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A Report on Work in Progress for the Reno 1° x 2° CUSMAP Project, Nevada, with additional bibliography

by

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INTRODUCTION

The Reno CUSMAP project is in its second year of a four-year program. Geologic mapping, geochemical sampling and analytical processing, geophysical data compilation, reduction, and interpretation, and other studies are currently underway. Several of these are topics of interest to both those in research and exploration. The purpose of this report is to keep the public informed of these activities and whom to contact for additional information. It also provides updated information to Sidder (1986) on deposit types and mining districts in the Reno quadrangle and additional pertinent references.

GEOLOGIC MAPPING

About eight 15' quadrangles are being remapped by a team of six geologists. Jack Stewart (Western Mineral Resources, Menlo Park), the project coordinator, is mapping the Wabuska and Silver Springs quadrangles. Jack finished his mapping of Tertiary tuff units in the Wabuska quadrangle during 1986. During the 1987 field season, Jack tried to correlate the stratigraphy of Tertiary sedimentary and volcanic rocks in the Silver Springs quadrangle with the type section at Red Mountain, and those for the Truckee and Desert Peak Formations. Jack's goal is to reconstruct the paleogeography of the Late Tertiary in these areas. Luis Fraticelli (WMR, Menlo Park) is mapping the Como and parts of the Churchill Butte and Dayton quadrangles. He is correlating tuff units in the Singatse Range with tuffs in different parts of his map area. This includes subdividing and correlating units of the Hartford Hill Rhyolite and correlating dacites and andesites of the Kate Peak Formation in the Churchill Butte and Como quadrangles. Dick Hardyman (Central Mineral Resources, Denver) is working north of Schurz in the Weber Reservoir and Allen Springs quadrangles. Dick's interests include the correlation of Tertiary tuff units across the area and to the south and structural disruptions caused by faults in the Walker Lane belt. Marty Sorenson (WMR, Menlo Park) is mapping in the southeasternmost part of the Reno quadrangle on the Fourmile Canyon, Chukar Canyon, Bell Canyon, Bell Mountain, Rawhide, Big Kasock, Slate Mountain, and Broken Hills 7-1/2' quadrangles. Marty is trying to establish the stratigraphy of the Tertiary volcanic rocks and identify possible sources for the ash flow tuffs in the area. Norm Silberling (Branch of Paleontology and Stratigraphy, Denver) is mapping pre-Tertiary sedimentary and metasedimentary rocks in the eastern half of the quadrangle in order to define correlative lithologic units, identify Mesozoic structures, and delineate boundaries of Mesozoic sedimentary sequences or terranes. Dave John (WMR, Menlo Park) has mapped in the southern Stillwater Range primarily on the La Plata Canyon, Table Mountain, IXL Canyon, and Cox Canyon 7 1/2' quadrangles. Dave has identified at least three ash flow tuffs that are more than 1 km in thickness. These unusually thick tuff units suggest possible nearby caldera sources, but the structures in the area are complex, and sources remain elusive. During the 1987 field season, Dave also spent some time mapping and sampling intrusive rocks in the eastern half of the quadrangle. Dave focussed particularly on rocks that intrude calcareous sedimentary or metasedimentary rocks. This study should help to evaluate the potential of intrusive-related hydrothermal deposits such as those of skarns, porphyry copper, and porphyry molybdenum. All of the mapping is intended to supplement the mineral resource assessment by noting areas of alteration and favorable structural controls for possible mineralization.

GEOCHEMISTRY

Geochemical studies on the Reno CUSMAP are being conducted by Dave Smith (Branch of Geochemistry, Denver). Regional reconnaissance geochemical studies are utilizing samples collected during the National Uranium Resource Evaluation (NURE) program. Splits of these samples have been reanalyzed for elements of interest for deposits other than uranium such as those of base and precious metals. Also, all field geologists on the project are collecting representative samples of unaltered, altered, and mineralized rocks for geochemical analyses as they map. A pilot study of biogeochemical sampling in known areas of mineralization in parts of the Stillwater Range was conducted during the summer 1987 field season by Robert Bruce Vaughn (BGC, Denver) and Dave Smith. The USGS Water Resources Division (WRD) in Carson City, Nevada, is conducting a major study of the Carson River Basin Drainage (Allan Welch, Project Chief). Ron Tidball (BGC, Denver) is collecting 370 soil samples as part of this study. Dave Smith will analyze these samples for trace metals not tested by WRD. Allan Welch is also compiling geothermal data for a Professional Paper. At least four geothermal fields (Steamboat Springs, Desert Peak, Brady, and Oxbow in Dixie Valley) are currently in production or development within the Reno quadrangle.

GEOPHYSICS

Don Plouff (Branch of Geophysics, Menlo Park) and John Hendricks (WMR, Flagstaff) are in charge of geophysical studies for the Reno CUSMAP. Don is reprocessing and interpreting gravity data, some of which he collected in July, 1987, and John is responsible for magnetic data. Goals set for geophysical studies include: 1) identify the depths to bedrock beneath basins; 2) model the Humboldt Lopolith; 3) construct geophysical models for specific mineral deposit types; and 4) investigate the Cleaver Peak magnetic anomaly that trends WNW through the southwestern part of the quadrangle. The approximate depth to bedrock is being determined via several different techniques. One method utilizes oil and gas, water, and geothermal well log data integrated with gravity interpretations. A map is in preparation by Gary Sidder (WMR, Menlo Park) and Fraticelli. Another method estimates the location and extent of pediments by integrating the density of Quaternary fault activity with the topography (structure) and geology of range fronts. John Dohrenwend (WMR, Menlo Park) is interested in pursuing this line of research; however, a lack of funds to purchase the required set of high altitude color aerial photographs, and perhaps problems related to Lake Lahontan sediment and eolian cover may inhibit such a study. Studies of seismic profiles may also help contour the depth to bedrock beneath basins. Recent data accumulated by the COCORP and PASSCAL programs or regional or local studies such as those of geothermal areas and specific structural problems in the Basin and Range will also contribute to the interpretation of the depth to bedrock. Rufus Catchings (Branch of Seismology, Menlo Park) has worked with the COCORP and PASSCAL data, and Plouff, Sidder, and others will assist with the other data. New interpretations and reinterpretations of seismic reflection data indicate that a rift zone exists beneath the Carson Sink and Dixie Valley and that the crust in the Basin and Range is about 35 km thick (Catchings and others, 1986).

The Humboldt Lopolith is a layered mafic intrusion that crops out in the West Humboldt, Stillwater, and Clan Alpine Ranges. Previous interpretations of geophysics and geology suggest that the intrusion is lopolithic in form (Speed, 1963, 1976). However, recent field inspections by Sidder, Norm Page and Ted Theodore (Branch of Resource Analysis, Menlo Park), and Mike Zientek (WMR, Menlo Park) question this conclusion. The lack of a metamorphic aureole and fault rather than intrusive contacts with country rocks raise doubt about the lopolithic nature of this complex. The interpretation of the complex as a lopolith or possibly as an ophiolite has a significant bearing on the mineral resource assessment. Field work by Page, Zientek, and Sidder, along with geophysical modelling by Catchings, Plouff, and Rick Blakely (Branch of Geophysics, Menlo Park) should shed further light on this problem.

Bob Jachens and others in the Branch of Geophysics are constructing geophysical models for specific mineral deposit types. The first types of deposits being modelled are Carlin-type sediment-hosted gold (Bagby and Berger, 1985; Tooker, 1985) and Comstock-type volcanic-hosted gold (Mosier, Singer, and Berger, 1986; Mosier, Singer, Sato, and Page, 1986).

There is interest in modelling pediment-hosted hot spring gold as well, but there are few data at present and lack of funds precluded any additional field work in 1987.

The Cleaver Peak magnetic anomaly is an aeromagnetic high that trends WNW through the southwestern part of the quadrangle and terminates just east of the Comstock area. A line of intrusions seems to coincide in part with this anomaly, and, together with a more arcuate pattern of faults and intrusions to the north, may indicate the presence of a caldera. Jack Stewart and John Hendricks are investigating these trends.

Additional geophysical studies that may assist the mineral resource assessment include re-evaluation of existing aeromagnetic and gravity data. Rick Blakely has produced a map of the state of Nevada (scale 1:1,000,000) that integrates magnetic and gravity data to identify magnetic boundaries. First, a pseudogravity anomaly is calculated from the magnetic data. Secondly, the magnitude of the maximum horizontal gradient at any point of pseudogravity is calculated, and then the location of the maxima in the horizontal gradient of the pseudogravity is plotted (Blakely, 1987). This method indicates the boundaries of magnetic sources and may be helpful in determining the form and location of pediments if the contacts between ranges and basin fill are sufficiently different magnetically. Maps generated from residual Bouguer anomalies that screen high frequency responses characteristic of Basin and Range structures may identify regional patterns in structures related to pre-Basin and Range activity. Plouff, Sidder, and others will be involved in these data manipulations.

ADDITIONAL STUDIES

A number of additional studies are being conducted as part of the mineral resource assessment program. Bill Ehman and Larry Rowan (Branch of Geophysics, Reston) are working with Landsat 5 thematic mapper (TM) imagery to produce alteration maps of the quadrangle. These data allow anomalies related to clay alteration or iron staining to be identified. Ground checks of many anomalies took place in July, 1987. In addition, thermal infrared multispectral scanner (TIMS) images may be acquired in the future for parts of the Stillwater and West Humboldt Ranges. These data may allow the recognition of silicification or alteration related to silica replacement. Such information will be particularly valuable in evaluating epithermal gold potential in the Reno quadrangle. Rowan and Ehman will also generate a lineament map from TM and side-looking airborne radar (SLAR) data.

The Bureau of Indian Affairs (BIA) has funded the USGS to do a mineral resource assessment of Indian reservations in Nevada. Initial work on the project, begun in FY87, focusses on a compilation of geophysical and geochemical data for the state of Nevada. An interpretive map of Nevada at a scale of 1:1,000,000 will utilize magnetic, gravity, and magnetic gradient data to identify plutons and outline their shape at depth (Grauch and others, 1987). Bruce Smith (Branch of Geophysics, Denver) is the project chief; Don Plouff will oversee data compilation for the Reno sheet. Mark Arnold (BGC, Denver) is in charge of geochemical data acquisition and compilation. Bill Bagby and Maureen Sherlock (WMR, Menlo Park), Alan Wallace (Central Mineral Resources, Denver), and Sherm Marsh (BGC, Denver) have categorized gold deposits by deposit type on a statewide scale. Subsequent work, if funded, will include field studies of specific reservations.

The Walker River, Pyramid Lake, and Fallon Indian Reservations are in the Reno quadrangle. The U.S. Bureau of Mines and the USGS have completed four reports on the Pyramid Lake and Walker River Indian Reservations (Albers and Magill, 1976; Whitebread and Magill, 1977; Satkoski and Berg, 1982; Satkoski and others, 1985). At present, these are available for viewing only in the offices at the Nevada Bureau of Mines and Geology in Reno.

Geologists of the Nevada Bureau of Mines and Geology have an ongoing program to map quadrangles at a scale of 1:24,000. Larry Garside, Trowbridge Grose, and Hal Bonham have recently conducted mapping in the Reno area. Larry has completed the Verdi quadrangle in the Peavine district. Hal is mapping the Vista quadrangle, and Trobe has mapped the Marlette

Lake sheet (Grose, 1986). Bonham and others (1985) completed a mineral inventory of deposits in the Sonoma-Gerlach and Paradise-Denio Resource Areas of the Winnemucca BLM District, which covers the northwestern portion of the Reno sheet. This report includes prospect and mine descriptions and results of geochemical analyses, all of which have been incorporated into the Mineral Resource Data System (MRDS). A study of the Walker and Lahontan Resource Areas in the Carson City BLM district, which largely encompasses the Reno quadrangle, may also be conducted by the NBMG. Jack Quade and Joe Tingley completed a mineral inventory study of proposed land withdrawals for the Navy (Quade and Tingley, 1987). This report discusses site investigations of the Fairview, Wonder, Chalk Mountain, La Plata, Sand Springs, and Holy Cross mining districts, and the Camp Gregory area southwest of Fallon in the Dead Camel Mountains.

Paul Lechler, Chief Chemist/Geochemist of the NBMG, has conducted research on the platinum potential of the Humboldt Lopolith. Paul has sampled mafic plutonic rocks of the lopolith from the West Humboldt, Stillwater, and Clan Alpine Ranges, as well as outcrops of mafic rocks in the Terrill Mountains to the south and the Mopung Hills to the west. Major, minor, and trace element analyses indicate that all of these mafic rocks may be petrogenetically related, ie., the lopolith may be larger than previously reported. Paul has also collected and analyzed rock samples from Ni-Co-Cu vein deposits at the Nickel and Lovelock Mines in Cottonwood Canyon in the northern Stillwater Range, and stream sediments in Cottonwood Canyon (Lechler and Desilets, 1986, 1987). Some samples contain detectable PGE metals, with some rock samples containing as much as 9 ppb (P. Lechler, 1986, personal communication).

Duane Champion (Branch of Isotope Geology, Menlo Park) and Bob Criss (Branch of Isotope Geology, Reston) are studying the effects of hydrothermal alteration and mineralization on magnetic susceptibility and oxygen isotopes at the Comstock epithermal gold deposit. Contours of $\delta^{18}O$ values show displacement near the Comstock fault. This indicates that the hydrothermal circulation system was controlled by the fault. Gradients in magnetic susceptibility correspond with those in oxygen isotopes. Propylitization commonly destroys the magnetic signature, whereas silicification increases the magnetic response with the concomitant formation of secondary magnetite (Champion and Criss, 1987).

Some companies in industry have data that are useful for the mineral resource assessment. For example, data from geothermal wells drilled in Nevada are available in the well log files at the Nevada Bureau of Mines and Geology. Also, information on mining districts is maintained by Richard Jones and Becky Weimer at the NBMG. These files include both published and unpublished data. Personal communications with many geologists in industry have also been helpful. Valuable information in the Anaconda Collection at the University of Wyoming may be available in the latter part of 1987, and aeromagnetic data obtained by U. S. Steel (now USX) for about 2/3 of the quadrangle is possibly available for purchase by interested parties.

Other individuals and companies have active research or exploration programs in the Reno quadrangle. Theses currently in progress include: John Black and Rick Saltus at Stanford University, Mark Hudson at the Colorado School of Mines, Dennis Geason and Craig Gibson at the University of Nevada-Reno, and Carolyn Perkins from the University of New England in Armidale, New South Wales, Australia. John Black is studying the alteration and ore genesis at the Rawhide deposit for a M.S. thesis. This deposit is the newest mine under development in Nevada, and it is operated as a joint venture between Kennecott Corporation, Plexus Resources Corp., and Kiewit Mining Group (Rocky Mountain PAY DIRT, 1986). Rick Saltus is beginning a Ph.D. study of paleomagnetism in the Sand Springs Range and at Slate Mountain to determine the amount of tilt and rotation, if any. Mark Hudson is completing a Ph.D. study on the paleomagnetism of Tertiary tuffs and basalts in the West Humboldt, Stillwater, and Clan Alpine Ranges and rocks of the Fencemaker Allochthon, which includes those of the Humboldt Lopolith and Triassic and Jurassic sedimentary rocks, in the northeastern part of the quadrangle (Hudson and Geissman, 1983, 1984, 1985, 1987). Dennis Geason is doing a M.S. thesis on the geology of the Olinghouse district, and Craig Gibson is completing a M.S. thesis on the Buckskin Mine west of Yerington (Gibson, 1987). Carolyn Perkins is working on ore genesis at the Gooseberry Mine and comparing it to an (some?) Australian deposit(s).

Peter Vikre (ASARCO, Reno), Don Hudson (Consultant, Reno), and Larry Buchanan (Fisher-Watt Mining Co., Sparks, NV) are among those working in industry who are conducting active research on mineral deposits in the Reno quadrangle. Peter and Larry have worked primarily on the Comstock district. Peter has dated many samples from the area (Vikre and McKee, 1987) and, with previously published data and data on $\delta^{18}O$ values and fluid inclusions, is compiling a paper on the geochronology of hydrothermal alteration and mineralization at the Comstock Lode. Larry has studied polished sections and fluid inclusions from the Comstock area and other epithermal deposits (Buchanan, 1981). Don has mapped extensively in the Steamboat Springs and Comstock districts, as well as surrounding areas (Hudson and Oriel, 1980). Additional detailed mapping (1:500 scale) and abundant X-ray diffraction analyses have allowed Don to identify distinct zones of alteration in the Comstock area. Samples selected to characterize the geochemistry of alteration have been submitted by Don and are being analyzed by Dave Smith as part of the Reno project.

Stan Keith and company (MagmaChem Exploration, Inc., Phoenix, AZ) have compiled the metallogeny of Nevada at a scale of 1:250,000. These maps are divided into geologically based mineral districts according to the type of metal present, the age of mineralization, and the chemistry of related igneous rocks. In addition, MagmaChem has produced maps that show: 1) the ferric/ferrous ratios for all igneous rocks in the state; 2) the location and petrochemistry of all igneous complexes; and 3) seventeen time-petrochemical slices of the igneous complexes from Jurassic to the present. According to Stan's observations, oxidized (magnetite-bearing) plutons are associated with base metals whereas reduced (ilmenite-bearing) plutons are associated with gold.

ADDITIONAL INFORMATION FOR MINING DISTRICTS

Mining and exploration activity in the Reno quadrangle has increased in the past year along with the flurry of activity throughout Nevada due to the increase in the price of gold. In this section, I will try to update those districts that have recently received the attention of this author or companies and identify sources of information other than personal communications. As mentioned previously, mining district files at the NBMG are valuable references for both published and unpublished data. Additional sources of data include NBMG Special Publications on The Nevada Mineral Industry (e.g., NBMG, 1985, 1986), and trade journals such as Skillings' Mining Review, Engineering and Mining Journal, The Northern Miner, Mining Engineering, California Mining Journal, Rocky Mountain PAY DIRT, The Mining Record, the Mining Magazine, and the Newsletter of the International Liaison Group on Gold Mineralization. A listing and maps of mining claims in the Reno and other quadrangles in Nevada are available from D. K. Marjaniemi and Associates in Spokane. These records are based on information from the U.S. Bureau of Land Management.

Shady Run (Fondaway Canyon)

Tundra Resources purchased a lease in 1983 from Occidental Minerals, which had a lease from Richard Fisk of Fallon, Nevada, to do gold exploration in the Shady Run (Fondaway Canyon) district on the west side of the Stillwater Range. In October, 1984, Tundra began a joint venture with New Beginnings Resources. Reserves of 2.8 m.t. at 0.13 oz Au/ton were announced by Tundra after drilling over 50 core and reverse circulation holes (The Northern Miner, July 18, 1985). The gold mineralization is hosted by Mesozoic sedimentary and metasedimentary rocks. Most of the ore is in black shale or phyllite and is carbonaceous;

only minor oxide ore is present. A major fault that trends about N70°E that dips 80°S appears to localize the ore in two zones about 150 m (500 feet) apart that are about 10 m (30 feet) wide and each about 1.6 km (1.0 mile) in strike length. Porphyritic andesite dikes cut (and offset?) the ore zones and are themselves offset by younger faults with minor displacement. Some dikes are propylitized and stained by copper oxide minerals. It is believed that Tundra sold its lease in early 1987 to another company (Westmin Resources?). Hitec Ore Processing Inc. of Meadowvale, Ontario, Canada, shipped a mobile vat leach tank facility in 1985 to process the carbonaceous ore. The tank is operated by Millcreek Mining (a subsidiary of Hitec) in Carson Sink and at full production could process 2000 tons/day. It utilizes flood, agitating, or trickle leaching techniques (The Northern Miner, July 18, 1985).

Tungsten (22,000 units averaging about 10.3% WO_3), mercury (47 flasks), antimony (3 tons of metal), iron, arsenic, and barite have also been mined in Fondaway Canyon. The iron and tungsten occurrences are contact metasomatic deposits related to a small (Cretaceous?) granitic pluton. Magnetite ore is located at the contact of the intrusion and carbonate wall rocks and extends at least 300 m south of the contact. Molybdoscheelite and cassiterite are also closely associated with magnetite (Lawrence and others, 1977). Skarn minerals such as diopside, actinolite, and garnet are absent or present only in trace amounts. For example, Lawrence and others (1977) described small green garnet crystals closely associated with the molybdoscheelite. The tungsten deposits (the Upper and Lower Quick-Tung Mines) are 0.8 to 1.6 km (0.5 to 1.0 miles) from the nearest granitic exposures and the magnetite skarn. Scheelite is present in recrystallized limestone that Lawrence and others (1977) interpreted to be the core of a reef. Again, skarn minerals are absent, which allows the recovery of tungsten from calcite to average greater than 90 percent. Cinnabar and stibnite are associated and commonly intergrown with the scheelite. It might be noted that Lawrence and others (1977) identified fluorite as an accessory mineral in the granite as well as a secondary mineral associated with magnetite. Although the chemistry of the granite is currently unknown (ie., is it peraluminous?), it is more likely an I-type metaluminous granite based on its mineralogy, which consists of microcline, oligoclase, quartz, biotite, hornblende, magnetite, and traces of zircon, allanite, and fluorite (Lawrence and others, 1977), than a peraluminous granite similar to the New York Canyon stock at the north end of the Stillwater Range (Johnson and others, 1986; Ludington and Johnson, 1986). Sidder (1986) interpreted the tungsten deposits in Fondaway Canyon to be skarn deposits. However, the gold occurrences were not known at the time of the report. Thus, the gold deposits could be considered Carlin-type, sediment-hosted disseminated gold similar to the Getchell deposit (Bagby and Berger, 1985). It is considered here that the skarn and disseminated deposits are contemporaneous, with the Carlin-type formed peripheral to the skarn mineralization. It is also possible that the gold mineralization is younger than the skarn deposits, but further work in the area is required to resolve this problem.

Broken Hills

The Broken Hills district has had Au, Ag, Sb, Mo, Cu, Pb, Zn, and fluorspar production (Sidder, 1986). Mineralization occurs as veins and stockworks along fault zones in Tertiary silicic to intermediate equicrystalline tuffs. The tuffs are moderately to pervasively silicified, and argillization and iron oxide stains are prominent. Propylitic alteration is evident in some areas as chlorite replacement of groundmass constituents. Traces of finely crystalline alunite replacing feldspar were identified in samples from a trench through altered volcanic rocks. The overall zone of alteration does not appear to be widespread on the surface, although younger andesitic flows in part cap the altered area. Thin (<1 cm) veinlets of quartz±calcite±manganese oxide±iron oxide cross-cut the volcanic rocks. Some veinlets contain copper oxide minerals, and copper oxide stains after sulfide(?) are also disseminated in altered tuffs. Veinlets and disseminations of pyrite were also identified in samples from a dump.

Interestingly, altered samples from the Broken Hills area are distinctly dense (heavy). Barite, tentatively identified in hand sample, may in part cause this high density. However, geochemical analyses have not been returned at present to account for the high density with anomalous metal concentrations. Numerous fracture sets are well developed in the tuffs, with N45°W, 65°NE dip, N25°W, 85°SW dip, and N30°E, 75°SE dip, the dominant trends. In general, the Broken Hills district appears to be a volcanic-hosted epithermal gold vein deposit of the Comstock type.

Chalk Mountain

Chalk Mountain was mined predominantly for lead with byproduct silver, zinc, and gold (Sidder, 1986). The deposits are skarns with host rocks of Triassic limestone and dolomite (perhaps correlative with the Milton Canyon member of the Luning Formation (Norm Silbering, personal communication, 1986)) that were intruded by a Cretaceous (?) granodioritic pluton (Willden and Speed, 1974). Alteration includes bleaching of dark gray carbonate to whitish rocks, recrystallization to marble, and formation of secondary minerals such as epidote, chlorite, actinolite, tremolite, talc, soapstone, serpentine, reddish garnet, and possibly pyroxene (diopside?). Zones of alteration minerals are not strongly developed. In general, epidote with minor garnet is present both within the intrusion as endoskarn and as replacement of carbonate in exoskarn. Bleached carbonate rocks with soapstone is peripheral to epidote exoskarn. The ore at Chalk Mountain is highly oxidized. Only minor amounts of sulfide minerals (dominantly pyrite with traces of chalcopyrite) as disseminations and veinlets are evident on the surface. Underground workings were not accessible for inspection; however, Vanderburg (1940) and Schrader (1947) reported that irregular replacement deposits up to 3 m (10 feet) in width were localized along faults and bedding planes in the carbonate host rocks. Iron oxide and hydroxide minerals such as limonite, hematite, and goethite, copper oxide, and lead oxide (wulfenite, PbMoO4) and carbonate (cerussite) minerals were identified on dumps of old mine workings. Small pods and bodies of massive magnetite are present in carbonate rocks on the west slope of Chalk Mountain. The pluton is a composite intrusion with at least four phases. The overall composition of the pluton is granodioritic, with possible variations to quartz monzonite and tonalite. The several phases, as identified in the field, include: 1) a finely crystalline leucocratic phase with plagioclase, quartz, potassium feldspar, minor biotite, hornblende, and traces of magnetite. Minor quartz veinlets cut this phase, and epidote weakly replaces the mafic minerals; 2) finely to medium crystalline intermediate phases that contain plagioclase, quartz, amphibole, biotite, potassium feldspar, and traces of magnetite. Epidote forms massive replacement pods and fills fractures, and quartz veins with a bleached halo cut these rocks; 3) porphyritic rocks with phenocrysts of plagioclase, quartz, potassium feldspar (to 1.5 cm), and minor biotite and hornblende, and groundmass of quartz, potassium feldspar, plagioclase, mafic minerals, sphene, and minor magnetite. Some chlorite replaces biotite and hornblende, and traces of epidote fill fractures and replace the ferromagnesian minerals; and 4) minor porphyroaphanitic rocks, which are present along the southern contact with carbonate rocks on the west side of Chalk Mountain. These rocks may be a chilled border phase of a medium crystalline intermediate phase. The medium crystalline phases in general contain xenoliths of more finely crystalline, more mafic rocks. Interestingly, Garside and Bonham (1984) reported that molybdenite is disseminated in aplitic (leucocratic?) phases of the intrusive, and U.S. Borax drilled Chalk Mountain several years ago as a potential porphyry molybdenum target. Willden and Speed (1974) collected two samples from dumps on the east side of Chalk Mountain that contained 20 and 150 ppm silver, 1.6 and 5.3 ppm gold, 1.5 and 5.0 percent zinc, and greater than 10 percent lead, iron, and arsenic. Quade and Tingley (1987) reported that samples from dumps contained high lead (30 to >20,000 ppm), zinc (10 to >10,000 ppm), iron (1.5 to >20%), and arsenic (10 to >2000 ppm) associated with moderate to high cadmium (<20 to 500 ppm), tin (<10 to 700 ppm), molybdenum (<5 to 1500 ppm), antimony

(<2 to 410 ppm), and copper (7 to >20,000 ppm), and sporadic gold (<0.05 to 1.4 ppm), silver (<0.5 to 1500 ppm), and bismuth (<10 to >1000 ppm). Thus, Chalk Mountain does appear to be a skarn deposit of lead and zinc with anomalously high values of precious metals as well. Data are lacking to determine the actual grade and tonnage of gold contained in the skarn and whether it could be classified as a gold-bearing skarn according to the criteria of Orris and others (1987).

Westgate

The Westgate mining district has had minor production of gold, silver, and lead (Sidder, 1986). Although reports from the literature suggested that ore may occur as a skarn-type occurrence, field inspections indicate that a Carlin-type, sediment-hosted disseminated gold model may be more appropriate. The host rocks are dark gray carbonate rocks and calcareous shale and slate, probably part of the Luning Formation and correlative with those at Chalk Mountain (Willden and Speed, 1974). Alteration and mineralization appear to be controlled by small shear zones that trend about N25°W to N50°W and dip steeply (about 80°) to the northeast. Alteration includes bleaching, iron and copper oxide stains, minor sericite, serpentine, silica flooding, clay, chlorite, rhodochrosite, and epidote replacement of wall rocks along faults, and veinlets of quartz or calcite. Some of the unaltered shale is pyritiferous, and pyrite is the only visible sulfide mineral in altered carbonate and shale. Some gossaneous material has formed in pyrite-bearing shale. Mesozoic volcanic rocks in the area include a lithic-rich tuff and andesite breccia. These units are generally propylitized and contain minor pyrite. Younger igneous rocks in the area include Tertiary (?) quartz porphyry dikes and Tertiary, crystal-rich felsic tuffs. A report from an issue of the Mining Record in 1933 that is in the NBMG mining district files indicates that 39 tons of ore containing 13 oz gold, 643 oz silver, and 8820 pounds lead were mined from Westgate. Skillings' Mining Review (1986) reported that Inland Gold Corp. of Reno, Nevada, had announced results of core drilling at Westgate. Inland holds 54 claims covering about 1080 acres. "Early-on potential" was estimated to be 500,000 tons of "mineralized rock" that contains about 0.04 oz Au/ton. Assays from 12 drill holes ranged from trace to 0.68 oz Au/ton and trace to 15.27 oz Ag/ton (Skillings' Mining Review, 1986).

IXL (Cox Canyon)

The IXL and Cox Canyon districts are in the central part of the Stillwater Range. Minor amounts of gold, silver, base metals, and fluorite have been produced from these areas (Vanderburg, 1940; Sidder, 1986). Pre-Tertiary sedimentary and metasedimentary rocks host the ore. IXL Canyon, which is on the east side of the range, contains a skarn-type deposit. Calc-silicate minerals such as diopside, garnet, actinolite, chlorite, and epidote, sulfide minerals, including sphalerite, galena, pyrite, and chalcopyrite, and iron and copper oxide and hydroxide minerals replace limestone near the contact with a composite granitic pluton. The intrusion is variably biotite- and hornblende-rich. Its composition was estimated in the field to be generally quartz monzonite to granodiorite. The phases are fine to medium grained, equicrystalline to slightly porphyritic, and contain xenoliths of porphyritic microdiorite. Plagioclase, quartz, pink potassium feldspar, biotite, hornblende commonly with pyroxene cores, sphene, and magnetite are visible in hand samples. The contact between the pluton and sedimentary wallrocks is apparently intrusive in most places in IXL Canyon. The intrusion is variably altered, with moderate propylitic (epidote and chlorite) and minor clay alteration and locally heavy iron oxide stains. The limestone is recrystallized to marble, bleached, or altered to skarn. Quartzite and black shale or slate are apparently weakly altered (hematitized and silicified, respectively), and iron oxide stains are heavy in both rock types near contacts with the limestone. In several locales, pods of massive magnetite skarn with copper oxide stains occur in limestone near contacts with quartzite. Vanderburg (1940) reported that two 10-pound chip samples contained 2.70 to 18.94 oz Ag, trace to 0.005 oz Au, and 2.87 to 15.58 percent Pb+Zn+Cu. A gossaneous sample collected from a dump by Dave John in 1986 contains 30 ppm Ag, 300 ppm Cu, 150 ppm Mo, 500 ppm Pb, and 300 ppm Zn, as determined by 6-step D.C. Arc semi-quantitative spectrographic analysis.

Cox Canyon is on the west side of the Stillwater Range, west-northwest of IXL Canyon. Rocks in this area consist of Mesozoic limestone, calcareous gray to reddish brown shale, and slate to phyllite. Breccia is developed locally in the carbonate rocks. These sedimentary and metasedimentary rocks are folded and fractured. Veinlets of calcite and quartz are multi-directional through all rock units, although the vein density is generally low. Some quartz veins are as much as 1 m wide and contain traces of copper and iron oxide minerals. Alteration is moderate and consists of bleached carbonate and shale and minor argillization and silicification. The shale is weakly pyritiferous and moderately iron oxide stained. Jiggs Amos of Fallon, Nevada, is currently prospecting claims of the Golden Star group in Cox Canyon.

Alteration and mineralization in the IXL and Cox Canyon districts are hosted by Mesozoic carbonate rocks, shale, and slate or phyllite. At IXL Canyon, a pluton is in direct contact with the host limestone bed, and contact metasomatic alteration is visible. Hence, IXL is clearly a skarn type deposit; however, the major metal (Pb, Cu, Fe, Au) is ill-defined, and at present the skarn must be defined as polymetallic. Mineralization at Cox Canyon is similar to that at Westgate and part of Fondaway Canyon in that it is not directly associated with an intrusion, although the role of a large rhyolite porphyry body near the range front is as yet undetermined. Thus, Cox Canyon might be considered a Carlin-type sediment-hosted disseminated gold prospect.

La Plata (Mountain Wells)

Mineral occurrences in the La Plata district are hosted by Mesozoic sedimentary and metasedimentary rocks near contacts with an undated (Cretaceous-Tertiary?) granitic pluton. The host rocks are dark gray pyrite-bearing shale, slightly metamorphosed to slate or phyllite, interbedded with whitish carbonate rocks. The intrusion is a composite pluton, with a fine to medium equicrystalline phase of granodiorite composition, a fine to medium equicrystalline phase with an approximate composition of tonalite, and a finely equicrystalline leucocratic quartz monzonite or granite. These units appear to be related petrogenetically, and the differences between the phases correspond to variable proportions of potassium feldspar and biotite. Other minerals identified in hand samples include plagioclase, quartz, and traces of chlorite and magnetite. The granitic rocks weather to grus and are weakly stained by iron and manganese oxide minerals. In general, the intrusive rocks do not appear to be altered deuterically or hydrothermally, although near contacts with the sedimentary rocks minor epidote is disseminated and in veinlets, and quartz veins become more abundant. The contact between the pluton and country rocks appears to be intrusive. Several dikes of probable Oligocene age cross-cut the intrusion. These include finely equicrystalline leucocratic aplite, quartz porphyry, and propylitized, porphyritic, andesitic volcanic rocks. Alteration in the country rocks varies with their composition. Minor skarn is developed in the carbonate units. Diopside, reddish brown garnet, and epidote are present in contact exoskarn with minor copper and iron oxide stains. Quade and Tingley (1987) also reported trace amounts of molybdenite, chalcopyrite, and scheelite in these contact zones. The carbonate rocks are weakly silicified and recrystallized further from contacts with the intrusion. Shale and slate are variably recrystallized, bleached, silicified, and argillized with moderate iron oxide stains. Alteration is locally intense in the nose of folds. At a prospect in lower La Plata Canyon south of the townsite and outcrops of the pluton, fluorite fills vugs and forms veinlets in interbedded shale and carbonate peripheral to small aplitic dikes and sills. Coarse-grained muscovite is localized in fractures and along bedding in silicified shale. Garside and others (1981) obtained a K-Ar date of 84 m.y. from a sample of muscovite associated with fluorite. They interpreted the date to be representative of the age of mineralization. Veins of bull quartz several cm to about 1 m thick are most abundant in the contact zones of the pluton with country rocks. Copper carbonate minerals such as malachite and azurite are in these veins, as well as traces of ferrimolybdite (hydrated iron-molybdenum oxide). Quade and Tingley (1987) reported that molybdenite and oxidized tetrahedrite and chalcopyrite also óccur in quartz veins in trace amounts. Phelps Dodge recently explored this area as a porphyry molybdenum target. Geochemical analyses of mineralized samples collected by Quade and Tingley (1987) from the La Plata district indicate that a suite of elements common to skarn deposits is present. Average values of silver (237 ppm; range: <0.5-1000 ppm), copper (2154; 7-15,000), molybdenum (161; <5-1500), lead (616; <10-5000), zinc (182; 5-630), arsenic (150; 10-1000), bismuth (562; <10-1000), and antimony (105; <2->1000) are moderate to high. Gold (1.42; <0.05-6.7) and tin (30; <10-50) were detected in only five and three samples, respectively, of twenty-three analyzed (Keryl Fleming, p. 81-86, in Quade and Tingley, 1987). As in IXL Canyon, the skarn at La Plata Canyon should be considered polymetallic rather than one of a single metal until additional work is completed. The style of alteration and mineralization is similar to that seen in most of the other districts discussed above, and potential for Carlin-type deposits also exists. However, the intensity of alteration, mineralization, and structural deformation in both the granitic rocks and the pre-Tertiary sedimentary and metasedimentary rocks is weak.

Bell Mountain

The Bell Mountain district is on the east side of Fairview Peak and has previously been included as part of the Fairview district (Sidder, 1986), which has produced significant amounts of gold, silver, copper, and lead. Quade and Tingley (1987) have reviewed the history, geology, and recent activity in the Fairview district, exclusive of Bell Mountain. Therefore, this review will include only the Bell Mountain subdistrict of the Fairview district. An east-west vein that dips about 45°S, crops out for more than 2 km along strike, and is as much as 11 m wide, cuts Miocene, rhyolitic, lithic-rich ash-flow and air-fall tuffs. Several narrower veins cut the main vein. The wall rocks are chloritized, silicified, argillized, and sericitized, especially in the hanging wall. The veins are composed of lamellar manganiferous calcite commonly with quartz pseudomorphs, adularia, barite, fluorite, rhodochrosite, and montmorillonite, and exhibit textures such as vug-filling, crustification, cockade structures, and banding. Electrum, argentite, and minor base metal sulfides and silver sulfosalts are the principal ore minerals (Garside and Bonham, 1984). Supergene oxidation has resulted in the formation of native silver, cerargyrite, and ocherous limonite. Oxide ore extends to depths of at least 120 m (Garside and Bonham, 1984). The veins are commonly brecciated and sheared, and basalt dikes may be associated with the veins. The ore is low-grade, but silver and gold are evenly distributed throughout the structures. Reserves include 1 m.t. of 0.055 oz Au/ton and 1.4 oz Ag/ton. The Sphinx zone to the east contains about 1.5 m.t. that averages 0.14 oz Au/ton and 3.3 oz Ag/ton (The Mining Record, July 7, 1982). These deposits are similar to those of the Comstock-type epithermal veins; however, the regularity and thickness of the veins, the abundance of carbonate gangue, and the low-grade but regular distribution of silver and gold are uncharacteristic of epithermal deposits. Alhambra Mines, Inc., a wholly-owned subsidiary of American Pyramid Resources, Inc., with Double Eagle Energy and Resources, will develop the mine (NBMG, 1986).

Talapoosa

The Talapoosa district has had minor production of silver, gold, lead, and copper (Sidder, 1986). Andesitic to rhyodacitic tuffs host the gold-silver ore, which is about 10 m.y. in age

(Garside and Silberman, 1973). The tuffs are variably altered, with propylitic, hematitic, and silicic alteration evident. Minor opaline and chalcedonic material and adularia were identified in samples collected on a dump. Thin (<2 cm) quartz veinlets, with moderate vein density, fill fractures that trend N30°W and dip >60°SW. Ore minerals include native gold, pyrite, chalcopyrite, argentite, cerargyrite, and native silver (Rose, 1969; Mosier, Menzie, and Kleinhampl, 1986). Athena Mines reported discovery of about 9 m.t. of ore that averages 0.04 oz Au and 0.067 oz Ag/ton. Seven drill holes contained 0.031 to 0.08 oz Au/ton over 5 to 30 m lengths. The ore is oxidized to depths of at least 100 feet (The Northern Miner, December 30, 1985; January 8, 1986). Talapoosa is a Comstock-type (or adularia-sericite type) epithermal vein deposit.

SUMMARY

There is much interest and activity in minerals exploration and geologic research in the Reno 1° x 2° quadrangle. This report summarizes and updates recently accumulated data. A final correction to be noted: the Yerington batholith is 169 m.y. old (Dilles and Wright, 1987). The Reno CUSMAP project will continue for at least another two years. Further updates will be written as more data are accumulated.

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