarn
N000405	MARSHALL GROUP	PEAVINE	polymetallic vein, undivided
M231162	FRAVEL MINE	PEAVINE	Au-Ag quartz-alunite vein

MRDS No.	SITE NAME	MINING DISTRICT	DEPOSIT TYPE
M231138	GOLDEN FLEECE	PEAVINE	Au-Ag quartz-alunite vein
M231163	MAZY MINE	PEAVINE	Au-Ag quartz-alunite vein
M231166	PAYMASTER	PEAVINE	Au-Ag quartz-alunite vein
M231167	PEAVINE PEAK GOLD MINE	PEAVINE	Au-Ag quartz-alunite vein
M231155	UNNAMED PROSPECT	PEAVINE	Au-Ag quartz-alunite vein
M231156	UNNAMED PROSPECT	PEAVINE	Au-Ag quartz-alunite vein
M231157	UNNAMED PROSPECT	PEAVINE	Au-Ag quartz-alunite vein
N000417	UNKNOWN	PEAVINE	volcanic-hosted magnetite
M231169	REDELIUS CLAIMS	PEAVINE	Cu-Au quartz-tourmaline vein
N000106	UNNAMED MINE	PEAVINE	Cu-Au quartz-tourmaline vein
N000107	UNNAMED MINE	PEAVINE	Cu-Au quartz-tourmaline vein
N000120	UNNAMED PROSPECT	PEAVINE	Cu-Au quartz-tourmaline vein
N000104	UNNAMED PROSPECT	PEAVINE	Cu-Au quartz-tourmaline vein
N000105	UNNAMED PROSPECT	PEAVINE	Cu-Au quartz-tourmaline vein
N000119	UNNAMED PROSPECT	PEAVINE	Cu-Au quartz-tourmaline vein
N000118	UNNAMED PROSPECT	PEAVINE	Cu-Au quartz-tourmaline vein
N000418	UNNAMED	PYRAMID	Au vein, undivided
N000399	DYKE MINE	RAMSEY	polymetallic vein, undivided
N000400	HAWKS NEST PROSPECT	RAMSEY	polymetallic vein, undivided
N000340	SECTION 12 SHAFTS	RAMSEY	polymetallic vein, undivided
N000341	SECTION 14 SHAFT	RAMSEY	Au vein, undivided
N000180	LAST DOLLAR CLAIM	RED CANYON	Cu skarn
M035896	RED CANYON CLAIMS	RED CANYON	Cu skarn
M035898	LUCKY BILL	RED CANYON	polymetallic replacement
M035901	WINTERS MINE	RED CANYON	polymetallic replacement
M035902	SE SECTION 6 PROSPECT	RED CANYON	polymetallic vein, undivided
M035906	GOLD BUG MINE	RED CANYON	Au vein, undivided
M035903	SECTIONS 4 & 5 PROSPECTS	RED CANYON	Au vein, undivided
D011078	BLACKHAWK MINE	RED MOUNTAIN	W skarn
M231185	DAYTON IRON DEPOSIT	RED MOUNTAIN	Fe skarn
N000401	IRON BLOSSOM PROSPECT	RED MOUNTAIN	Fe skarn
N000134	PIRI #3 CLAIM	RISUE CANYON	W skarn
N000350	RISUE CANYON	RISUE CANYON	W skarn
D011342	VERA JO PROSPECT	RISUE CANYON	W skarn
D000910	WHITE GOAT CLAIM	RISUE CANYON	W skarn
N000363	SWEETWATER MINE	RISUE CANYON	porphyry Mo
M035940	NE SECTION 33 PROSPECTS	RISUE CANYON	polymetallic replacement
M035942	NORTH SECTION 27 PROSPECTS	RISUE CANYON	polymetallic replacement
M035939	NW SECTION 33 PROSPECTS	RISUE CANYON	polymetallic replacement
M035938	SECTIONS 27 AND 34 PROSPECTS	RISUE CANYON	polymetallic replacement
N000135	ARROWHEAD EXTENSION MINE	RISUE CANYON	polymetallic vein, undivided
M035941	ARROWHEAD MINE	RISUE CANYON	polymetallic vein, undivided
M035635	BLUE STAR CLAIM	SANTA FE	Fe skarn
M035967	BROKEN BOW	SANTA FE	polymetallic vein, undivided
N000196	UNNAMED SHAFT	SANTA FE	Au vein, undivided
N000158	UNNAMED SHAFT AND PROSPECTS	SANTA FE	Cu-Au quartz-tourmaline vein
N000428	GREEN CREEK PROSPECT	STAR CITY	porphyry Mo
N000427	TIGER II MINE	STAR CITY	porphyry Mo
N000426	UNNAMED PROSPECT	STAR CITY	porphyry Mo
N000108	UNNAMED MINE	STATELINE PEAK	unknown
N000113	UNNAMED MINE	STATELINE PEAK	Cu skarn
N000404	BIRCH COPPER PROSPECT	STATELINE PEAK	polymetallic vein, undivided
N000111	UNNAMED MINE	STATELINE PEAK	polymetallic vein, undivided
N000116	UNNAMED PROSPECT	STATELINE PEAK	polymetallic vein, undivided
M009140	MADONNA MIA	STATELINE PEAK	U-bearing vein or pegmatite
M231121	ANTELOPE	STATELINE PEAK	Cu-Au quartz-tourmaline vein
N000112	BLACK STAR MINE	STATELINE PEAK	Cu-Au quartz-tourmaline vein
M009129	FLYING DUTCHMAN MINE	STATELINE PEAK	Cu-Au quartz-tourmaline vein
N000117	TILLIE MINE	STATELINE PEAK	Cu-Au quartz-tourmaline vein
N000412	UNKNOWN SHAFT AND ADIT	STATELINE PEAK	Cu-Au quartz-tourmaline vein
N000110	UNNAMED MINE	STATELINE PEAK	Cu-Au quartz-tourmaline vein
N000109	UNNAMED MINE	STATELINE PEAK	Cu-Au quartz-tourmaline vein
N000114	UNNAMED MINE	STATELINE PEAK	Cu-Au quartz-tourmaline vein
X024488	LA TRINIDAD	TAHOE	polymetallic vein, undivided
M021908	LOST EMIGRANT #1 SOUTH	TAHOE	polymetallic vein, undivided
N000100	LOST EMIGRANT #1 NORTH	TAHOE	polymetallic vein, undivided
M021994	BONNIE BELL	TAHOE	Au vein, undivided
M021828	CHICAGO	TAHOE	Au vein, undivided
N000101	LOST EMIGRANT # 3	TAHOE	Au vein, undivided
N000102	LOST EMIGRANT # 7	TAHOE	Au vein, undivided
N000408	OHIO CLAIM	VOLTAIRE	polymetallic vein, undivided
N000131	OPEN-CUT PROSPECT	VOLTAIRE	polymetallic vein, undivided
M231174	PREMIER MINE	VOLTAIRE	polymetallic vein, undivided
M231065	SOPHIE GROUP	VOLTAIRE	U-bearing vein or pegmatite
N000136	BOULDER HILL CLAIMS (SOUTH)	WELLINGTON	W skarn
M035946	BOULDER HILL MINE	WELLINGTON	polymetallic vein, undivided
N000343	SECTION 19 WORKINGS	WELLINGTON	Au vein, undivided
N000342	SECTION 31 GOLD PROSPECT	WELLINGTON	Au vein, undivided
D000911	BROWN HORSE	WEST WALKER	W skarn
F000165	JOE MINE NO. 1	WEST WALKER	W vein
C010264	AL MONO	WEST WALKER	polymetallic vein, undivided
C010266	GOLDEN GATE	WEST WALKER	polymetallic vein, undivided
D001272	COWBOY MINE	WILSON	W skarn
M035949	JACKPOT MINE	WILSON	polymetallic vein, undivided
M035820	OWEN PROSPECT	WILSON	polymetallic vein, undivided

MRDS No.	SITE NAME	MINING DISTRICT	DEPOSIT TYPE
N000140	SECTION 32 ADIT	WILSON	polymetallic vein, undivided
M035948	SMITH VALLEY MINE	WILSON	polymetallic vein, undivided
M035819	SOUTH SECTION 6 PROSPECTS	WILSON	polymetallic vein, undivided
N000139	TELLURIDE CLAIMS	WILSON	polymetallic vein, undivided
M232540	WHEELER MINE	WILSON	polymetallic vein, undivided
W002907	WILSON DISTRICT	WILSON	polymetallic vein, undivided
M035826	SECTIONS 31 AND 36 PROSPECTS	WILSON	Au vein, undivided
M035825	WILSON MINE	WILSON	Au vein, undivided
M008607	UNNAMED	UNKNOWN	polymetallic vein, undivided
N000142	NEW STRIKE CLAIMS	UNKNOWN	polymetallic vein, undivided
W025584	THOUSAND-AND-ONE	UNKNOWN	polymetallic vein, undivided
M035076	WALKER LAKE PROSPECT	UNKNOWN	polymetallic vein, undivided
M021658	BUTCHER RANCH	UNKNOWN	Au vein, undivided
C008604	OCCURRENCE	UNKNOWN	Au vein, undivided
M021767	UNIDENTIFIED WORKINGS	UNKNOWN	Au vein, undivided
M021766	UNIDENTIFIED WORKINGS	UNKNOWN	Au vein, undivided
N000420	UNNAMED	UNKNOWN	Cu-Au quartz-tourmaline vein
N000419	UNNAMED	UNKNOWN	Cu-Au quartz-tourmaline vein
M035852	NE SECTION 13 PROSPECTS	YERINGTON	unknown
M035849	NE SECTION 25 PROSPECTS	YERINGTON	unknown
M035841	NORTH SECTION 16 PROSPECTS	YERINGTON	unknown
M035850	NORTH SECTION 25 PROSPECTS	YERINGTON	unknown
M035851	NW SECTION 19 PROSPECT	YERINGTON	unknown
M035836	SECTIONS 20	YERINGTON	unknown
M035840	SECTION 15 PROSPECTS	YERINGTON	unknown
M035838	SECTION 17 PROSPECTS	YERINGTON	unknown
M035837	SECTION 18 PROSPECTS	YERINGTON	unknown
M035890	SECTION 23 PROSPECTS	YERINGTON	unknown
M035835	SECTION 30 PROSPECTS	YERINGTON	unknown
N000332	LGCS CLAIMS	YERINGTON	W skarn
N000368	AIRPORT DEPOSIT	YERINGTON	porphyry Cu
N000367	ANN MASON DEPOSIT	YERINGTON	porphyry Cu
N000424	BEAR DEPOSIT	YERINGTON	porphyry Cu
N000425	LAGOMARSINO DEPOSIT	YERINGTON	porphyry Cu
N000335	MACARTHUR	YERINGTON	porphyry Cu
M035828	MCCOY PROSPECT	YERINGTON	porphyry Cu
M035859	YERINGTON	YERINGTON	porphyry Cu
M035864	BLUESTONE MINE	YERINGTON	Cu skarn
M035872	CASTING COPPER MINE	YERINGTON	Cu skarn
M035873	DOUGLAS HILL MINE	YERINGTON	Cu skarn
M035874	LUDWIG MINE	YERINGTON	Cu skarn
M035868	MALACHITE MINE	YERINGTON	Cu skarn
M035865	MASON VALLEY MINE	YERINGTON	Cu skarn
M035869	MCCONNELL MINE	YERINGTON	Cu skarn
M035877	NEVADA - DENVER MINE	YERINGTON	Cu skarn
M035866	SPRAGG MINE	YERINGTON	Cu skarn
M035878	THANKSGIVING MINE	YERINGTON	Cu skarn
M035870	WESTERN NEVADA	YERINGTON	Cu skarn
M035876	YERINGTON CENTRAL	YERINGTON	Cu skarn
N000369	PUMPKIN HOLLOW	YERINGTON	Fe skarn
M035853	BLACK ROCK MINE	YERINGTON	polymetallic vein, undivided
M035857	BLUE JAY MINE	YERINGTON	polymetallic vein, undivided
N000337	BLUE ROSE CLAIMS	YERINGTON	polymetallic vein, undivided
M035855	BRADLEY MINE	YERINGTON	polymetallic vein, undivided
M035858	COPPER RIDGE MINE	YERINGTON	polymetallic vein, undivided
M035854	EAST SECTION 21 PROSPECTS	YERINGTON	polymetallic vein, undivided
N000336	G.B. MARTIN CLAIMS	YERINGTON	polymetallic vein, undivided
N000339	GAP CLAIM	YERINGTON	polymetallic vein, undivided
N000374	GOLD DYKE	YERINGTON	polymetallic vein, undivided
M035871	HOMESTAKE MINE	YERINGTON	polymetallic vein, undivided
M035860	MAY QUEEN MINE	YERINGTON	polymetallic vein, undivided
M035861	MONTANA - YERINGTON MINE	YERINGTON	polymetallic vein, undivided
M035863	NATIVE COPPER	YERINGTON	polymetallic vein, undivided
M035856	NW SECTION 21 PROSPECTS	YERINGTON	polymetallic vein, undivided
N000328	OCCAISION CLAIM	YERINGTON	polymetallic vein, undivided
N000372	RENO-YERINGTON MINE	YERINGTON	polymetallic vein, undivided
N000324	SECTION 13 COPPER PROSPECTS	YERINGTON	polymetallic vein, undivided
M035891	SECTION 23 AND 26 PROSPECTS	YERINGTON	polymetallic vein, undivided
M035842	SW SECTION 10 PROSPECTS	YERINGTON	polymetallic vein, undivided
M035848	TEDE BOY CLAIMS	YERINGTON	polymetallic vein, undivided
N000143	UNNAMED MINE	YERINGTON	polymetallic vein, undivided
N000375	BLACK DIAMOND	YERINGTON	Au vein, undivided
N000364	BOOKMAN COPPER PROSPECT	YERINGTON	Au vein, undivided
N000333	CMB CLAIM #6	YERINGTON	Au vein, undivided
N000394	EASTER PROSPECT	YERINGTON	Au vein, undivided
N000370	GREENWOOD PROSPECT	YERINGTON	Au vein, undivided
N000334	MARTHA WASHINGTON SHAFT	YERINGTON	Au vein, undivided
M035847	NW SECTION 30 PROSPECT	YERINGTON	Au vein, undivided
M035893	SECTION35 PROSPECTS	YERINGTON	Au vein, undivided
N000345	SECTION 27/28 SHAFT	YERINGTON	Au vein, undivided
M035843	SECTION 9 PROSPECTS	YERINGTON	Au vein, undivided
N000141	UNNAMED MINE	YERINGTON	Au vein, undivided
N000325	VALEMAR CLAIM	YERINGTON	Au vein, undivided
M035811	REGAN MINE	YERINGTON	sedimentary gypsum

Appendix 2.--Rock Geochemical Data

Selected minor- and trace-metal analytical data for rock samples collected during this study. Analytical methods are described in the section "Rock Geochemistry". All values are in ppm unless otherwise noted.

Abbreviations:

AA - atomic absorption
S - emission spectroscopy
.N - not detected
.L - present but below indicted lower detection limit
.G - greater than indicated upper detection limit

The following samples were included in the rock geochemistry data base for this study. The analytical data and sample descriptions for these samples can be found in Quade and others (1990b).

0519, 3298, 3315, 3318, 3319, 3321, 3323, 3329, 3330, 3332, 3333, 3401, 3402, 3404, 3406, 3407, 3412, 3413, 3414, 3417, 3453, 3454, 3456, 3457, 3458, 3459, 3482, 3483, 3484, 3485, 3486, 3560, 3591, 3592, 3593, 3594, 3603, 3604, 3608, 3609, 3617, 3618, 3619, 3620, 3621, 3622, 3626, 3628, 3629, 3637, 3639, 3640, 3641, 3642, 3643, 3644, 3645, 3646, 3649, 3651, 3652, 3654, 3659, 3660, 3661, 3662, 3663, 3664, 3668, 3669, 3670, 3671, 3672, 3673, 3674, 3680, 3681, 3682, 3683, 3684, 3697, 3699, 3700, 3709, 3710, 3763, 3764, 3776, 3780, 3781, 3784, 3786, 3790, 3791, 3792, 3793, 3794, 4058, 4059, 4060, 4104, 4105, 4106, 4116, 4122, 4140, 4141, 4142, 4143, 4204, 4205, 4211, 4212, 4213, 4214, 4216, 4226, 4227, 4235, 4238, 4239, 4240, 4241, 4244, 4246, 4247, 4248, 4250, 4251, 4252, 4253, 4256, 4266, 4267, 4270, 4271, 4272, 4273, 4274, 4275, 4276, 4278, 4280, 4281, 4282, 4291, 4293, 4294, 4295, 4297, 4298, 4299, 4300, 4322, 4323, 4404, 4405, 4407, 4408, 4409, 4410, 4411, 4412, 4413, 4414, 4415, 4416, 4419, 4421, 4422, 4423, 4424, 4426, 4427, 4428, 4429, 4430, 4431, 4432, 4433, 4434, 4435, 4436, 4437, 4447.

Sample No.	Latitude	Longitude	AA-Au	S-Ag	S-Cu	S-Pb	S-Zn	AA-As	AA-Sb	AA-Bi	AA-Cd	S-Ba	S-B	S-Mn	S-W	S-Mo	S-Sn	S-Cr	S-Ni	S-Co	S-Fe%	S-Ti%
4501	39.73	120.13	.35	30	7000	700	200.L	100	200	1.L	3.40	1500	500	500	20.N	30	10.N	15	10	100	5	1
4502	39.74	120.12	.05.N	1.50	1500	10.N	200.N	10.L	2.L	1.L	.10.L	70	2000.G	2000.G	100	20.L	5.N	10.N	10.N	20	10	.50
4503	39.74	120.12	.05.N	.50	1000	15	200.N	10.L	2.L	1	.10	50	2000	200	20.N	2000G	10.N	10.N	30	700	10	.50
4504	39.74	120.12	.05.N	.50.N	10	10.N	200.N	10.L	2.L	1.L	.60	1000	500	20	20.L	50	10.N	10.L	5.N	10.L	5	.50
4505	39.70	120.00	.05.N	7	300	100	200.N	20	4	1.L	.10.L	200	150	5000G	20.N	7	10.N	10.N	5.N	10.N	7	.15
4506	39.70	119.99	.15	100	7000	70	200.N	10.L	2.L	85	.10.L	150	500	1000	20.N	50	10.N	30	10	10.N	3	.15
4507	39.73	120.00	.80	300	20000	30	200.N	30	35	1000G	1.30	1000	2000G	200	20.N	20	10.N	10.L	5	15	10	.30
4508	39.74	120.00	.40	10	10000	10.N	200.N	10.L	4	1.L	.10	30	2000G	100	20.L	5.N	10.N	10.N	20	10	10	.20
4510	39.53	120.02	.05	10	3000	150	200.N	10.L	4	1000.G	.50	50	2000.G	200	20.N	5.N	10.N	50	50	15	7	.30
4511	39.53	120.05	.05.N	7	500	30	200.N	60	8	1.L	.70	50	2000.G	200	20.N	5.N	10.N	100	70	300	15	.20
4512	39.55	120.07	.10	100	20000.G	20000	200.N	60	2.L	1.L	17	700	20	1000	20.N	5.N	10.N	150	50	20	5	.30
4513	39.62	120.01	.05.L	.70	100	10.L	200.N	30	2	1.L	.10	1500	150	20	20.N	10	10.N	10.N	5.N	10.N	3	.15
4514	39.62	120.01	.15	1	700	10.N	200.N	10	2	1.L	.20	150	2000.G	300	20.N	5.N	10.N	10.N	5.L	20	20.G	.15
4515	39.70	120.09	.45	20	7000	10.N	200.N	10.L	2.L	1.L	.40	700	10.N	500	30	50	10.N	10.N	10	30	20.G	.10
4516	39.71	120.10	.05.N	.50.N	100	10	200.N	10.L	2.L	1.L	.20	1000	10	1000	20.N	5.N	10.N	10.L	5	15	5	.70
4517	39.66	120.07	.10	5	5000	30	200.N	10	2.L	4	.60	300	20	1500	20.N	20	10.N	10.N	5.N	20	7	.20
4518	39.67	120.07	.05.N	.50.N	100	20	200.N	10.L	2.L	1.L	.10.L	1000	15	300	20.N	5.N	10.N	10.N	5.N	10.L	5	1
4519	39.73	120.08	.05.N	3	500	10	200.N	10.L	2.L	1.L	.30	500	2000.G	100	20.N	5.N	10.N	10.N	15	300	5	.30
4520	39.72	120.10	.65	30	10000	15	200.N	10	4	16	1.10	1500	2000.G	700	20.N	15	10.N	20	15	50	5	.70
4521	39.72	120.11	16	100	20000	15	200.N	10.L	2.L	160	.40	200	700	1500	20.N	20	10.N	10.N	15	20	10	.10
4524	39.54	120.02	.70	5	300	15	10000.G	190	4.50	590	580	20.N	50	5000.G	700	10	20	15	15	70	5	.15
4525	39.35	119.76	9.20	100	50	1000	500	3700.G	160	220	2.60	20.N	2000	200	20.N	5.N	10.N	10.L	5.N	70	15	.02
4526	39.28	119.73	.05.N	1	500	20	200.L	600	6.20	1.60	.31	70	2000.G	150	20.N	5.N	10.N	10.N	5	50	15	.15
4527	39.24	119.69	.05.N	.50.N	7	10	200.N	45	.77	1.10	.59	700	1000	150	20.N	5.N	10.N	10	20	50	7	.50
4528	39.25	119.69	.10	.50.N	5.N	10.L	200.N	52	.60.N	.60.N	.08	20.N	2000.G	700	20.N	5.N	10.N	10.N	5	30	2	.10
4529	39.23	119.70	.05.N	.50.N	5.N	10.L	200.N	29	.60.N	.60.N	.06	20.N	2000.G	1000	20.N	5.N	10.N	10.L	7	15	3	.15
4530	39.07	119.55	.05.N	.50.N	30	15	200.N	14	1.90	2	.14	70	10	150	20.N	5.N	10.N	20	5.L	10.L	10	.30
4531	39.07	119.60	.20	7	70	30	200.N	170	510	7.10	.18	200	2000.G	150	20.N	150	10.N	70	50	100	10	.07
4532	39.56	119.89	.05.N	5	200	15	300	29	2.60	2.80	.08	20.N	2000.G	300	20.N	10	10.N	10.L	10	10.N	15	.10
4533	39.71	119.67	.05.L	5	10000	10.N	200.N	330	59.N	59.N	3.N	300	50	30	20.N	5.N	10.N	10.N	5.N	10.N	.70	.02
4551	39.34	120.54	1.70	1	300	10	200.N	10	2.L	1.L	.10.L	1000	2000.G	200	50	5.N	10.N	150	20	15	15	.20
4553	39.44	120.57	.05	1.50	5000	10.N	200.N	10.L	2.L	1.L	.30	200	10.N	70	20.N	500	10.N	10	100	1000	20.G	.10
4554	39.44	120.56	.10	1	1000	10.L	200.N	10.L	2.L	1.L	.10.L	100	20	500	20.N	10	10.N	200	70	10	7	.30
4555	39.21	120.43	.55	.50.L	150	10.N	200.N	30	2	1.L	.20	100	30	50	20.N	5.N	10.N	30	5	50	3	.07
4556	39.21	120.43	.90	15	700	50	200.N	600	6	100	.50	200	50	200	20.N	5.N	10.N	20	5.N	10.N	5	.07
4557	39.40	120.51	1.35	.50.N	100	10.N	200.N	200	4	3	.40	70	2000.G	30	20.N	50	10.N	10.L	15	300	10	.10
4558	39.40	120.54	6.20	5	150	10.L	200	140	2	2	.20	20	2000	300	20.N	70	10.N	10.N	50	2000	20	.07
4651	38.47	118.46	7.90	70	1500	2000	1000	1700	1000.G	10	9	200	50	700	20.N	5.N	10.N	10.N	5.N	10.N	20	.07
4652a	38.47	118.46	8.50	500	500	20000.G	7000	200	240	2	15	500	100	5000.G	20.N	70	10.N	10.N	5.N	15	15	.15
4652b	38.47	118.46	.30	15	150	10000	2000	200	28	1.L	2.90	1000	100	500	20.N	5.N	10.N	10.L	5.N	10.N	10	.50
4652c	38.47	118.46	.05.N	10	50	1500	1500	140	14	1.L	1.40	1500	50	5000	20.N	5.L	10.N	10.N	5	30	10	.30
4653a	38.47	118.46	.45	30	300	20000	2000	1600	36	1.L	28	500	70	2000	20.L	10	10.N	10.N	5.N	10.L	15	.70
4653b	38.47	118.46	2.20	50	200	1500	2000	1400	58	1.L	7.60	150	10	5000.G	20.N	5.L	10.N	10.N	5.L	10.L	7	.03
4654a	38.46	118.45	.05	10	150	2000	1500	300	58	1.L	28	700	100	700	20.N	5.L	10.N	10.L	5.L	10.N	10	.15
4654b	38.46	118.45	.20	7	200	1000	2000	700	100	3	24	300	50	5000	20.L	5	10.N	10.N	5.L	10.L	15	.20
4655	38.46	118.45	.05.N	.50.N	5.L	50	200.L	10.L	2	1	.80	2000	70	70	20.N	5.N	10.N	10.N	5.N	10.N	.20	.07
4656	38.16	118.52	5.N	.50.N	30	20	200.N	10	2.L	1.L	.10.L	1000	10	500	20.N	15	10.N	10.N	5.N	10.L	2	.15
4657	38.64	118.53	.05.N	.50.N	500	15	200.N	50	8	1.L	.10.L	1500	50	70	20.N	5.N	10.N	10.N	5.L	10.L	15	.15
4658	38.62	118.50	.05.N	.50.N	5	30	200.N	10	2.L	1.L	.10.L	200	15	30	20.N	5.N	10.N	500	5.L	10.N	2	.50
4659	38.62	118.50	.05.N	.50.N	20	10.L	200.N	10.L	2.L	1.L	.10.L	500	300	20	20.N	5.N	10.N	150	5	10.N	10	.50
4660	38.62	118.50	.05.N	.50.N	5.L	30	200.N	10.L	2.L	6	.10.L	2000	200	10	20.N	5.L	10.N	1000	5.L	10.N	.50	.30
4661	38.62	118.50	.05.N	.50.L	1000	15	200.N	10	4	1.L	.10.L	1000	2000.G	200	20.N	5.N	10.N	150	500	200	20	.50
4662	38.62	118.50	.05.N	.50.N	70	20	200.N	10.L	2.L	1.L	.10.L	2000	700	100	20.N	5.N	10.N	300	7	10.N	7	.70
4663	38.62	118.50	.05.N	.50.N	50	30	200.N	10.L	2	8	.10.L	1000	2000	50	20.N	10	10.N	200	5.L	10.N	15	.70
4664	38.55	118.48	.05.N	.50.L	50	70	200.N	20	14	8	.10.L	700	100	10	20.L	7	10.N	70	5.N	10.N	.70	1
4665	38.55	118.48	.05.N	1	100	30	200.N	10.L	2.L	1.L	.10.L	1500	150	15	20	5.L	10.N	150	5.N	10.N	.50	.05
4666	38.62	118.51	.05.N	.70	500	10.N	200.N	30	6	2	.10.L	200	10.L	50	20	5.L	10.N	10.N	5.L	10	20	.05
4667	38.62	118.51	.05.N	1	50	10	200.N	20	2	4	.10	300	50	30	20.L	200	10.N	10.N	5.L	15	3	.20
4668	38.54	118.46	.05	30	1500	50	200.N	10	4	2	.30	5000.G	70	10	20.N	5.N	10.N	10.N	5.N	10.N	7	.70
4669	38.54	118.46	1.55	100	10000	15	200.N	10	2	160	.60	5000.G	15	1500	20.N	5.N	10.N	10.N	5.L	30	20	.15
4701	38.46	118.68	.05.N	100	500	1500	200.N	.05.N	150	1.N	5.10	5000.G	10.L	2000	20.N	5.N	10.N	10.N	5.L	10.N	3	.003
4702	38.46	118.68	.05	5000	5000	1500	500	80	1000.G	1.N	99	5000.G	50	300	20.N	100	10.N	10.N	5.N	10.N	1	.05
4744	38.59	118.21	1	500	10000	2000	7000	500	1000.G	1.N	100.G	200	30	3000	20.L	5	10.N	10.N	15	10.L	7	.15

Sample	Latitude	Longitude	AA-Au	S-Ag	S-Cu	S-Pb	S-Zn	AA-As	AA-Sb	AA-Bi	AA-Cd	S-Ba	S-B	S-Mn	S-W	S-Mo	S-Sn	S-Cr	S-Ni	S-Co	S-Fe%	S-Ti%
4745	38.59	118.23	.05	.50.L	15000	10	1500	40	2.N	1.N	1.10	200	70	2000	20.N	5.N	20	10.N	5.L	70	20	.01
4747	38.60	118.31	.05.N	10	15000	1500	7000	1100	10	1.L	52	100	50	1000	20.N	500	10.N	15	300	1000	20	.02
4748	38.60	118.31	.05.N	.50.N	100	500	5000	1000	44	1.L	16	5000.G	30	200	20.N	100	10.N	10.L	300	700	20.G	.05
4749	38.58	118.31	.05.N	.50.L	20	50	200.N	10.L	2.L	1.L	.10.L	150	30	700	20.N	5.N	10.N	15	5	10.L	2	.02
4801	39.46	120.57	4.20	.50.N	50	10.N	200.L	50	2.L	2	.20	20	2000.G	70	20.N	10	10.N	10.N	10	1000	20	.15
4802	39.46	120.57	100	50	15000	10.N	200.N	400	2.L	1.L	1	20.L	2000.G	50	200	15	10.N	10.N	7	500	7	.07
4803	39.34	120.54	2.30	7	500	10.N	200.N	20	2.L	2	.10	20.L	2000	20	50	5.L	10.N	30	5.L	10.N	10	.03
4804	39.34	120.54	2.80	.50	300	10.N	200	20	2.L	3	.10	20	2000.G	70	100	20	10.N	50	10	10.L	20	.20
4805	39.34	120.54	1.55	.50.N	200	10.L	200.N	10.L	2.L	1.L	.10	15	1000	300	20.N	5.N	10.N	10.N	5	15	7	.30
4806	39.34	120.54	.05	.50.N	50	10.L	200.N	10.L	2.L	1.L	.10	15	30	500	20.N	5.N	10.N	150	30	10	5	.30
4808	39.20	120.43	1.75	.50.N	500	20	300	300	2.L	6	2.40	150	70	700	20.N	5.N	10.N	100	10	50	20	.20
4809	39.20	120.49	6.60	2	150	150	200	2000.G	14	3	2.50	150	15	70	20.N	5.L	10.N	10.L	7	10.N	3	.10
4811	39.20	120.43	.05	.50.N	150	10.N	200.N	30	2.L	1.L	.10.L	50	10.L	70	20.N	5.N	10.N	10.N	5.N	10.N	.70	.01
4812	39.20	120.43	3.80	10	1000	10	200.N	180	2.L	1.L	2.20	200	1000	500	20.N	5.N	10.N	50	70	500	10	.15
4813	39.20	120.43	3.40	50	1500	200	200.N	200	2.L	86	1.60	200	2000	1000	20.N	5.N	10.N	10.N	5.L	15	7	.05
4814	39.46	120.57	.05	5	7000	10.N	200.N	10.L	2.L	1.L	1.40	70	10.L	50	20.N	1000	10.N	10.N	200	1500	20.G	.005
4815	39.18	119.67	.05	.50.N	200	10.N	200.N	400	30	1	.10.L	200	500	70	70	5.L	10.N	10.N	5.L	70	10	.005
4816	39.15	119.68	.05.N	.50.L	5000	10.L	200.N	70	6	1.L	.20	300	20	1500	20.N	10	10.N	10.N	20	10	5	.02
4817	39.14	119.68	.05.N	1	300	100	1000	20	2	1.L	1.50	50	10.L	10.L	20.N	5.N	10.N	10.N	5.L	10.L	20.G	.002
4819	38.47	118.47	.35	200	100	1500	3000	300	18	1.L	30	700	70	5000.G	20.L	15	10.N	15	5	50	10	.50
4820	38.49	118.45	.05.N	.50.N	5	10.N	200.N	100	10	1.L	.40	70	100	300	20.N	5.N	10.N	10.N	5.N	10.N	20.G	.01
4821	38.75	118.62	.25	700	1000	1000	200	200	1000.G	1	100.G	150	50	100	20.L	5.N	10.N	10.N	5.N	10.N	3	.05
4823	38.62	118.51	.05.N	.50.L	5.L	50	200.N	10.L	2.L	1.L	.10.L	700	30	15	20.N	5.N	10.N	500	5.N	10.N	.30	.20
4824	39.22	118.43	.75	100	10000	10.N	200.N	10	2.L	7	.50	1500	50	70	20.L	5.N	10.N	10.N	5.L	15	3	.30
4825	38.54	118.80	.10	.50.L	100	20	200.N	10.L	2.L	1.L	.10.L	700	20	70	20.N	5.L	10.N	10.N	5.N	10.N	1.50	.15
4826	38.42	118.47	.05.N	1500	1500	300	200.N	20	700	1.L	11	700	20	100	20.N	5.N	10.N	10.N	5.N	10.N	.50	.07
4827	38.46	118.70	1.35	2000	7000	20000.G	7000	.60.N	1100	19	40	500	30	30	20.N	5.L	10.N	10.N	5.L	10.L	1.50	.10
4828	38.46	118.68	.07.N	300	300	15000	200	7.20	190	.60.N	5.10	700	50	300	20.N	7	10.N	50	20	10	1	.70
4829	38.46	118.68	.05	1000	1500	20000.G	200	7.60	910	.60.N	24	5000.G	30	1500	20.N	5.N	10.N	30	7	10.N	2	.15
4830	38.46	118.68	.05	2000	3000	20000.G	700	9.70	1900	.60.N	31	5000.G	10.L	150	20.N	5.N	10.N	10.N	5.N	10.N	.20	.007
4831	38.46	118.68	.05.N	300	700	2000	200.L	3.20	120	1.10	3.40	5000.G	20	1500	20.N	5.L	10.N	10	5.L	10.L	3	.10
4832	38.46	118.68	4.60	700	1000	20000.G	500	24	580	.60.N	17	700	30	1500	20.N	20	10.N	15	10	10	3	.10
4833	38.47	118.67	.05.N	70	150	15000	200.N	.60.N	.60.N	.60.N	.70	700	10.L	150	20.N	70	10.N	10.L	5.L	10.N	.15	.002
4834	38.46	118.66	.40	50	70	20000.G	200.L	.60.N	.60.N	.60.N	.62	1000	50	1500	20.N	15	10.N	100	15	10	3	.30
4835	38.45	118.46	4.20	50	700	1500	1500	300	190	.60.N	36	1000	15	5000.G	30	5.L	10.N	10.L	5	10.N	3	.005
4836	38.45	118.46	.15	300	7000	10000	1500	130	590	.60.N	7.10	200	15	5000.G	20.N	5.L	10.N	10.L	5.L	10	3	.005
4837	38.45	118.47	.05.N	50	300	7000	500	300	170	50	5.60	700	10	5000.G	100	5	10.N	10.L	5.L	10.N	2	.003
4838	38.45	118.47	.10	100	3000	2000	700	250	470	6.40	21	70	15	500	20.N	5.N	10.N	10.L	5.N	10.N	1	.01
4839	38.45	118.47	.20	10	100	500	1500	6.80	.60.N	.60.N	7.30	70	10	1000	20.N	5.N	10.N	10.N	5.L	10.N	.20	.01
4840	38.45	118.47	.45	150	500	2000	500	140	150	36	7.20	50	15	300	20.L	5.N	10.N	10.L	5.L	10.N	1	.01
4841	38.45	118.47	.15	150	500	5000	300	52	180	120	5.20	100	20	1500	20.N	5.N	10.N	10.L	5.N	10.N	1.50	.01
4842	38.46	118.47	.10	7	20	700	300	22	12	20	.79	70	10.L	500	20.N	5.N	10.N	10.L	5.N	10.N	.30	.005
4843	38.47	118.46	.20	70	30	20000	2000	530	.60.N	.60.N	51	200	15	5000.G	20.N	20	10.N	10	5.L	10.N	2	.03
4844	39.11	119.67	1.55	10	20000	100	200.N	.60.N	21	140	1.50	700	10	700	30	10	10.N	10.L	5.L	15	3	.30
4845	39.11	119.67	2.20	50	15000	50	500	6.90	12	42	2.20	20.N	10.N	1500	20.N	15	15	10.L	5.L	10.N	20	.01
4847	39.12	119.67	.50	7	3000	100	200.N	16	6.90	6.40	1.80	1500	10.N	5000.G	20.N	15	10.N	50	50	30	15	.15
4848	39.12	119.67	3.90	7	2000	20	200.N	78	7.10	.60.N	.03.N	500	20	1500	20.N	5.N	10.N	10.L	5.L	10	5	.005
4849	39.12	119.67	.80	3	20000.G	15	200.N	.60.N	13	30	1.30	500	30	5000.G	20.N	5.N	10.N	10	10	10	3	.03
4850	39.54	120.02	.05	.50.N	150	10.L	10000	16	.60.N	64	340	20.N	30	5000.G	20.N	5.N	30	30	15	50	3	.15
4853	38.59	118.37	.05	15	100	50	2000	2000.G	140	1.L	24	700	200	5000.G	20.N	150	10.N	10	50	500	20	.30
4856	38.56	118.39	.50	.50	2000	10.L	200.N	10.L	2.L	1.L	.10.L	5000.G	20	300	20.N	5.N	10.N	10.N	5.N	10	1.50	.10
4857	38.56	118.39	.35	5	3000	10	200.N	10	2.L	1.L	.10.L	3000	20	200	20.N	5.N	10.N	10.N	5.N	10	3	.30
4858	38.56	118.40	.05.L	.50.L	5000	10	200.N	10.L	2.L	1.L	.10.L	5000	15	500	20.N	5.N	10.N	10.N	5.L	20	5	.50
4859	38.57	118.42	.10	1	10000	10.L	200.N	200	22	16	.10.L	5000.G	70	700	20.N	5.N	10.N	10.N	5.N	10.L	3	.20
4861	39.04	118.98	.05	1	100	10.L	200.N	2000.G	58	4	.10.L	200	50	70	20.N	50	10.N	10.N	7	20	10	.03
4862	39.05	118.98	.05	.50.N	150	10.L	200.N	700	32	2	.10.L	1000	15	50	20.N	5.N	10.N	10.N	5.L	10.L	15	.02
4863	38.77	118.60	.05	30	5000	20000.G	5000	100	26	4	1000.G	1000	15	1000	20.N	5.N	10.N	10.N	5.L	10.L	2	.05
4864	38.62	118.51	.05	.70	150	10	200.N	300	20	1	.10.L	700	20	500	70	5	10.N	100	5.L	10.N	5	.20
4865	38.62	118.51	.05	.50.L	200	20	200.N	10.L	2.L	2	.10.L	100	10.N	100	20.N	10	10.N	10.N	5.L	15	20	.05
4868	38.62	118.51	.05	.50.N	500	30	200.N	10	2.L	1.L	.10.L	100	30	10.L	30	5.N	10.N	300	5.N	10.N	.10	.50
4871	38.54	118.42	.10	.50.N	3000	10	200.N	30	2.L	7	.10.L	5000.G	15	70	20.N	5.N	10.N	10.N	5.N	10.N	.50	.03
4872	38.62	118.51	.05	.50	15	100	200.N	20	2.L	1.L	.10.L	1000	20	10.L	20.N	5.N	10.N	500	5.N	10.N	.05	.15
4874	38.62	118.51	.45	2	20	10.N	200.N	100	2.L	1	.10.L	300	100	10	20.N	5.L	10.N	70	5.N	10.N	1	.50

Sample	Latitude	Longitude	AA-Au	S-Ag	S-Cu	S-Pb	S-Zn	AA-As	AA-Sb	AA-Bi	AA-Cd	S-Ba	S-B	S-Mn	S-W	S-Mo	S-Sn	S-Cr	S-Ni	S-Co	S-Fe%	S-Ti%
4876	38.62	118.51	.05.N	.50.N	20	150	200.N	20	2.L	4	.10.L	1500	2000	70	20.N	5.N	10.N	300	5.N	10.N	1.50	.30
4879	38.65	118.50	.15	1.50	1000	7000	200.N	20	2.L	84	.10.L	300	15	1000	20.N	1500	10.N	10.N	5.L	20	3	.15
4881	38.65	118.50	.05.N	.50.N	500	50	200.N	10	2.L	1.L	.10.L	300	20	70	20.N	20	10.N	10.N	5.N	10.N	5	.15
4882	38.45	118.47	.05.N	1.50	50	100	200	200	56	1.L	1.90	30	15	150	20.L	5.N	10.N	10.N	5.N	10.N	2	.002
4883	38.45	118.47	.10	7	70	500	200.N	850	18	1.L	1.80	500	100	50	20.N	5.N	10.N	10.N	5.N	10.N	1	.07
4884	38.45	118.47	.15	100	300	10000	2000	60	36	11	9.70	50	10.L	200	20.N	5.N	10.N	10.N	5.N	10.N	.15	.02
4885	38.45	118.47	.15	100	1500	1000	500	200	1000.G	56	15	50	10.L	100	20.N	5.N	10.N	10.N	5.N	10.N	.50	.002
4886	38.48	118.45	.75	10	150	100	1500	700	66	10	2	700	30	5000.G	20.N	5.N	10.N	15	5	10.N	20	.01
4887	38.54	118.44	.15	20	5000	20	200.N	10	6	160	.30	5000.G	15	1000	20.N	5.N	10.N	10.N	5	100	20	.10
4888	38.54	118.43	.05.N	15	70	5000	10000	20	18	2	10	5000.G	10.L	30	20.N	7	10.N	10.N	5.N	10.N	.70	.02
4901	38.93	119.60	.05.L	.50.N	30	20	200.N	6.70	.66	.60.N	.58	700	10.N	5000	20.N	5.N	10.N	10.N	5.L	15	5	.15
4902	38.93	119.61	.05	.50.N	50	30	200.L	200	13	4.30	.68	100	10.N	200	30	5.N	10.N	10.N	5.N	10.N	20	.02
4903	38.88	119.58	.05.N	2	30	10	700	4.20	8.50	3.90	32	500	10	2000	1000	10	10.N	10.L	5.L	10.N	2	.07
4904	38.87	119.58	.05.N	.50	100	10.N	200.N	40	5.40	1.80	.55	50	10	700	50	500	10.N	10.L	5.L	10.N	2	.005
4905	38.88	119.58	.05.N	.50.N	20	70	200.N	3	.62	28	1.80	100	10.N	3000	200	50	20	10.L	5.L	10.L	3	.15
4906	38.88	119.58	.05.N	.50.N	5	10.L	200.L	.60.N	.60.N	.60.N	.61	150	10.N	5000	20.N	200	30	10.L	5.L	10.L	3	.15
4907	38.87	119.58	.05.N	.50.N	20	10.L	300	2.10	.60.N	.60.N	5.10	20	10.N	5000	20.N	7	15	15	15	10	5	.20
4908	38.87	119.58	.05.N	2	70	20	200.N	22	86	.94	.14	700	10	300	20.N	200	10.N	10.N	5.L	10.L	2	.15
4909	38.88	119.58	.05.N	1	30	30	200.N	3.60	7.50	1.60	.19	700	10.L	30	20.N	300	10.N	10.N	5.L	10.N	1	.10
4910	38.88	119.60	.05.N	20	15	1500	200.N	27	1.30	310	1.50	100	10.N	1500	20.N	200	10.N	15	5	10	5	.15
4911	38.88	119.60	.05.N	.50.N	5.N	30	200.L	.60.N	.60.N	1.20	.44	20.N	10.N	2000	20.N	5.N	10.N	10.L	5.L	10.N	1.50	.002
4912	38.89	119.59	.05.N	20	5.N	15	200.N	3.40	.60.N	.84	.09	20.N	10.N	1500	20.N	5.N	10.N	10.N	5.L	10.N	.70	.007
4913	38.89	119.59	.05.N	5	5.L	150	200.L	1.10	.60.N	15	3.10	50	10.N	2000	20.N	20	10.N	10.L	5.N	10.N	2	.05
4914	38.88	119.59	.05.N	.70	20	30	200.N	5	6	2.50	3.40	2000	15	700	20.N	15	10.L	10.N	5.N	10.L	2	.20
4915	38.88	119.59	.05.N	.50.N	15	50	500	1.80	6.40	51	25	30	10.N	5000.G	1000	30	70	10.L	5.L	10.N	3	.10
4916	39.07	119.33	.05.N	.50.N	500	10	200.N	2.10	1.60	2.10	.17	20.N	10.N	300	20.N	5.N	10.N	10.L	20	100	20	.01
4917	39.07	119.33	.05.N	.50.N	1000	10	200.N	.60.N	2.30	4.30	.25	50	10	200	20.N	5.N	10.N	15	30	150	20.G	.01
4918	39.07	119.33	.05.L	7	7000	30	700	39.N	200.N	200.N	10.N	5000.G	10.N	1500	20.N	2000	10.N	10.L	5.L	50	2	.05
4920	38.99	119.35	6.90	30	20000	30	300	120.N	200.N	200.N	16	500	10.N	1000	20.N	5.N	10.N	10	30	30	10	.30
4921	38.99	119.35	35	30	20000.G	30	500	200.N	200.N	200.N	10.N	20.N	10.N	700	20.N	5.N	10.N	10.L	30	30	15	.007
4922	39.05	119.24	.05.N	.50.N	7000	10.L	200.N	39.N	200.N	200.N	2.N	300	10	200	20.N	5.N	10.N	10.L	7	10	2	.50
4923	38.96	119.23	.05.N	50	20000.G	15	200.L	200.N	200.N	200.N	10.N	20.N	10.N	300	20.N	5.N	10.N	10.N	30	30	15	.05
4924	38.95	119.22	.05.N	7	7000	10	200.N	200.N	200.N	200.N	10.N	20.N	10.N	150	20.N	20	10.N	10.L	150	200	15	.01
4925	38.95	119.22	.05.N	5	20000.G	10.L	200.N	200.N	200.N	200.N	10.N	20.N	20	1500	20.N	5.N	10.N	10.N	100	500	5	.007
4926	38.94	119.23	.05.N	.70	20000	10.L	200.N	120.N	200.N	200.N	5.90.N	20.N	10.N	1000	20.N	5.N	10.N	10.L	100	300	7	.03
4927	38.94	119.04	.05.N	.50.N	500	15	200.N	4.30	.72	1.40	.04	20.N	10.N	500	20.N	50	10.N	500	50	50	7	.30
4928	38.94	119.04	.05.N	.50.N	700	15	200.N	3.50	1.90	3	.10	20.N	10.N	200	20.N	5.N	10.N	70	30	30	20	.07
4929	38.94	119.04	.05.L	.50.N	1000	15	200.N	62	1.90	5	.13	20.N	10.N	200	20.N	5.N	10.N	200	100	300	20	.07
4930	38.94	119.04	.05	.50.N	1000	15	200.N	220	100.N	100.N	2	20.N	10.N	200	20.N	5.N	10.N	100	100	100	20	.07
4932	38.94	119.04	.05.N	.50.N	1000	10	200.N	20	2.30	4.70	.15	20.N	10.N	200	20.N	5.N	10.N	100	150	200	20.G	.05
4933	38.94	119.04	.10	5	7000	10	200.N	78	200.N	200.N	4.10	20.N	10.N	300	20.N	5.N	10.N	10	70	30	15	.03
4934	39.37	119.45	.05.N	.50.N	30	10	200.N	.60.N	.63	1.10	.10	200	10.N	150	20.N	5.N	10.N	20	20	70	20.G	.05
4935	39.37	119.45	.05.N	.50.N	30	15	200.N	1.60	.64	.86	.30	20.N	10.N	500	20.N	5.N	10.N	10.L	30	50	15	.02
4936	39.35	119.49	.05.N	.50.N	15	15	200.N	.60.N	.60.N	.60.N	.05	200	10.N	500	20.N	5.N	10.N	70	70	30	10	.20
4937	39.10	119.66	.05.N	.50.N	30	15	200.N	.60.N	2.10	3	.42	20.N	10.N	300	70	5.N	10.N	10.N	5.N	10.L	20.G	.002
4938	39.09	119.65	.05.N	.50.N	100	30	200.N	.60.N	.72	.60.N	.38	20.N	10.N	5000	20.N	5.N	50	10.L	10	10.N	7	.07
4939	39.08	119.65	.05.N	.50.N	7	15	200.N	.60.N	.60.N	.60.N	.75	20.N	10.N	5000	20.L	100	30	10.L	5	10.L	10	.20
4940	39.08	119.65	.05.N	.50.N	7	20	200.N	.60.N	.60.N	.60.N	.35	150	10.L	700	20.N	5.N	10.N	10.L	5.L	10.N	.70	.20
4945	38.37	118.62	.05.N	.70	50	10.N	200.N	10	2.L	1.L	.10	1000	70	10	20.N	5.N	10.N	30	5.N	10.N	.70	.15

Appendix 3.--Rock Sample Descriptions

Sample descriptions for rock samples collected during this study and for which analytical data is presented in appendix 2. Site and mining district names can be found in appendix 1.

4501 -- Flying Dutchman prospect; Stateline Peak mining district; meta-andesite with spotty quartz-tourmaline veins containing chlorite, Fe and Cu oxides, pyrite, chalcopyrite, and chalcocite(?); selected sample from prospect pit.

4502 -- Flying Dutchman mine, Stateline Peak mining district; quartz-tourmaline vein material with pyrite and local molybdenite; dump sample.

4503 -- same as 4502.

4504 -- same as 4502.

4505 -- prospect, Peavine mining district; quartz vein with piemontite; selected sample.

4506 -- prospect, Peavine mining district; quartz-tourmaline vein material with Fe and Cu oxides and sparse pyrite and chalcopyrite(?); dump sample.

4507 -- Antelope mine, Stateline Peak mining district; quartz-tourmaline vein material with Fe and Cu-oxides, and epidote; selected sample.

4508 -- same as 4507.

4510 -- prospect, Peavine mining district; banded quartz-tourmaline vein material with minor Cu and Fe oxides; dump sample.

4511 -- Beacon Point prospect, Peavine mining district; banded quartz-tourmaline-limonite vein material; composite selected sample from prospect pits.

4512 -- prospect, Peavine mining district; meta-andesite with garnet and Cu oxides; selected sample.

4513 -- prospect, Peavine mining district; pyritic quartz-rich rock; dump sample.

4514 -- prospect, Peavine mining district; quartz-tourmaline-magnetite-hematite rock; dump sample.

4515 -- prospect, Peavine mining district; quartz-tourmaline vein material with sparse magnetite, chrysocolla, limonite, and malachite; dump sample.

4516 -- mine, Peavine mining district; garnet-bearing metarhyolite; dump sample.

4517 -- prospect, Peavine mining district; mineralized metarhyolite with limonite, Cu oxides, epidote-garnet skarn; dump sample.

4518 -- prospect, Peavine mining district; pyritized rhyolite; selected sample from prospect pit

4519 -- mine, Peavine mining district; quartz-tourmaline vein material with epidote and limonite; dump sample.

4520 -- Black Star mine, Peavine mining district; quartz-tourmaline vein with Cu oxides; selected sample.

4521 -- mine, Peavine mining district; quartz-tourmaline material with Cu oxides, calc-silicates, and minor bornite; dump sample.

4524 -- Guy Walt's Zinc property, Peavine mining district; sphalerite-bearing foliated siliceous rock; composite selected sample from outcrop.

4525 -- Rocky Hill mine, Galena mining district; quartz-tourmaline vein material with arsenopyrite; dump sample.

4526 -- prospect, Jumbo mining district; limonite gossan and quartz-tourmaline vein material; composite dump and outcrop sample.

4527 -- prospect, Carson City mining district; tourmaline-breccia material with sparse limonite and pyrite; dump sample.

4528 -- prospect, Carson City mining district; calcite-tourmaline vein material with local limonite; selected sample from surface outcrop.

4529 -- outcrop, Carson City mining district; tourmaline-calcite-limonite vein and altered wallrock; composite selected sample from road cut.

4530 -- prospect, Delaware mining district; magnetite vein with minor pyrite; selected sample from trench.

4531 -- Utopian mine, Delaware mining district; quartz-tourmaline vein material with pyrite; selected sample from outcropping vein.

4532 -- prospect, Peavine mining district; quartz vein material and tourmaline-magnetite rock; composite dump sample.

4533 -- prospect, Pyramid mining district; quartz vein with limonite and sparse malachite; dump sample.

4550 -- Signal Peak, Meadow Lake mining district; quartz-tourmaline-pyrite vein material; dump sample.

4551 -- Red Mountain mine, Meadow Lake mining district; quartz-tourmaline-pyrite vein material; dump sample.

4553 -- Tony Moly #2 mine, English Mountain, Meadow Lake mining district; quartz-magnetite-pyrrhotite-pyrite vein material with massive sulfide; dump sample.

4554 -- Molly mine, English Mountain, Meadow Lake mining district; hornfelsed metasediments with stockwork veinlets containing garnet, epidote, pyrite, molybdenite, bornite, magnetite, and chalcopyrite(?); also disseminated in wallrock; dump sample.

4555 -- Lost Emigrant mine #1 (south), Tahoe mining district; milky-white quartz vein with minor pyrite and carbonate; dump sample.

4556 -- Lost Emigrant mine #1 (north); milky-white quartz vein with minor pyrite; dump sample.
4557 -- Excelsior mine #1, Meadow Lake mining district; quartz-tourmaline-pyrite vein material; selected sample.
4558 -- Excelsior mine #2, Meadow Lake mining district; quartz-tourmaline-pyrite vein material; dump sample.
4651 -- Central mine area, Pamlico mining district; brecciated quartz vein with boxwork limonite material; selected sample.
4652a -- Central mine area; argillized/silicified fault breccia; selected sample from shear zone.
4652b -- Central mine area; argillized gouge; selected sample.
4652c -- Central mine area; fractured and Fe-stained feldspar porphyry with quartz stringers; selected sample.
4653a -- Central mine area; argillized wallrock with hairline quartz stringers; selected sample from adjacent to shear zone.
4653b -- Central mine area; brecciated quartz vein material with abundant Fe oxides; selected sample.
4654a -- Main Pamlico mines area, Pamlico mining district; argillized intrusive(?) rock with hairline quartz veinlets containing Fe oxides; selected sample.
4654b -- Main Pamlico mines; brecciated quartz vein with Fe oxides; selected sample.
4655 -- Main Pamlico mines; silicified rhyolite porphyry; selcted sample.
4656 -- Ryan Canyon, Fitting Mining district; silicified and pyritized feldspar porphyry; selected sample collected from Ryan Canyon road.
4657 -- Ryan Canyon, Fitting mining district; heavily Fe-stained silicified feldspar porphyry intrusion; selected sample from Ryan Canyon road.
4658 -- Dover mine, Fitting mining district; sericitic metarhyolite(?) with specular hematite; selected sample.
4659 -- Green Talc mine, Fitting mining district; quartz-sericite schist with stringers and blebs of magnetite; selected sample.
4660 -- Green Talc mine; quartz-sericite schist with aluminosilicates and talc(?); selected sample.
4661 -- Green Talc mine; meta-andesite with clotty biotite masses, and interstitial magnetite and pyrite/pyrrhotite; selected sample.
4662 -- Green Talc mine; bleached quartz-sericite schist; selected sample.
4663 -- Green Talc mine; pyritized and bleached quartz-sericite schist; selected sample.
4664 -- Deep prospects, Fitting mining district; limonitic and sericitic felsic metavolcanic rock; selected sample.
4665 -- Deep prospects; metarhyolite altered to quartz-sericite and talc(?) with disseminated pyrite; selected sample.
4666 -- Dover mine area, Fitting mining district; quartz-sericite altered rock (metarhyolite?) with massive vein-like replacement by hematite and magnetite; composite selected sample.
4667 -- Dover mine area; same as 4666
4668 -- mine, Fitting mining district; andesite with Cu-stained fractures; composite selected sample.
4669 -- prospect, Fitting mining district; brecciated meta-andesite with malachite, chrysocolla, magnetite, and limonite; composite selected sample.
4701 -- Lucky Boy mining district; barite vein with pyrite, spalerite, galena, tetrahedrite(?), and bornite(?); dump sample.
4702 -- Lucky Boy mining district; quartz vein with malachite and azurite; dump sample.
4744 -- Blue Star mine, Santa Fe/Fitting mining district; mineralizd rock with tetrahedrite(?), and Fe, Mn, and Cu oxides; dump sample.
4745 -- Broken Bow mine, Santa Fe/Fitting mining district; mineralized limestone with malachite, chrysolcolla, magnetite, and limonite; dump sample.
4747 -- Col claims, Fitting mining district; jasperoid with limonite, malachite, chrysocolla, and yellow antimony oxide (?); dump sample.
4748 -- Col claims; jasperoid and gossan with limonite; dump sample.
4749 -- H.C. claims, Fitting mining district; aplite-like rock (pegmatitic) with tremolite and green amphibole(?); selected sample.
4801 -- north side of English Mountain, Meadow Lake mining district; massive magnetite with disseminated pyrite, tremolite-actinolite, and black tourmaline; dump sample.
4802 -- north side of English Mountain; pyrite-rich quartz-tourmaline vein; dump sample.
4803 -- Signal Peak, Meadow Lake mining district; vuggy smoky gray quartz material with abundant Fe-oxide and disseminated pyrite cubes; from wall of prospect pit.
4804 -- Signal Peak; massive to vuggy gray-black magnetite with minor stringers and patches of pyrite; from wall of prospect pit.
4805 -- Signal Peak; silicified fine-grained diorite; from wall of prospect pit.

4806 -- Signal Peak; unaltered fine-grained diorite; from wall of prospect pit.
4808 -- Lost Emigrant mine #7, Tahoe mining district; limonitic metasediment with disseminated pyrite; composite dump sample.
4809 -- La Trinadad mine, Tahoe mining district; milky-white quartz with bands and aggregates of arsenopyrite, graphite, and carbonate; composite dump sample.
4811 -- Lost Emigrant mine #3, Tahoe mining district; milky-white to bull quartz with bands and patches of dark green chlorite and chalcopyrite and disseminated pyrite; dump sample.
4812 -- Lost Emigrant mine #1 (south); pyritic quartz vein material; composite dump sample.
4813 -- Lost Emigrant mine #1 (north); gossanous malachite-bearing quartz vein; selected sample from adit.
4814 -- Tony Moly mine #2, English Mountain, Meadow Lake mining district; vein material consisting of massive pyrite-pyrrhotite-chalcopyrite-magnetite and calc-silicates; dump sample.
4815 -- unworked quartz vein, Delaware mining district; vuggy Fe-stained and locally brecciated quartz vein with chalcedonic quartz rimming vugs; composite selected sample.
4816 -- prospect, Delaware mining district; vein material, locally brecciated, consisting of quartz and red-brown powdery ferruginous material with unidentified dark green mineral; composite dump sample.
4817 -- prospect, Delaware mining district; gossanous quartz vein material with dark-brown to yellow-orange Fe oxides and white sulfate; from wall of shaft.
4819 -- shafts south of Sunset mine, Pamlico mining district; massive black Mn-oxide that has replaced argillized wallrock adjacent to vein/stope; composite selected sample.
4820 -- La Panta mine, Pamlico mining district; geothite gossan; from wall of northern pit.
4821 -- Sun claims, Fitting mining district; fault gouge and breccia with abundant Fe oxide; selected sample.
4823 -- Slightly west of Green Talc mine, Fitting mining district; material containing green talc, gray hard siliceous material (andalusite?), and sericite; composite selected sample from prospect pit.
4824 -- Chicago mine, Tahoe mining district; malachite-stained metasediment; composite dump sample.
4825 -- West section 18 prospect, Mt. Grant mining district; quartz vein; selected sample.
4826 -- Lucky Boy mining district; quartz vein; dump sample from western area.
4827 -- Lucky Boy mining district (SW corner, section 13); silicified gouge, vuggy, containing abundant galena, malachite, and Fe oxide; composite dump sample.
4828 -- Lucky Boy mining district, (SW section 18); silicified gouge containing patches and veinlets of galena; composite dump sample.
4829 -- Lucky Boy mining district; quartz vein material containing galena, ankerite, pyrite, barite, and tetrahedrite; composite dump sample.
4830 -- Lucky Boy mining district; barite vein with seams and patches of galena, tetrahedrite, and pyrite; composite dump sample.
4831 -- Lucky Boy mining district; quartz vein material with galena, ankerite(?), pyrite, and tetrahedrite rimmed by azurite; composite dump sample.
4832 -- Lucky Boy mining district; quartz vein material with yellow-orange limonite, galena, tetrahedrite, and Cu oxides; composite dump sample.
4833 -- Lucky Boy mining district; quartz vein material with drusy quartz and patches of galena; composite dump sample.
4834 -- Old Lucky Boy mine at base of Lucky Boy pass; argillite with stockwork veining; veins contain milky white quartz, orange Fe carbonate, patches of galena and disseminated pyrite; composite dump sample.
4835 -- Gold Bar mine, Pamlico mining district; quartz vein material with fine-grained disseminated galena, abundant Mn-oxide, and metallic silver-gray sulfosalts(?); composite dump sample.
4836 -- Pamlico mining district; Fe-oxide-stained quartz vein material with minor galena, tetrahedrite(?) altered to malachite, and pyrite; composite dump sample.
4837 -- Pamlico mining district; quartz vein breccia with Mn-oxide and hematite filling interclast areas and minor galena; composite dump sample.
4838 -- Good Hope mine, Pamlico mining district; quartz vein material with minor galena, pyrite, and Cu-oxides; composite dump sample.
4839 -- Pamlico mining district; vuggy brecciated quartz vein material with patches of galena and Fe- and Mn-oxides filing interclast areas; composite dump sample.
4840 -- Pamlico mining district; quartz vein material with minor galena, pyrite, and Cu- and Fe-oxides; composite dump sample.
4841 -- same as 4840.
4842 -- Pamlico mining district; vuggy milky-white quartz vein material with sparse galena and pyrite; composite

dump sample.
4843 -- Pamlico mining district; vuggy brecciated quartz vein material with interclast fillings of Mn and Fe oxides, and coarse-grained patches of galena; composite dump sample.
4844 -- Valley View mine, Delaware mining district; gossanous, garnetiferous, Cu-stained skarn with epidote and diopside; composite dump sample.
4845 -- Valley View mine; siliceous material with pervasive malachite throughout, Fe oxide, and euhedral garnet; composite dump sample.
4847 -- Bunker Hill mine, Delaware mining district; Fe-oxide "sand" from hanging wall of vein exposed in pit wall; composite sample from wall of pit.
4848 -- Bunker Hill mine; siliceous gouge with abundant Fe oxide, and no Cu staining; composite dump sample.
4849 -- Bunker Hill mine; vuggy Cu-stained siliceous gouge with colloform malachite in vugs; composite dump sample.
4850 -- Guy Walt's zinc property; sphalerite-bearing siliceous material (altered limestone or rhyolite?); sample from wall of prospect pit.
4853 -- BB claims, Fitting mining district; limonite-bearing sheared andesite; selected sample.
4856 -- prospect, Fitting mining district; quartz-barite vein; dump sample.
4857 -- prospect, Fitting mining district; mineralized andesite with chrysocolla, malachite, and tenorite or melaconite(?); dump sample.
4858 -- prospect, Fitting mining district; silicified andesite with secondary Cu mineral; dump sample.
4859 -- Red Hill claims, Fitting mining district; mineralized andesite with limonite and secondary Cu mineral; dump sample.
4861 -- prospect, Mountain View mining district; quartz vein with Fe oxides; dump sample.
4862 -- prospect, Mountain View mining district; quartz vein and gossan; dump sample.
4863 -- prospect, Gillis Range; quartz vein with Fe oxides and secondary Cu minerals; dump sample.
4864 -- Dover mine, Fitting mining district; gossan; dump sample.
4865 -- prospect, Fitting mining district; hematite-bearing quartz-sericite schist; selected sample.
4868 -- Dover mine, Fitting mining district; andalusite(?)- and sericite-bearing rock; dump sample.
4871 -- Crystal mine/Lewis barite mine, Hawthorne mining district; barite vein with secondary Cu minerals; dump sample.
4872 -- Green Talc mine, Fitting mining district; andalusite(?)-bearing rock; dump sample.
4874 -- Green Talc mine; silicified wallrock with pyrite; selected sample.
4876 -- Green Talc mine; tourmalinized rock with pale-green sericite (or talc?); selected sample.
4879 -- Shaft claims, Fitting mining district; mineralized rock with Fe, Mn, and As(?) oxides; dump sample.
4881 -- Shaft claims; Fe-oxide stained mineralized shear; selected sample.
4882 -- Pamlico claim, Pamlico mining district; quartz vein with Fe-oxides; dump sample.
4883 -- Gold Bar claim, Pamlico mining district; quartz vein with Fe and As(?) bloom; dump sample.
4884 -- mine, Pamlico mining district; quartz vein with galena and tetrahedrite; dump sample.
4885 -- Early Dawn claim, Pamlico mining district; quartz vein with pyrite, tetrahedrite, galena, and chalcopyrite; dump sample.
4886 -- La Panta mine, Pamlico mining district; gossanous mineralized fault zone; selected sample.
4887 -- Gary claims, Hawthorne mining district; mineralized volcanic rock with magnetite and secondary Cu minerals; dump sample.
4888 -- Gary claims; barite vein with galena; dump sample.
4901 -- Gardnerville mining district, north end; quartz vein material with smoky-gray to milky-white quartz, dark-green chlorite, orange-brown to dark-brown Fe carbonate and orange-yellow limonitic material; composite dump sample.
4902 -- Gardnerville mining district, north end; botryoidal and laminated geothite-limonite gossan; composite dump sample.
4903 -- Cherokee mine, Gardnerville mining district; quartz vein material with smoky-gray quartz, Mn and Fe oxides, pale-orange-brown garnet, and minor disseminated grains of scheelite (observed under UV lamp); from north wall of pit.
4904 -- Alpine mine pit, Gardnerville mining district; smoky-gray quartz vein material with pyrite, Mn and Fe oxides and minor scheelite (observed under UV lamp); from west wall of pit.
4905 -- Alpine mine pit; vuggy skarn with diopside, garnet, epidote, minor sheelite (observed under UV lamp) and pervasive Fe-oxide staining; composite sample from floor of pit.
4906 -- Alpine mine pit; skarn with abundant dark-brown garnet, molybdenite(?), and very minor scheelite

(observed under UV lamp); selected sample from north end of pit.

4907 -- Alpine mine adit; garnetiferous pink-orange-brown skarn with pervasive Mn- and Fe-oxide staining and minor scheelite (observed under UV lamp); from pillar in lower workings.

4908 -- east of Alpine mine adit; bleached quartz-sericite-pyrite altered quartz monzonite porphyry with stockwork veins of smoky-gray quartz, white potassium feldspar and pyrite; composite sample from area of abundant float over poorly exposed stock.

4909 -- south of Cherokee mine; quartz monzonite porphyry with quartz-potassium feldspar stockwork veins; composite sample from area of abundant float over poorly exposed stock.

4910 -- Divide mine area, Gardnerville mining district; skarn with patches of dark-gray calcite and spots of Fe oxide throughout; from pit wall at south end of property.

4911 -- Divide mine area; pyroxene-wollastonite-calcite skarn with minor scheelite and powellite(?) (observed under UV lamp); composite dump sample.

4912 -- Divide mine area; wollastonite-pyroxene-calcite skarn with patches of yellow-orange Fe carbonate and minor scheelite (observed under UV lamp); composite selected sample from portal.

4913 -- Divide mine area; same as 4911 and 4912 with more dark-gray to black calcite; composite sample from floor of trench.

4914 -- west of Cherokee mine; quartz-sericite-pyrite altered quartz monzonite porphyry with stockwork veining; composite selected sample from area of poorly exposed stock.

4915 -- mine west of Cherokee mine; skarn with calcite, garnet, wollastonite/tremolite(?), Fe oxide pseudomorphs after pyrite, and minor scheelite (observed under UV lamp); sample from portal wall.

4916 -- Minnesota mine, northern Buckskin Range; massive fine-grained magnetite skarn ore with bands of pyrite and tremolite; selected sample from south end of pit.

4917 -- Minnesota mine; same as 4916 but from bottom of pit.

4918 -- Minnesota mine; quartz-molybdenite(?)-pyrite-malachite vein material; composite selected sample from west side of pit.

4920 -- Buckskin mine, southern Buckskin Range; green chloritized rock with abundant pyrite and chalcopyrite; selected sample.

4921 -- Buckskin mine; dark-blue ore with abundant pyrite and chalcopyrite and bornite(?); selected sample.

4922 -- MacArthur property, Yerington mining district; pervasively Cu-stained quartz monzonite; sample from trench wall.

4923 -- Bluestone mine, Yerington mining district; gossanous material with malachite; from high up northwall of pit.

4924 -- Mason Valley mine, Yerington mining district; gossanous material with some remnant pyrite; composite sample from south wall of pit.

4925 -- Mason Valley mine; coarse-grained malachite-stained actinolite skarn; composite sample from south wall of pit

4926 -- McConnell mine, Yerington mining district; malachite-stained actinolite-garnet-epidote skarn with minor pyrite; composite selected sample from north end of pit.

4927 -- Pumpkin Hollow, east orebody, Yerington mining district; skarn with epidote, calcite, pyrite and magnetite; core sample.

4928 -- Pumpkin Hollow, east orebody; black magnetite ore with bands and veinlets of sulfide minerals and pyroxene; core sample.

4929 -- Pumpkin Hollow, east orebody; same as 4828 with more sulfide minerals and calc-silicates; core sample.

4930 -- Pumpkin Hollow, east orebody; magnetite ore with abundant disseminated and veined pyrite, pyroxene, and calcite; core sample.

4932 -- same as 4930

4933 -- Pumpkin Hollow, east orebody; magnetite ore with calcite veins; core sample.

4934 -- Dayton deposit, Red Mountain mining district; massive magnetite ore; composite sample from wall of prospect pit.

4935 -- Dayton deposit; sulfide- (pyrite-pyrrhotite) bearing magnetite ore; composite dump sample.

4936 -- Iron Blossom prospects, Red Mountain mining district; magnetite endoskarn in granodiorite; composite sample from wall of trench.

4937 -- Alex Eske property, Delaware mining district; massive magnetite skarn ore; composite sample of seam in wall of trench.

4938 -- Alex Eske property; epidote-garnet-calcite skarn with minor Fe oxide; composite sample from wall of trench.

4939 -- War Bond mine, Delaware mining district; garnet-epidote-calcite skarn; composite sample from wall of pit.

4940 -- War Bond mine; endoskarn; selected sample from west of 4939.

4945 -- Mt. Grant mining district; quartz vein; selected sample.