Supplemental road log 2: From Lordsburg to Duncan, Arizona, and Steeple Rock district, New Mexico and Arizona

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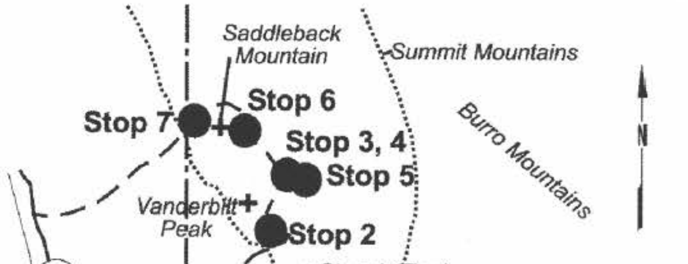
SUPPLEMENTAL ROAD LOG 2, FROM LORDSBURG TO DUNCAN, ARIZONA, AND STEEPLE ROCK DISTRICT, NEW MEXICO AND ARIZONA

VIRGINIA T. McLEMORE

Summary

The main objective of this 120-mi road log with 7 stops is to demonstrate how the distribution and timing of the alteration assemblage are related to the formation of precious- and base-metal veins in an epithermal environment. The Steeple Rock district in southwestern New Mexico and southeastern Arizona provides an opportunity to examine this geologic relation. Five distinct types of ore deposits (base metals with gold-silver, gold-silver, copper-silver, fluorite, and manganese) occur in the district, and they appear to be related spatially to two types of alteration assemblages (1) acid-sulfate and (2) neutral pH (alkali-chloride or propylitic–sericitic) (McLemore, 1993a, b; 1996a, b; *in press* a, b). Furthermore, district-wide variations in both alteration and mineralization also can be studied at Steeple Rock. A secondary purpose of this road log is to tour a historic mining district.

The Steeple Rock district is in the Summit Mountains in Grant County, New Mexico, and Greenlee County, Arizona (Fig. S.2.1). The district derives its name from a prominent mountain peak, Steeple Rock (Fig. S.2.2), in the southern part of the area. Other reports refer to various mining districts and subdistricts in the area; including Twin Peaks in the northern part of the mapped area (Biggerstaff, 1974; Keith et al., 1983), Bitter Creek district along Bitter Creek (Hedlund, 1990b), Duncan fluorspar district in the western part of the area (Hedlund, 1990b), and Goat Camp district west of Vanderbilt Peak (Keith et al., 1983). Some reports separate the Carlisle and East Camp into separate districts. It is appropriate to describe the entire area as one district (Steeple Rock) because the geology is similar throughout the area and the various types of deposits are similar and possibly related to each other. The major mines are shown in Figure S.2.3; Figure S.2.4 shows the stratigraphic section.



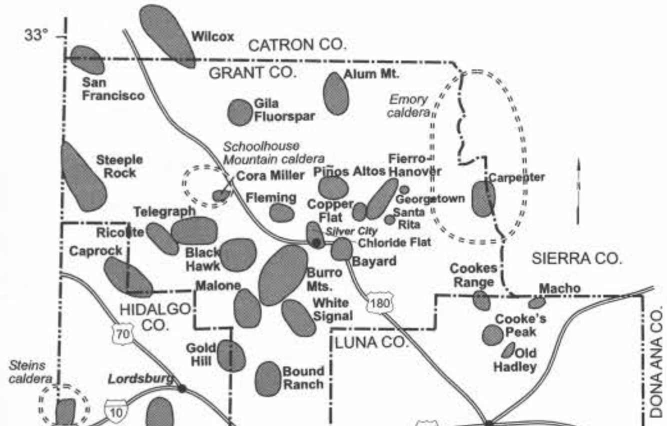


FIGURE S.2.1. Location of Steeple Rock district in relation to other metal districts in southwestern New Mexico (modified from North and McLemore, 1986, McIntosh et al., 1990, 1991; New Mexico Geological Society, 1982; McLemore, *in press* b).

Exploration began about 1860, but production was not reported until 1880. An estimated $10 million worth of metals were produced from the district in New Mexico between 1880 and 1991, which includes approximately 151,000 oz of gold, 3.4 million oz of silver, 1.2 million lbs of copper, 5 million lbs of lead, and 4 million lbs of zinc (McLemore, 1993). In addition, approximately 11,000 short tons (st) of fluorspar have been produced from the Mohawk, Powell, Leta Lynn, and other mines (McAnulty, 1978; Richter and Lawrence, 1983; Hedlund, 1990b). In the Goat Camp Springs area, 2000 st of ore containing 74,500 lbs of manganese ore produced, probably in the 1940s. Two rock quarries were opened and mined for decorative or building stone, but total production is not known.

The ore deposits were first described by Lindgren et al. (1910), who recognized that these deposits are epithermal. During World

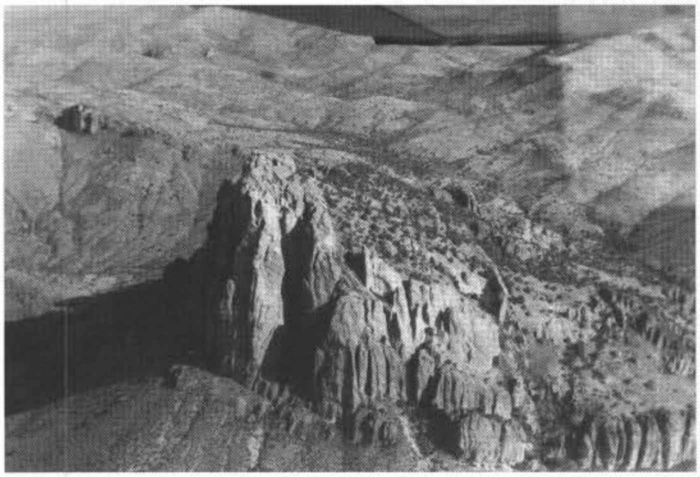


FIGURE S.2.2. Steeple Rock, looking northeast. Note the spiral configuration giving its name that is formed by the rhyolite of Steeple Rock (age 33.1 Ma).

War II, the U.S. Geological Survey and U.S. Bureau of Mines (USBM) examined the ore deposits along the Carlisle fault and conducted surface and underground mapping, drilling, and sampling as part of the national strategic minerals evaluation (Johnson, 1943; Russell, 1947; Griggs and Wagner, 1966). This investigation failed to locate any additional base-metal ore bodies based on the economics at that time (Russell, 1947). The fluorspar vein deposits were described by Trace (1947), Wilson (1950), Williams (1966), Rothrock et al. (1946), McAnulty (1978), and McLemore (1993). Hedlund (1990b) briefly summarized the geology of the mineral deposits in the Steeple Rock district. Sharp (1991) and McLemore (1993) presented geochemical analyses of some igneous rocks in the district.

Geologic mapping of the area has been accomplished only in the last 40 yrs (Elston, 1960; Griggs and Wagner, 1966; Wargo, 1959; Biggerstaff, 1974; Powers, 1976; Wahl, 1980; McLemore, 1993). In the late 1970s and early 1980s, regional reconnaissance geologic mapping of six quadrangles (Tillie Hall Peak, Crookson

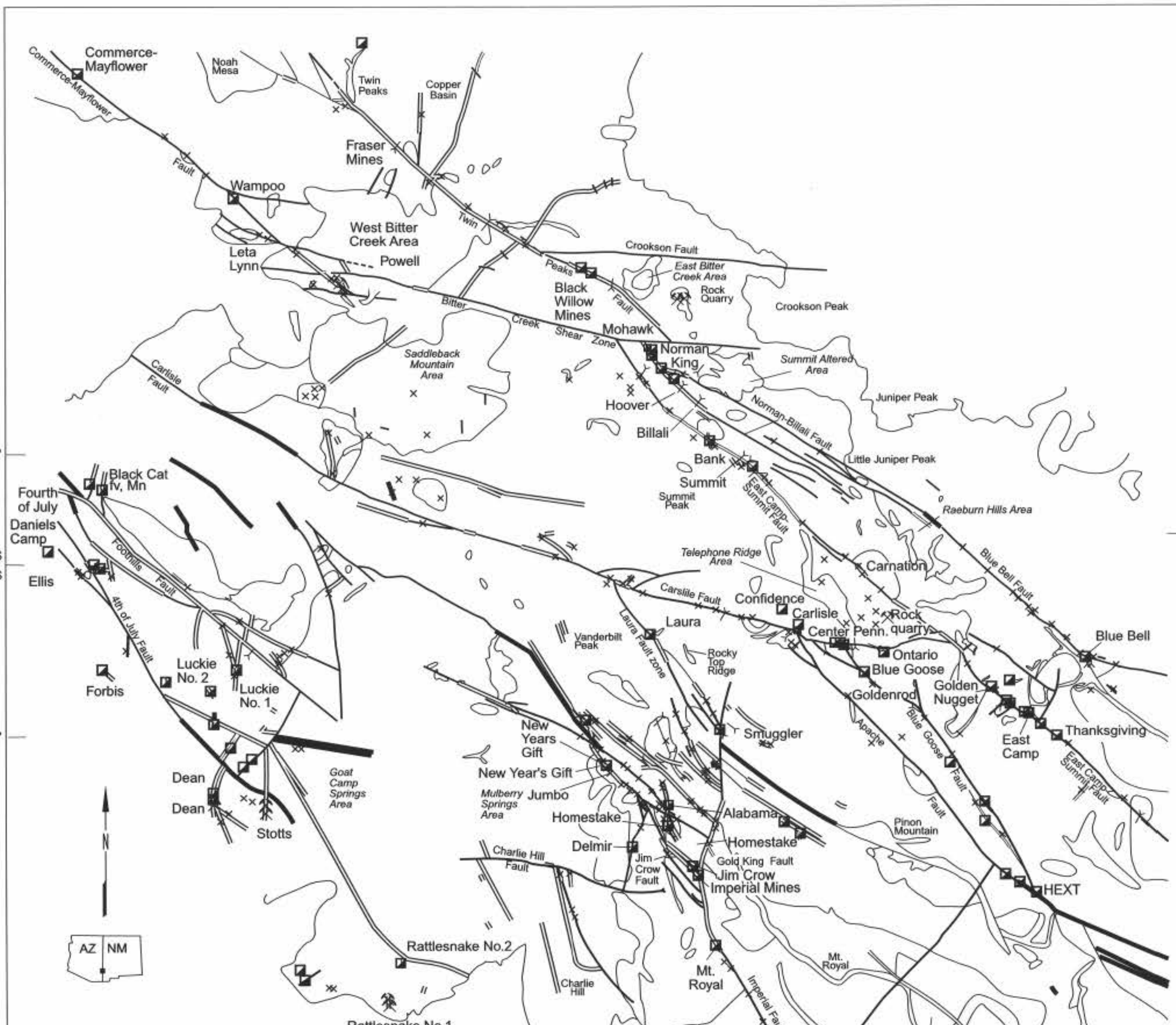


FIGURE S.2.3. Mines, prospects, and major faults in the Steeple Rock district.

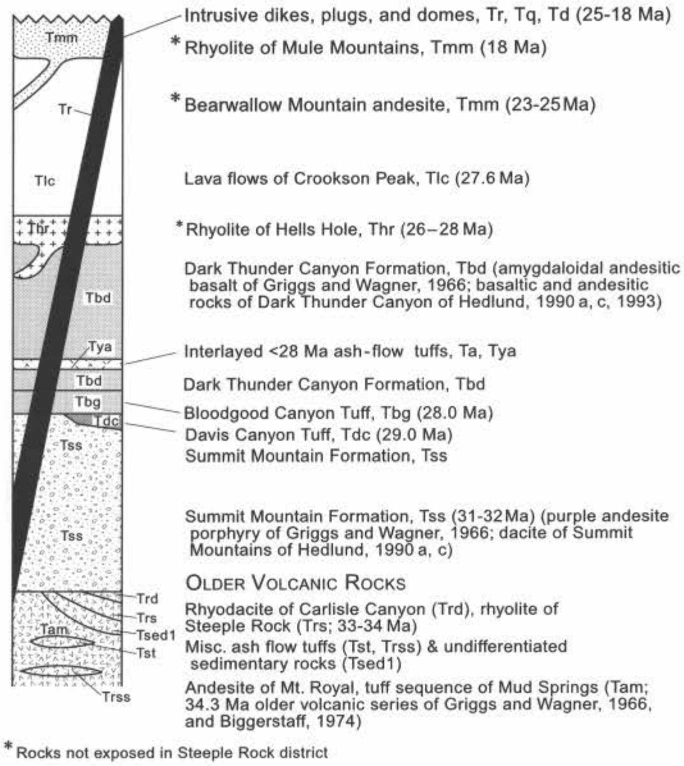


FIGURE S.2.4. Generalized stratigraphy of the Summit Mountains (McLemore, 1993; Hedlund, 1990a, b, c, d, 1993). Age dates are from Wahl (1980), Rattè et al. (1984), McIntosh et al. (1990, 1991), Hedlund (1993), and McLemore (1993). See McLemore (1993, table 2.1) for compilation of age determinations.

Peak, Applegate Mountain, Goat Camp Spring, Steeple Rock, Walker Canyon, and parts of Canador Peak and Nichols Canyon), including the Steeple Rock area, was completed as part of the Silver City CUSMAP project. These maps were available to the author for this study (Hedlund, 1990a, c, d, 1993). McLemore (1993) mapped the entire area covered previously by Powers (1976). The stratigraphy, structural geology, and geochemistry of the volcanic rocks are described in McLemore (1993) and McLemore et al. (this volume, p. 127). District zonation is described by McLemore (1993, 1996b).

At Stop 1 we will examine Proterozoic basement rocks exposed in a road cut on Lordsburg Mesa. We will examine a typical precious-metal vein deposit associated with silicification and neutral pH (or alkali-chloride or propylitic to sericitic) alteration at the Alabama mine at Stop 2. The Carlisle mine, a base- and precious-metal vein deposit, is the largest mine in the district and will be examined at Stops 3 and 4. Stop 5 is at the Center mine, another base- and precious-metal deposit along Carlisle fault and we will also examine the acid-sulfate alteration on Telephone Ridge. Acid-sulfate alteration will also be examined at Stop 6. Stop 7 is at the Bank mine, a precious-metal vein deposit along the East Camp-Summit fault. McLemore et al. (this volume, p. 127) discussed the stratigraphy and geology in more detail.

ALTERATION TERMINOLOGY

Alteration is a general term describing the mineralogic, textural, and chemical changes of a rock as a result of a change in the physical, thermal, and chemical environment in the presence of water, steam, or gas (Bates and Jackson, 1980; Henley and Ellis, 1983). Alteration halos surrounding ore deposits are typically more widespread and easier to recognize than some of the ore bodies themselves (Guilbert and Park, 1986). Research by White (1981) established the now recognized association between epithermal mineral deposits and modern, active geothermal systems. Alteration assemblages associated with epithermal-vein deposits are similar to alteration assemblages found in modern geothermal systems (Buchanan, 1981; Mitchell and Leach, 1991; Reed, 1994). Therefore, analogies between modern geothermal systems and ancient epithermal deposits will aid in understanding the genesis of epithermal-vein deposits, such as those found in the Steeple Rock district.

Alteration can be classified and defined in many ways, but most classifications are based upon mineral assemblages (Guilbert and Park, 1986). A number of terms is applied to various alteration assemblages. In modern geothermal systems, the alteration-mineral assemblages reflect the composition of the prevailing fluid chemistry and it is common to describe the alteration assemblage according to fluid chemistry (Table S.2.1; Browne, 1978; Mitchell and Leach, 1991; Simmons et al., 1992; Reyes, 1990; Reed, 1994). Modern geothermal systems consist

TABLE S.2.1. Characteristics of geothermal fluids and associated alteration (modified from Hedenquist, 1991; Browne, 1978; Henneberger and Browne, 1988; Simmons et al., 1992; Henley and Ellis, 1983).

Fluid type	Neutral pH	Acid-sulfate	Bicarbonate
Source of fluid	deep circulation	surfaced steam-heated condensate, locally with magmatic gases	condensation of steam and CO_2 into shallow ground water
Typical pH	6–7.5 (neutral)	<2.5 (acidic)	5–6
Surface discharge	boiling spring, geyser, silica sinter	mud pools, collapse craters, hot springs	warm hot springs
Typical alteration	propylitic, potassic	advanced argillic	argillic
Mineral assemblage	chalcedony, quartz, albite, adularia, illite/smectite, chlorite, zeolites, epidote, calcite, pyrite	opal, kaolinite, alunite, diaspore, pyrophyllite, quartz, pyrite, sulfur	chalcedony, kaolinite, illite/smectite, chlorite, carbonates, pyrite
Predominant fluid chemistry	chloride waters	sulfate waters	bicarbonate waters
Form of alteration	direct deposition and replacement, ejecta	leaching followed by direct deposition and replacement, ejecta	direct deposition and replacement
Modern example	Luzon, Philippines, Broadlands and Wairakei, New Zealand	Norris Geyser Basin, USA, Bacon-Manito, Philippines	Mammoth Springs, Yellowstone, USA

of three end-member types of fluid compositions: (1) neutral pH or alkali-chloride, (2) acid-sulfate, and (3) bicarbonate. Specific mineral assemblages and other characteristics (Table S.2.1) characterize each type. Mixing of these end-member fluid types is common and more than one type of fluid can be present (Browne, 1978). Geothermal systems are dynamic, constantly changing, and rarely in equilibrium. Processes such as boiling, mixing, and condensation constantly occur in the geothermal system, producing a wide range of overlapping mineral assemblages and associations. For the purposes of this study, the alteration types are classified according to the type of fluids as indicated by the alteration mineralogy because it is typically difficult to discriminate and map classic deuteric, propylitic, argillic, and advanced-argillic alteration types in the epithermal deposits (Table S.2.1; McLemore, 1993; *in press b*).

Mileage

0.0 Holiday Inn Express. Proceed north (**turn right**) on Main Street (NM-494), under I-10 overpass. **0.8**

0.8 Intersection with Motel Drive (flashing red light). **Proceed to center lane and turn left**, under the railroad overpass to US-70. **0.1**

0.9 **Turn right** at stop sign onto US-70, heading north. **2.0**

2.9 Junction with US-90, continue on US-70. Burro Mountains on skyline to right and Peloncillo Mountains on skyline to left. Broad mesa ahead is known as Lordsburg Mesa.

The Burro Mountains were named long ago because the mountain range is identified on Juan Nentwig's 1762 map (Julyan, 1996). The mountains consist mostly of Proterozoic granite, gneiss, schist, quartzite, and amphibolite that are unconformably overlain locally by Cretaceous Beartooth Quartzite and Colorado Shale, and mid-Tertiary volcanic rocks; Laramide and Mid-Tertiary plutons, dikes, and plugs have locally intruded the older rocks. The Peloncillo Mountains may be derived from the Spanish peloncillo meaning "little baldy" or from the Spanish piloncillo meaning "sugar lump" or conical pieces of unrefined sugar (Julyan, 1996); the mountain range certainly resembles either term. Mid-Tertiary volcanic rocks make up most of the Peloncillo Mountains, but Cretaceous and Proterozoic granite and Paleozoic sedimentary rocks are exposed in northwest-trending fault blocks in the central part of the mountain range (Armstrong et al., 1978; Drewes and Thorman, 1980; McIntyre, 1988). The prominent bajada, Lordsburg Mesa, west of the Burro Mountains was formed by coalescing Quaternary alluvial fans derived from the Burro Mountains (Clemons et al., 1980).

US-90 cuts through the middle Burro Mountains and passes the Tyrone porphyry-copper mine operated by Phelps Dodge Corporation. The Tyrone porphyry-copper deposit in the Burro Mountains district occurs within a quartz-monzonite laccolith and adjacent Proterozoic rocks. The age of the Tyrone stock is 54.5 ± 0.5 Ma (unpublished data, Phelps Dodge Corporation). The ore contains minor amounts of gold and silver, especially in local enriched zones. At least three cycles of supergene enrichment have concentrated the ore (DuHammel et al., 1995). Approximately 300 million st of ore grading 0.81% Cu were processed at the concentrator from 1969 to 1992. Approximately 425 million st of ore grading 0.35% Cu have been leached. Gold and silver were recovered only in the concentrate. In 1998, leaching reserves (recoverable copper) are estimated as 466.3 million st of ore grading 0.32% copper. **1.6**

4.5 Junction with NM-464 (Redrock Road; see supplemental road log 1, this volume). **4.1**

8.6 **Stop 1** at road cut to examine Proterozoic granite intruded by Proterozoic gabbro dike and medium-grained, biotite granite dike. Similar relationships occur throughout the Proterozoic terrain in the Burro Mountains (see McLemore et al., this volume, p. 117). **7.6**

16.2 MP-14 and gravel pits on both sides of the highway. Summit Mountains at 1:00. Caprock Mountains at 2:00. Black Mountain and Lone Mountain at 2:30. Summit Hills at 10:00. **9.3**

25.5 Road junction, **turn right** onto NM-92. Steeple Rock at 11:30 was named because the 34-Ma ash-flow tuff (Hedlund, 1990a) resembles a church steeple (Fig. S.2.2). **9.3**

27.8 Descend into Gila River valley. View of valley ahead. Farms in the valley produce hay, alfalfa, corn, chili, cotton, melons, and pumpkins. **2.3**

29.2 Cross bridge over Gila River. **1.4**

30.2 Bend in road to left. Road cuts in Quaternary alluvium. **1.0**

33.1 Town of Virden was established along the Gila River about 1870, when the New Mexico Mining Co. at Ralston, south of Lordsburg, required more water (Hill, 1976; Julyan, 1996). The promoters named the Virginia mining district in the Pyramid Mountains (Lordsburg district, see McLemore and Elston, this volume) and named the settlement along the Gila River, Richmond, after the capital of the state of Virginia. The company planned to build a 25-stamp mill in Richmond and connect Richmond with the Lordsburg district at Shakespeare by a tramway. The silver veins in the Lordsburg district were mined out before these plans were realized (Hill, 1976). Richmond became a small trading center in the Gila River valley. A U.S. Post Office was established in 1875.

In the 1870s and 1880s, a group of Mormons settled in northern Mexico at Colonia Diaz and several other colonies to escape persecution in the United States (Hilliard, 1998). About 1912, the Mexican Revolution drove the Mormons from Mexico. They settled at Poverty Flats at Hachita and began looking for new homes. Some of the Mormons found the Gila Valley area around Richmond desirable. The Mormons bought much of the valley from the Gila Ranch Co., a large landowner in the area at the time. In 1916, the Mormons changed the name Richmond to Virden, after Earnest W. Virden, the president of the Gila Ranch Co. (Hill, 1976). Today Virden remains a small ranching and farming community. A llama ranch is on the right in the center of town. **0.5**

33.6 Cross Carlisle Creek. **1.4**

35.0 Cross arroyo and state line into Arizona. **1.6**

36.6 Pass dairy farm. Road cuts in Quaternary alluvium ahead. **0.9**

37.5 Road cut in light greenish-gray Quaternary lake beds. **0.2**

37.7 Gravel pits at 3:00. **1.9**

39.6 Pass cotton gin. **0.4**

40.0 Junction with AZ-75, **turn right**. Vanderbilt Peak at 1:00, Saddleback Mountain at 12:00. Vanderbilt Peak consists of andesites of the Summit Mountain Formation (Hedlund, 1990a, 1993; McLemore, 1993; McLemore et al., this volume, p. 127). Saddleback Mountain consists of altered andesites and ash-flow tuffs of the Summit Mountain Formation; it is one of the largest areas of acid-sulfate alteration in the district (McLemore, 1993). **0.6**

40.6 Junction with Carlisle Road (gravel), **turn right** (past MP-380). **0.5**

41.1 Road junction with Billingsley Road, continue straight. Billingsley was a Duncan businessman and mining promoter. Cross Quaternary terraces ahead. **1.2**

42.3 Ascend hill. Road cut in light greenish-gray Quaternary lake beds overlain by alluvial fan deposits. **2.3**

44.3 Cattle guard. Mt. Royal at 12:00, Steeple Rock at 12:30. Vanderbilt Peak at 11:00. Saddleback Mountain at 10:00. **2.5**

47.1 Cross cattle guard. Hills at 3:00 are capped by Bloodgood Canyon Tuff (Fig. S.2.4). The tuff is a light-gray to white, typically welded, devitrified ash-flow tuff that is crystal-rich and is contains round "eyes" of sanidine and bipyramidal quartz (Ratté et al., 1984; Hedlund, 1990a, b, c, d, 1993). The tuff is poorly sorted, angular–subangular and consists of 10–20% phenocrysts, as much as 3–5 mm across, of sanidine, quartz, and accessory titanite, biotite, hornblende, and iron oxides. The Bloodgood Canyon Tuff is probably one of the most widespread ash-flow tuffs in the Mogollon-Datil volcanic field. It extends from its source, the Bursum caldera in the Mogollon Mountains, northward to Aragon and a few miles south of Steeple Rock. It extends as far west as Clifton and as far east as Beaverhead (McIntosh et al., 1990, 1991). The age of the unit has been determined by high-precision $^{40}Ar/^{39}Ar$ dating as 28.05 ± 0.01 Ma (McIntosh et al., 1990, 1991). Cross border into New Mexico. Road ahead is in Summit Mountain Formation. **1.2**

48.3 Sharp bend in road to left. Low hills at 3:00 are older volcanics of Hedlund (1990a, c). Road ahead is in Summit Mountain Formation. Charlie Hill at 2:00. Saddleback Mountain at 12:00. **0.7**

49.0 Cattle guard. **0.1**

49.1 Fork in road, right fork to Jim Crow, Imperial and Gold King mines. **Keep left**.

The Jim Crow, Imperial, and Gold King mines occur along various north- and northwest-trending faults in sec. 14, T17S, R21W. Eight patented claims make up this group (Imperial, Jim Crow, Gold King, Tunnel, Gold Bug, Red Prince, Three Brothers, and Contention), which were patented on July 11, 1899 by the Steeple Rock Development Co. (mineral survey #1012A-H, patent #31323).

Most of the development work was completed prior to patenting in 1899. However, early records of the mining claims were lost during the San Francisco earthquake in 1906, so very little concerning the early history is known. In 1914, George Utter purchased the group of claims and continued development and production. Two diamond drill holes were drilled prior to 1936. Sludge samples had assays ranging from 1 ppm Au and 139–243 ppm Ag. By 1941, development consisted of two 200-ft shafts (Jim Crow and Imperial), four 100-ft shafts, and at least ten additional shafts ranging in depths from 10 to 60 ft. Several adits, crosscuts, trenches, and pits also expose the veins. In 1967, McFarland and Hullinger conducted a percussion drilling program near the Imperial shaft, but results are unknown. In 1969, Grant County Mining Co. leased the property and made one ore shipment. In 1977, Oak Creek Contracting, Inc., obtained the property and in 1981 entered a joint venture agreement with Queenstake Resources, Ltd.

Production prior to 1912 is largely unknown due to loss of most of the early records, but at least 430 st of ore averaging 28 ppm Au and 1310 ppm Ag were produced (L. Utter, unpubl. report, 1936). Production from 1912 to 1969 was sporadic (1915–1917, 1920, 1932, 1936–1938, 1940, 1969) and amounted to 1341 st of ore averaging 11 ppm Au and 477 ppm Ag. Most of this production (1915–1938) was by George Utter. Oak Creek Contracting, Inc., produced 5035 st of ore averaging 3 ppm Au and 114 ppm Ag from 1980 to 1984 (unpubl. report, Queenstake Resources Ltd., 1987). Total production is estimated as 6806 st of ore averaging 6 ppm Au and 261 ppm Ag (McLemore, 1993). Copper, if present, rarely exceeded 0.4% Cu.

Ore from this group of claims occurs along several northwest-trending faults (McLemore, 1993, map 1). The host rocks consist of younger ash-flow tuff interbedded within the porphyritic andesite of the Dark Thunder Canyon Formation. Several minor faults split from the main fault and many are mineralized. Underground, several post-mineralization faults cut and offset the ore bodies (Queenstake Resources Ltd., unpubl. report, 1982). The ore occurs in silicified hematite breccia, similar to ore at the Alabama and Homestake mines. Veins vary in width from 2 to 40 ft and dip steeply (60–80°) to the west or southwest. The breccia zone consists of fragments of rhyolite, andesite, and vein quartz all cemented by silica and iron oxides. Locally small breccia fragments of high-grade ore (3 ft diameter) occur in the veins. Ore minerals include native gold, native silver, galena, sphalerite, chalcopyrite, covellite, and bornite in a gangue of quartz, sericite, pyrite, chlorite, calcite, feldspar, and hematite (McLemore, 1993, 1996b). Sulfide minerals, except for pyrite, are extremely small (<0.04 in.). Mottramite, a yellow-green mineral with the composition of $(Cu,Zn)Pb(VO4)(OH)$, is a common alteration product associated with the sulfides. It is reported that the upper portions of the Imperial ore body contained more gold than silver (Lindgren et al., 1910) grading at depth to predominantly silver. Base-metal sulfides appear to also increase with depth. Queenstake Resources Ltd. reported reserves of 155,535 st of ore averaging 4 ppm Au and 118 ppm Ag from the property (Queenstake Resources Ltd., unpubl. report, 1987). **0.8**

49.9 Sharp bend in road to right. Cross fault between

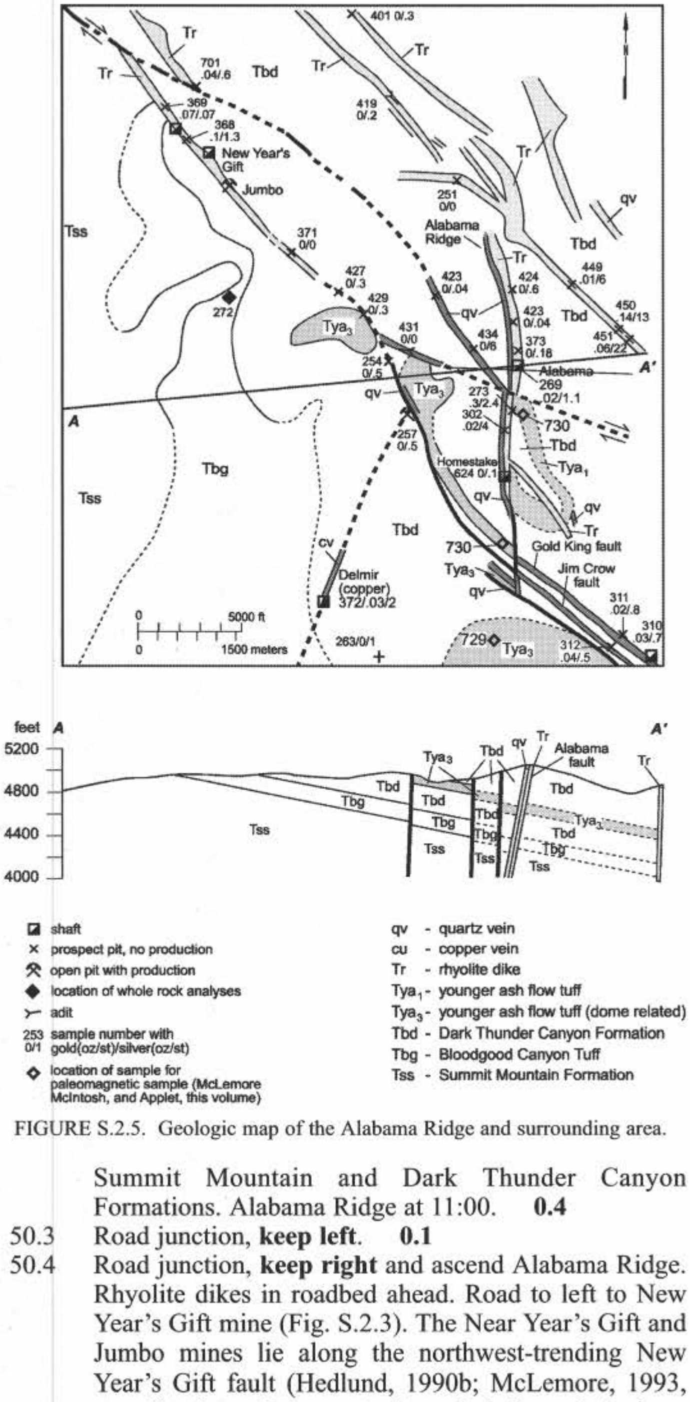


FIGURE S.2.5. Geologic map of the Alabama Ridge and surrounding area.

Summit Mountain and Dark Thunder Canyon Formations. Alabama Ridge at 11:00. **0.4**

50.3 Road junction, **keep left**. **0.1**

50.4 Road junction, **keep right** and ascend Alabama Ridge. Rhyolite dikes in roadbed ahead. Road to left to New Year's Gift mine (Fig. S.2.3). The Near Year's Gift and Jumbo mines lie along the northwest-trending New Year's Gift fault (Hedlund, 1990b; McLemore, 1993, map 1). Several prospect pits and shallow shafts have exposed the vein. The New Year's Gift shaft is the deepest, 270 ft deep. Production occurred prior to 1941, but Doug Hanson worked the property in the early 1980s and in 1991. The veins consist of hematite breccia cemented by quartz. Only two stages of brecciation occurred. Silicification and chloritization are common adjacent to the veins. The breccia zone is up to 6 ft wide. Assays as much as 3.4 ppm Au and 34.3 ppm Ag occur along the vein (McLemore, 1993, sample number 368, appendix 11.6). **0.7**

51.1 **Stop 2** at saddle, Alabama mine. New Year's Gift mine at 9:00, Vanderbilt Peak at 11:00. The precious-metal veins are associated with rhyolite and are exposed south

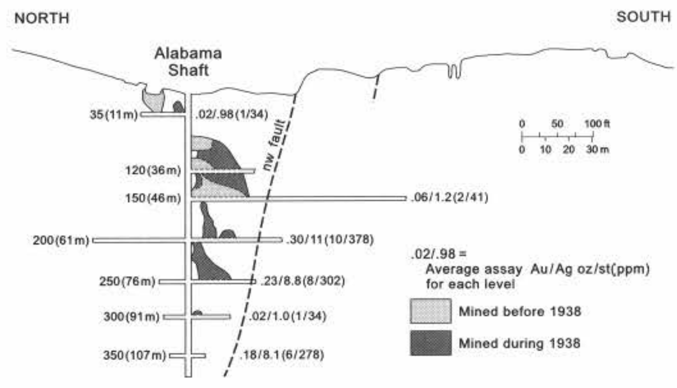


FIGURE S.2.6. Longitudinal section of the Alabama mine (F. W. Smith, unpubl. report, 1910). Does not show mining in 1950 and 1951.

of Alabama shaft. Samples of the mined ore are present in the mine waste pile at the shaft.

The northern Alabama and southern Homestake mines occur along the north-trending Alabama fault (Fig. S.2.5). The Alabama group of claims consists of nine patented claims, which were patented on October 2, 1915, by the Torreroca Mining Co. (mineral survey #1624). The Homestake No. 1 was patented on October 18, 1904, (patent #39753, mineral survey #1448) by the Dixie Gold Mining and Reduction Co.

Several shallow pits and shafts comprise the Alabama-Homestake groups. The Alabama mine consists of a 1½-compartment shaft with eight levels at depths of 36, 78, 112, 150, 200, 250, 300, and 360 ft below the shaft collar (Fig. S.2.6). The 150- and 200-ft levels are the most extensive and are 200–300 ft long. The shaft dips 80°W and is 370 ft deep. The underground workings are flooded to the 36-ft level and are currently inaccessible. In July 1991, Great Lakes Exploration Co. began a surface sampling and drilling program at the Alabama mine to evaluate the economic potential. Two holes were drilled in 1991 by Great Lakes Exploration Inc.; a summary of the drill data is in McLemore (1993, appendix 11.1.2).

The Homestake mine, south of the Alabama mine (Fig. S.2.5), consists of several shallow pits, a few short adits and a 130-ft shaft. The shaft consists of two levels at depths of 65 and 115 ft. Ore was produced from the Homestake mine in 1936, 1938, 1939, and 1941; but, fewer than 500 st of ore averaging 8 ppm Au and 199 ppm Ag were shipped (NMBMMR files). Doug Hanson reopened the Homestake mine about 1995 and shipped a few truck loads of silica flux to ASARCO smelter in El Paso. Total production is estimated at approximately 4000 st of ore averaging 10 ppm Au, 446 ppm Ag, and 0.03% Cu.

The Alabama vein occurs along the north-trending Alabama fault in a silicified hematite-rhyolite breccia (Fig. S.2.5). Fragments of andesite, rhyolite, and vein quartz are cemented by silicified hematite. The breccia zone occurs along the fault, striking N10°E and dipping 80°W. The zone is about 6–10 ft wide at the Alabama shaft and varies along strike between 4 and 20 ft in width. The ore zone is <6 ft wide, but varies from 4 to 6 ft in width in most places. Some ore shoots were up to

60 ft long (H. Schmidt, unpubl. report, 1953). Early reports state that ore averaged 34 ppm Au and 186 ppm Ag (Engineering Mining Journal, March 16, 1895, p. 302). The host rocks consist of the younger ash-flow tuff overlain by the porphyritic andesite of the Dark Thunder Canyon Formation. Rhyolite dikes and plugs have intruded along the Alabama fault (McLemore and Quigley, 1992).

The ore at the Alabama and Homestake mines consists of gold and silver, with trace amounts of galena, sphalerite, and chalcopyrite in a gangue of quartz, hematite, pyrite, sericite, and mixed-layer chlorite/smectite. Visible gold or electrum is found locally on the surface south of the Alabama shaft. Seams of calcite, 0.04 in. or less wide, cut the ore and altered rocks and were reported to be associated with zones assaying low gold values (unpubl. report, G. Utter, 1938). Averages of gold and silver assays from each level of the Alabama mine suggest an increase in gold and silver with increase in depth (Fig. S.2.6; McLemore, 1993).

A northwest crossfault (strike N70°W, dip 70°N) offsets the Alabama fault south of the Alabama shaft, through the saddle (Fig. S.2.5). Subsurface mine maps indicate that this fault also offsets the ore body (unpubl. report, F. W. Smith, 1910). Additional faults occur in the vicinity (McLemore, 1993), but the offset in mineralization is unknown.

Return to vehicles and continue up Alabama Ridge. **0.4**

51.5 Sharp bend in road to right, north of Alabama Ridge. Rhyolite dikes underlie ridges on both sides of the road. **0.5**

52.0 Road junction, **keep right**. Road to left up canyon to Laura mine. Rocky Top Ridge at 1:00 is capped by Bloodgood Canyon Tuff overlying andesites of the Summit Mountain Formation. **1.4**

53.4 Cross arroyo in Summit Mountain Formation. **0.3**

53.7 Whiskey Creek to the left. During the height of the town of Carlisle, prostitutes built their houses along Whiskey Creek. The creek cuts through volcaniclastic sedimentary rocks belonging to the Summit Mountain Formation. **0.4**

54.1 **Stop 3**, Carlisle mine and Telephone Ridge overlook (Fig. S.2.3). The principal mine in the Steeple Rock district is the Carlisle mine, located on the Carlisle fault at the junction with the Apache fault, and much of the production from the district is attributed to this mine. Although there was reported production from the mine prior to 1880, the first mining claims were not filed until 1881. In 1883, the Carlisle group of claims was sold to a group of Chicago merchants who formed the Carlisle Mining Co. In January 1887, the Carlisle Mining Co. was sold, reportedly for \$1 million, to a group of London investors. From 1880 to 1890 total production is reported as \$4 million of gold and silver (unpubl. report, R. Blanchard, 1928). The new company developed the Carlisle mine to 600 ft depth, via a winze on the 500-ft level and enlarged the mill from 20 stamps to 60 stamps. Ore from throughout the district was processed at the Carlisle mill. In 1887, a smelter was built and attempted unsuccessfully to recover lead, gold, and silver from the mill concentrates.

The mine closed in 1890 when the easily recoverable gold and silver ore bodies were exhausted. Although gold and silver were found in the lead-zinc sulfide ore bodies, the sulfide ore could not be processed at that time. Attempts at recovering the sulfides and gold and silver were unsuccessful until the 1900s. By 1892, only 10 stamps remained operating at the mill. The Steeple Rock Development Co. was organized in 1896 and assumed the assets of the Carlisle Mining Co. The mine was reopened in the 1890s and again in 1904 and 1913, but only minor production occurred. Figure S.2.7 is a photograph of the town in the early 1890s.

From 1876 to 1914, the Steeple Rock Development Co. consolidated numerous claims throughout the district and milled much of the ore at the Carlisle mill (Fig. S.2.8). However, as silver prices dropped, the company was forced to sell off portions of the properties. In 1914, George H. Utter bought the remaining assets, including the Carlisle and began processing mill tailings at the Carlisle until 1920. Utter may have produced from the Carlisle mine during 1914–1920 as well. In 1927, United Metals Corp. dewatered the Carlisle and continued development. By 1928, total development consist-

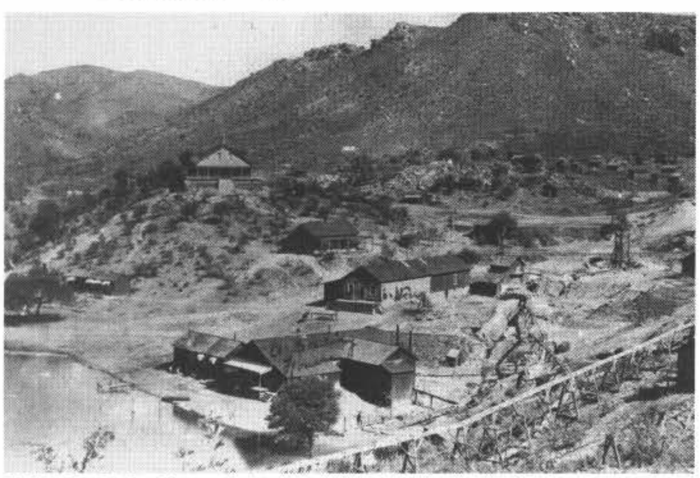


FIGURE S.2.7. Photo of the town of Carlisle in the early 1890s. Telephone Ridge is in the background and the headframe is to the right (from Douglas Hanson collection).

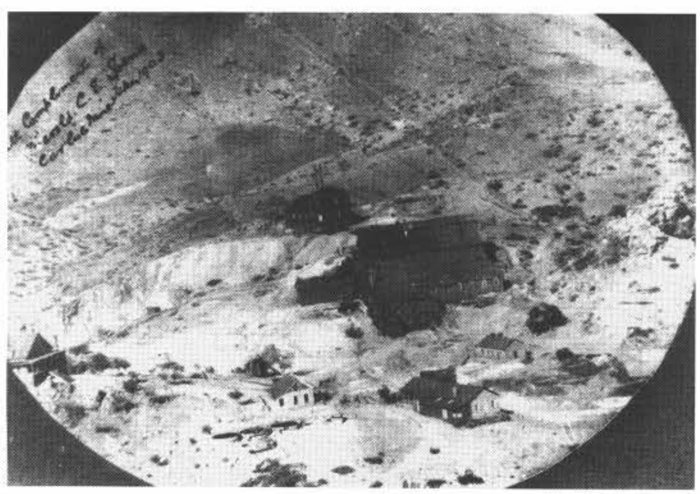


FIGURE S.2.8. Photo of mill at the Carlisle mine in 1903 looking north (from Douglas Hanson collection).

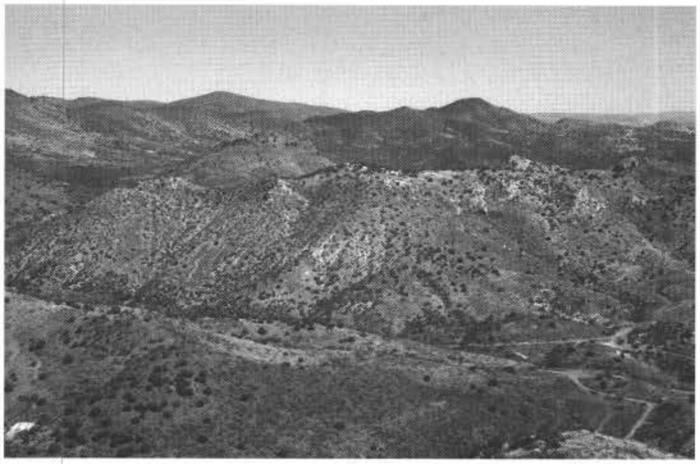


FIGURE S.9. Photo of Telephone Ridge from the air near Carlisle overlook.

ed of approximately 9800 ft of drifts, crosscuts, winzes, raises, and the 520-ft shaft (unpubl. report, R. Blanchard, 1928). The ultimate depth reached in the mine is 720 ft.

The mine closed again in 1930. In 1936–1941, Veta Mines, Inc. and other lessors operated the mine. Minor production occurred. In 1941–1942, Southwest Minerals Co. produced from the Carlisle (Gillerman, 1964). The USBM examined the Carlisle mine and other operating mines from 1942 to 1944 in response to government directives as a result of World War II. Description of drill core data is in McLemore (1993). The East Camp Syndicate, Inc. (later, the Exploration Syndicate, Inc.) leased and operated the Carlisle mine from 1943 to 1946. The mine closed again in 1951 and was allowed to fill with water to the 200-ft level. Some production occurred from the open pit in 1954, 1960, 1970s, 1982, and 1989–1990.

The Carlisle mine, now flooded, consists of a three-compartment shaft (515 ft deep) with a winze on the 500-ft level to 720 ft total depth. Levels are reported at 40, 160, 200, 250, 300, 335, 400, 450, 500, 600, and 700 ft (Griggs and Wagner, 1966; McLemore, 1993). An open pit with a decline connects to the 40-ft level. A second short adit occurs on the west side of the pit.

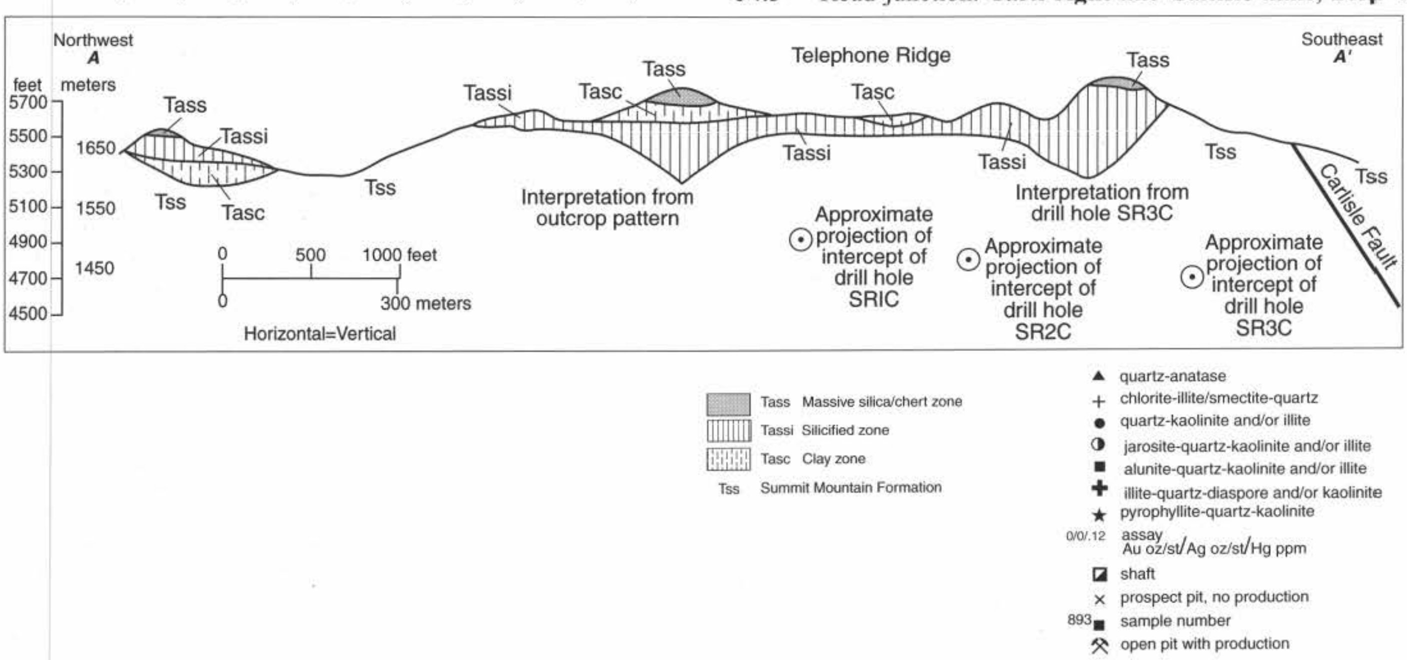
Telephone Ridge at 12:00 (Fig. S.2.9). The rocks on Telephone Ridge are intensely altered by acid-sulfate alteration and the original lithology is locally difficult to determine. Outcrop examinations and petrographic studies suggest that the original rocks were ash-flow tuffs, sandstones, and hydrothermal breccias (McLemore, 1993).

The altered areas can be differentiated into three zones on the basis of mineralogy, chemical composition, texture, and inferred temperatures (Fig. S.2.10) as (1) clay zone, (2) silicified zone, and (3) massive silica/chert zone (McLemore, 1993, *in press b*). Boundaries between the zones are typically gradational and are distinguished by quartz content and texture. The most impressive outcrops on Telephone Ridge are the massive silica/chert zone, which forms some of the largest and best exposures of this zone in the district. Silicified and clay zones surround the massive silica/chert zone and together overlie slightly altered andesite flows and tuffs. Some areas of alkali-chloride altered rocks are surrounded by acid-sulfate altered rocks. Some fractures within the alkali-chloride altered rocks are bleached and the alkali-chloride altered andesites are sandwiched between acid-sulfate altered rocks, suggesting that permeability and lithology controlled fluid migration. Fossil fumaroles occur in andesite beneath the massive silica/chert zone and indicate migration of gases. Fossil fumaroles (or vesicle cylinders) may also indicate gases escaping during deuteric cooling of the flows; however, they are only found at Telephone Ridge beneath zones of acid-sulfate alteration and suggest a spatial relationship to the alteration.

Return to vehicles and continue north along dirt road. **0.1**

54.2 Road junction. **Turn right** across Carlisle Creek. Road to left to Summit Mountain. **0.1**

54.3 Road junction. **Turn right** into Carlisle mine, **Stop 4.**



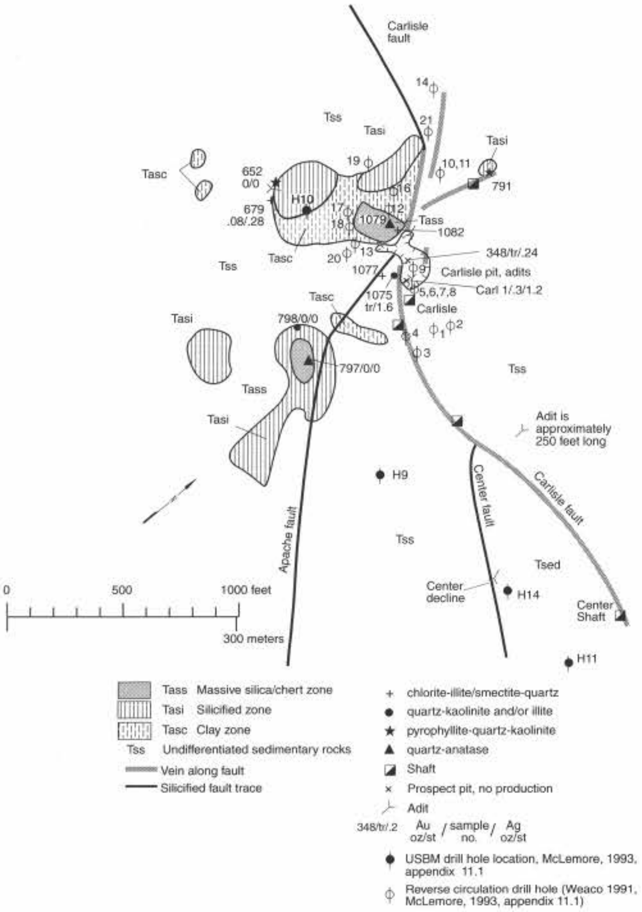


FIGURE S.2.11. Geologic and alteration map of the Carlisle mine.

Examine Carlisle mine.

The Carlisle mine was first mined by underground methods. High-grade, gold ore shoots were mined upwards and eventually the stopes broke through the surface. Open-pit mining was then used as well as underground room-and-pillar operations. Slag from the smelter is exposed in the drainage below the mine waste piles. The mill tailings were pumped downstream. Some of the mill tailings form orange-brown to tan, fine-grained material along the walls of Carlisle Canyon. In the late 1980s and early 1990s, production was from open pit and reprocessing of the mine waste piles. Foundations of the hotel, mill, and other buildings are present on the hills surrounding the mine.

The Carlisle ore bodies occur at the junction of the normally west-northwest-trending Carlisle fault and the northwest-trending Apache fault (Fig. S.2.11). The Apache fault has caused the Carlisle fault to strike locally N45°W with a 65–80°S dip (Fig. S.2.12). The Carlisle fault resumes a more westerly strike about 100 ft east of the shaft and 800 ft west of the shaft (Gillerman, 1964; McLemore, 1993). The Carlisle ore bodies are within the northwest-trending segment.

The host rock is altered andesite and andesite porphyry of the Summit Mountain Formation. Rhyolite ash-flow tuffs may be present, but the alteration is too intense to be certain. The ore bodies occur in one to three major breccia veins consisting of rock fragments, quartz, pyrite, illite, kaolinite, chlorite, and adularia

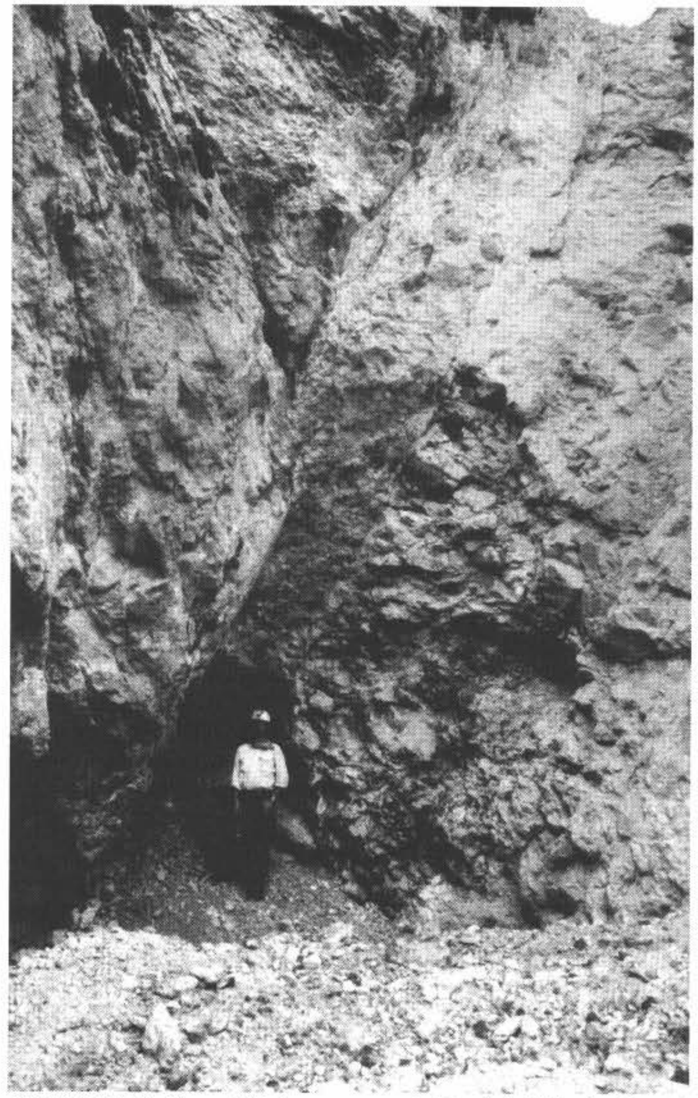


FIGURE S.2.12. View of fault zone on west side of Carlisle pit where the Apache fault merges with the Carlisle fault.

(Fig. S.2.13). The surface ore minerals include oxidized copper and lead minerals, whereas galena, sphalerite, chalcopyrite, bornite, and chalcocite are found in the mine. Ore shoots are pods, stringers, and irregular masses within the breccia veins. Some shoots were up to 8 ft wide and 200 ft long (Gillerman, 1964). Bladed calcite (lattice texture) is present. Base-metal concentrations increased with depth to the 700-ft level (Gillerman, 1964; Griggs and Wagner, 1966). Drilling by the USBM on the 700-ft level did not indicate reserves at depth (Griggs and Wagner, 1966), but early descriptions suggest not all reserves were mined. Weaco Exploration Ltd. encountered mineralized zones west of the pit in drill holes in 1991 (McLemore, 1993, appendix 11.1).

The acid-sulfate alteration extends from Telephone Ridge southward to the hanging wall of the Carlisle fault at the Carlisle mine (Fig. S.2.11). Acid-sulfate alteration is present at the Carlisle mine forming a partial cap to epithermal mineralization (Fig. S.2.14), but some veins do penetrate the acid-sulfate alteration and cut the earlier altered rock. No acid-sulfate alteration is

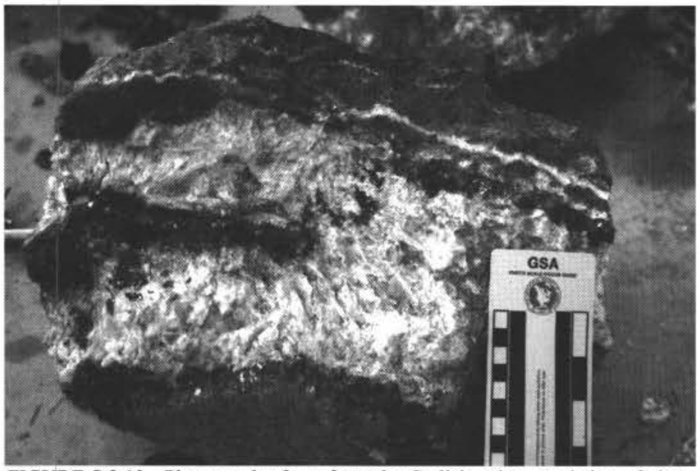


FIGURE S.2.13. Photograph of ore from the Carlisle mine consisting of alternating zones of chlorite-quartz (light gray), sulfides (black and consists of galena, chalcopyrite, sphalerite), and quartz (white).

exposed at the Center or Pennsylvania mines, east of the Carlisle mine.

The Carlisle pit floods periodically and the water may have a pH as low as 2.3 (McLemore, 1993, table 2.5). When the water evaporates, crusts of soluble copper and iron hydroxides and sulfates form along the bottom of the pit. The shaft is flooded to approximately the 100-ft level.

Return to vehicles and retrace route to main road to Center mine. **0.4**

MILLING AND SMELTING AT THE STEEPLE ROCK MINING DISTRICT

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Precious and base-metal mineralization in the Steeple Rock district occurs as siliceous veins along faults and fractures within faulted zones. Most faults in the district are exposed as siliceous outcrops and dike-like masses (Gillerman, 1964). Base-metal veins with gold and silver occur along the Carlisle fault at the center of the district, and precious-metal veins with minor base-metal sulfides occur along the north- and northwest-trending veins. Base-metal veins contain 5–20% sulfides, predominantly sphalerite, galena, and chalcopyrite, typically 0.1–0.4 oz per short ton (oz/st) gold and 1–12 oz/st silver (McLemore, 1996b). Gangue minerals consist of quartz, pyrite, chlorite, fluorite, iron oxides, and clay minerals. Fluorite and manganese veins occur along the western fringes of the district (McLemore, 1996b).

Because of the remoteness of the area and scarcity of water and fuel, most of the ores produced from the district were shipped to area smelters as siliceous flux. However, several episodes of milling activity occurred in the district. At the Carlisle mine, the largest producer in the district, a 20-stamp mill was built in 1880. Gold was recovered by amalgamation. In 1886, high-grade gold-silver ore was exhausted and only ten stamps were operating. The Carlisle Gold Mining Company Ltd. of London, England, acquired the property and enlarged the mill to 60 stamps (Anon., 1888). An average of 170 st of ore was processed daily, mostly from the second (300-ft) level. Water for the mill was pumped from the third (400-ft) level; more water was encountered when the shaft reached the 500-ft level.

Ore was hoisted through the three-compartment shaft and dumped directly into three jaw crushers from the ore cars. Crushed ore was stored in three ore bins, one for each set of 20 stamps. The ore was ground in a mortar by stamps. Stamps, weighing 850 lbs each, were lifted 10.5 in. by cams keyed to a camshaft and dropped into the mortar, at

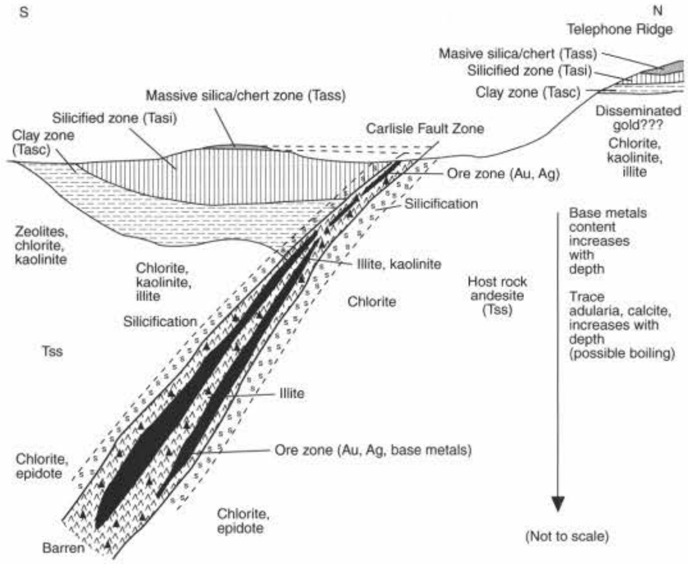

FIGURE S.2.14. Relationship between alteration and vein deposits along the Carlisle fault.

90 drops/minute. There was a set of five stamps to a mortar, called a battery, and two batteries to a camshaft. Capacity per stamp was 2–4 st of ore in a 24-hr period.

One to two ounces of mercury was added to the mortars per ounce of gold in the ore. Gold particles were freed from the gangue minerals during crushing and grinding, and formed a superficial alloy with mercury. Ground ore was continuously washed off the mortars through punched-plate screens and (gold-mercury) amalgam was recovered from the pulp on amalgamation plates and mercury traps. The amalgamation process thus recovered 86% of gold assay values.

Amalgamation tailings were fed into the gravity concentration circuit to recover the remaining gold and silver associated with sulfide minerals. The gravity circuit was composed of 36 Frue vanners arranged in three rows. Vanners were like short belt conveyors, slightly inclined, swaying back and forth horizontally. Light gangue minerals were washed downward with water, while the heavy minerals were carried upstream toward the discharge end. Concentrate production averaged 18 short tons per day (stpd) when all 60 stamps were operating. The average composition of the bulk sulfide concentrates during the summer of 1888 was 12.6% SiO_2, 1.8% Al_2O_3, 23.4% Pb, 20.6% Zn, 2.8% Cu, 11.6% Fe, and 27% S (Weinberg, 1896).

Initially, the concentrates were shipped to area smelters, including the Socorro, New Mexico, and Pueblo, Colorado, smelters. The company later decided to install a smelter at the site and several thousand short tons of concentrates were stockpiled. The smelter started in March 1888. Sulfide concentrates were first roasted in four rotary roasters, 6–7 ft in diameter, and 16–18 ft long. Eight tons of concentrate were charged to each and roasted for 36 hrs, consuming 6–7 cords of wood in the process, at $6.50 a cord. In all, 25 cords of wood were required per day, 15 cords for steam engine boilers for hoist and mill, and 10 cords for the roasters (Anon., 1888).

The smelting furnace was a square brick stack outside, and cylindrical inside. Internal diameter was 3 ft in the hearth, while at the top the furnace it was 5 ft across at the feed floor. Metallurgical coke was hauled 16 mi in wagons from the railroad in Duncan and fed into the furnace along with the roasted concentrates. A steam-powered blower supplied air-blast to the furnace. In the process, lead and copper oxides were reduced to a lead alloy (bullion) by carbon, while iron and zinc oxides were rejected into the slag along with the gangue minerals. Periodically, molten metal and slag were tapped from the furnace at about 1200°C. Slag composition varied within 23–32% SiO_2, 28–35% FeO, 5–9% Al_2O_3, 7–10% CaO, 0.2–3.0% Pb, and 16–18% Zn as ZnO and ZnS (Weinberg, 1896).

The nominal capacity of the furnace was 30 st, but it did not exceed

15 st of concentrates per day. Roasted and partially sintered furnace feed contained 6–8% sulfur and averaged 1.35 oz gold and 13 oz silver/st. About 1000 st of roasted ore were smelted during this period. Lead bullion assayed 16 oz gold and 62 oz/st silver. Gold, silver, and copper were recovered from the bullion during refining.

Overall, smelting of mixed lead-zinc concentrates at the site was not successful. Technology to make separate lead and zinc concentrates was not available at the time; the Wifley table became available in early 1900s and selective flotation in the early 1920s. Therefore, high-zinc concentrations reporting to the slag hindered proper operation of the lead-smelting furnace. Incomplete sulfur removal during roasting, which produced a layer of molten sulfides (matte) in the furnace, was another factor contributing to the failure of this venture. The mine closed in 1890.

During the war period of 1914 to 1920, high metal prices sustained production from the district. The Steeple Rock Development Company consolidated several claims and milled much of the ore at the Carlisle mill. A 100-stpd flotation mill was erected in 1916 to process the Carlisle mill tailings, producing bulk flotation concentrates.

In 1927, United Metals Corporation dewatered the Carlisle mine, sunk a winze from the 600 to the 700-ft level and drifted on this level. The company also explored the feasibility of a lead-zinc selective flotation mill. Laboratory and pilot plant tests established that it was possible to produce a 55.8% lead concentrate containing 90% of the lead, 80% of the copper, gold, and silver in the ore, and a 54% zinc concentrate containing 90% of the zinc in the ore. However, the company did not produce any ore, and in 1930, the mine was again and allowed to flood. Between 1936 and 1941, Veta Mines Inc., and in 1941 and 1942, Southwest Minerals Company, operated the mine and treated the ore and old mill tailings in their 100-tpd selective flotation mill in Duncan, AZ (Gillerman, 1964).

The East Camp Exploration Syndicate began producing from the East Camp group of claims in 1934. A 50–75-stpd cyanide mill was erected in 1940 and gold-silver ore, containing some lead and copper, was mined until 1942. The ore was crushed and ground into a fine pulp and gold and silver were leached in a dilute cyanide solution in agitated tanks. Leached solids were then separated, washed, and discarded. The leach solution was recovered, filtered, and the precious metals recovered by cementation on zinc powder. When the Priority Regulations of 1941 and early 1942 forced the closure of gold operations, East Camp Syndicate obtained a sub-lease on the Carlisle mine and five adjacent properties, and began mining for lead and zinc. Initially, the ores were hauled to Duncan and treated at the Southwest Minerals mill. In the summer of 1944, the Syndicate converted the East Camp cyanide mill into a selective flotation mill. This operation continued until 1946; the mill was dismantled in the 1950s (Gillerman, 1964).

Fluorspar and manganese were also produced in the district. A total of 6500 st of fluorspar was shipped from the Mohawk mine along Bitter Creek. During 1940–41, 1850 st of Mohawk ore analyzing 60–70% CaF_2 and 30–35% SiO_2 were shipped to Southwestern Minerals Co. mill in Duncan for upgrading by flotation (McAnulty, 1978).

Since the 1970s, sporadic production from the district, mainly for gold-bearing siliceous flux for the copper smelters in the region, was recorded. Exploration efforts intensified in the 1980s, mostly by junior mining companies. R&B Mining Co. operated the Center Mine during 1987–1994 until the ore was depleted. Mine owner, Mount Royal Mining Co., investigated the feasibility of a small flotation mill for the Center Mine and requested assistance from the New Mexico Bureau of Mines and Mineral Resources. Flotation tests conducted on both the Center and Carlisle mine ore samples produced very similar results to those obtained in the 1920s. A simple reagent scheme to produce a Pb-Cu concentrate containing 4–6 oz gold and 20–25 oz silver/st, and optionally, a zinc concentrate with small amounts of silver was developed. A flowsheet was designed and mill components were selected (M. Brueggemann and I. Gundiler, unpubl. report, 1990). Facing increasing costs, declining ore grades and metal prices, the company decided to close the mine.

In 1996, a local miner, Doug Hanson, stockpiled 500 st of ore from the Bank mine (Rubin, 1997), and in 1998, built a small flotation mill at the Center mine to process the Center mine ore with high fluorite content. The mill components were purchased from a small operation in the Gold Hill district in the Burro Mountains. The mill includes a Universal Engineering portable crushing plant (Junior B) equipped with a 10- x 16-in. jaw and a 18- x 18-in. roll crusher, fine ore bin, 4- x 6-ft ball mill, a spiral classifier, a conditioning tank, and two banks of (6) flotation cells. During trial runs in the fall 1999, Mr. Hanson opted to produce bulk concentrates, and tailings free of sulfide minerals, while trying to develop more ore reserves at the Center mine.

54.7 **Turn right** to Center mine. **0.3**

55.0 Center mill at 3:00 (Fig. S.2.15). Cross Carlisle fault. Road to left to Pennsylvania mine, middle road to Center decline and road to right to Center mill. Center shaft on ridge at 12:00. **Stop 5**, examine Center mine and climb up Telephone Ridge to examine acid-sulfate alteration.

The Center mine is located along the Carlisle fault (Fig. S.2.11) and consists of a shaft and a decline (McLemore, 1993, map 3). As ore shoots were not exposed at the surface, production did not occur until 1937. The Center mine was found when miners drifted from the adjacent Pennsylvania mine on the 120-ft level. In 1941, a raise was driven to the surface that subsequently became the Center shaft and used to haul the ore to the surface. From 1944 to 1946, the Carlisle Development Co. sank the shaft to 300 ft and developed about 3000 ft of drifts. Four levels were developed at 120, 150, 250, and 300 ft.

Various operators controlled the Center mine from 1942 to 1975, but little development occurred. In 1975, Dresser Industries Corp. began minor production, development, and core drilling (Hedlund, 1990b). In 1985, Mt. Royal Mining and Exploration Co. acquired the Center mine and in 1987 leased it to R and B Mining Co., who drove a decline below the old Center shaft and began production. R and B Mining Co. produced and shipped the ore (as siliceous flux) to ASARCO smelter in El Paso, Texas, until 1994. The ore was hauled by truck through the decline. R and B Mining Co. drilled underground and descriptions of drill core are in McLemore (1993, appendix 11.1.1). The Center decline is at an elevation of 5300 ft and extends to about 400 ft below the surface. In 1998, Doug Hanson built a mill at

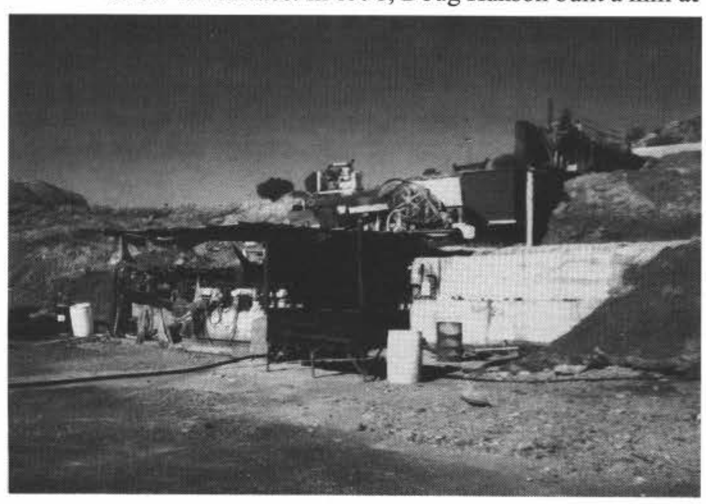

FIGURE S.2.15. Photograph of Center mill in 1999.

the Center mine and plans to reprocess the mine waste piles as well as continue mining.

The Center deposit consists of a breccia zone up to 80 ft wide along the Carlisle fault. The host rocks consist of altered purple–green andesite porphyry flows and purple–green–white tuffs, sandstones and volcanic breccias of the Summit Mountain Formation. Ore consists of gold, electrum, silver minerals, sphalerite, galena, and chalcopyrite in a gangue of quartz, pyrite, chlorite, iron oxides, adularia, gypsum, calcite, illite, siderite, dolomite, and clay minerals. Ore shoots are 1–6 ft thick and occur in bends and splays of the Carlisle fault.

Hike up ridge and examine acid-sulfate alteration. The rocks on Telephone Ridge are intensely altered and

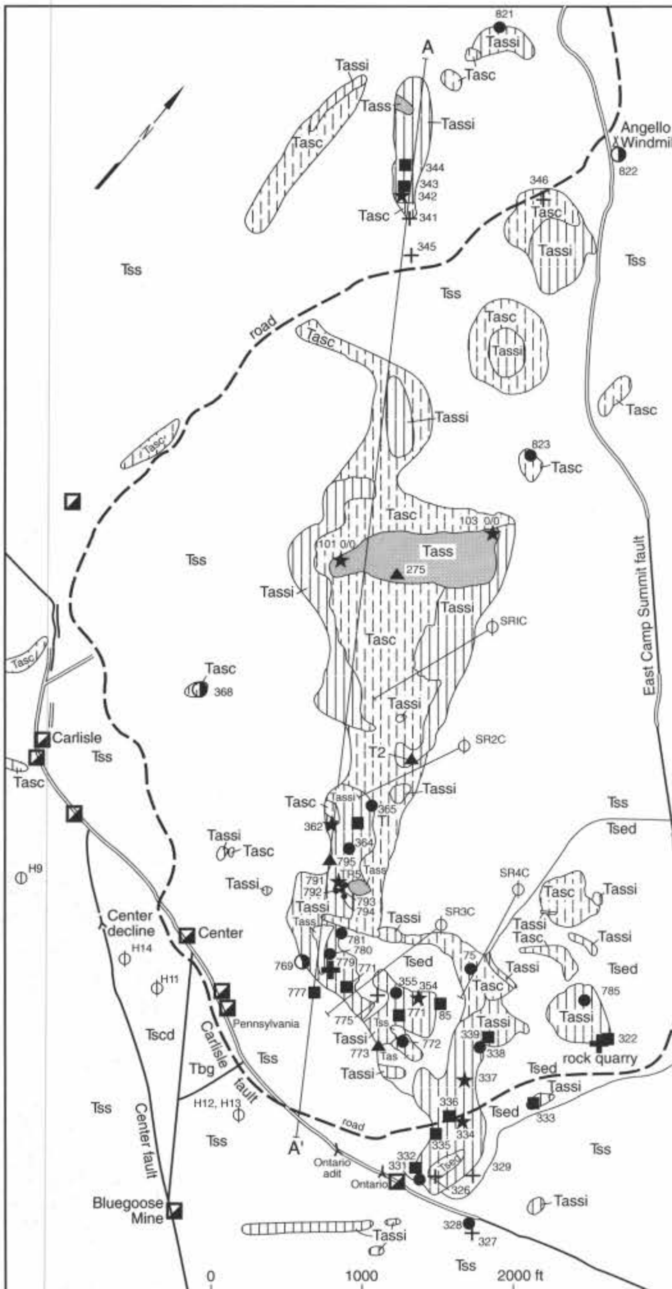

FIGURE S.2.16. Geologic and alteration map of Telephone Ridge. Cross-section A–A' (Fig. S.2.10) indicated

the original lithology is locally difficult to determine. Hedlund (1990a) mapped them as rhyolite intrusions. Biggerstaff (1974), Powers (1976), and Wahl (1980) mapped them as rhyolite ash-flow tuff. Outcrop examinations and petrographic studies suggest that the original rocks were ash-flow tuffs, sandstones, and hydrothermal breccias (McLemore, 1993; appendix 11.2). Drill data do not support an intrusive rhyolite (Fig. S.2.10). Hydrothermal breccias are common along the ridge and are similar to autobreccias observed in rhyolite plugs and domes.

The altered areas can be differentiated into three zones on the basis of mineralogy, chemical composition, texture, and inferred temperatures (Fig. S.2.16) as (1) clay zone, (2) silicified zone, and (3) massive silica/chert zone (McLemore, 1993, *in press a*). Boundaries between the zones are typically gradational and are distinguished by quartz content and texture. The most impressive outcrops are the massive silica/chert zone, which forms some of the largest and best exposures of this zone in the district (Figs. S.2.17, S.2.18). Silicified and clay zones surround the massive silica/chert zone and together overlie slightly altered andesite flows and tuffs. Some areas of preserved neutral-pH altered rocks are surrounded by acid-sulfate altered rocks (Fig. S.2.19). Some fractures within the neutral pH altered rocks are bleached and the neutral pH altered andesites are sandwiched between acid-sulfate altered rocks, suggesting that permeability and lithology controlled fluid migration.

Return to vehicles and turn around and retrace route to Carlisle Road. **0.6**

55.6 Carlisle turn-off, keep straight. **0.1**

55.7 Road junction, **keep straight** (north). **0.1**

55.8 Road junction. **Turn right** on Summit Peak Road toward Summit Mountain. **0.1**

55.9 Cross Carlisle Creek and cattle guard. **0.3**

56.2 Variegated colors along hillslope above mine waste pile at 9:00 indicate acid-sulfate alteration (Fig. S.2.20). Many of the shallow pits and adits were dug solely as exploration; no production occurred from most of them. **0.3**

56.5 Road junction, **keep left**. **0.1**

56.6 **Stop 5** at road cut in acid sulfate alteration. The varie-

FIGURE S.2.17. Massive silica/chert zone at Telephone Ridge overlying silicified zone. Looking north.

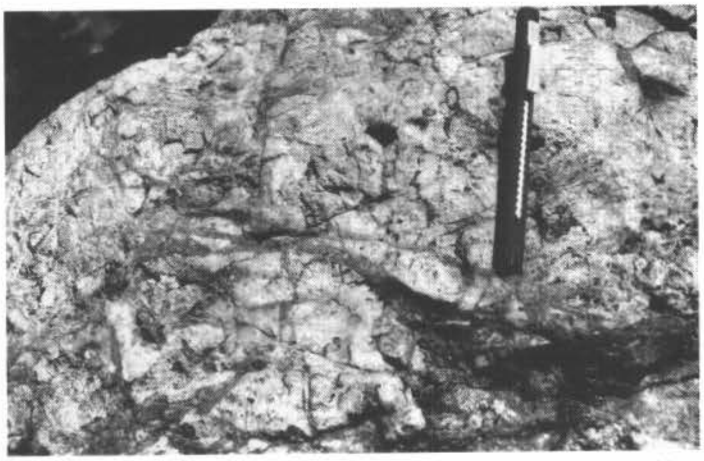

FIGURE S.2.18. Close-up view of massive silica/chert zone at Telephone Ridge.

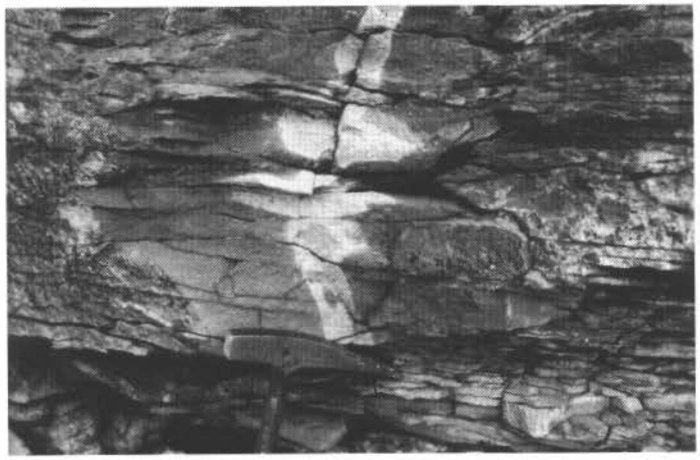

FIGURE S.2.19. Bleached clay zone along fracture in slightly altered andesite lava. The lava is overlain by the silicified zone.

gated, liesegang-banded rocks are typical of clay and intermediate silica/clay zones of acid-sulfate alteration. Road junction, **keep left**. Road to right to corral. **0.2**

56.8 Road junction, **keep right**. Road bends to right. Begin ascent to Summit Mountain. May require four-wheel-drive vehicles. Summit fault exposed on ridge (Fig. S.2.21). **0.4**

57.2 Loading facility, Apex adit. Mining of the Apex-Summit deposits was by horizontal adits. **0.1**

57.3 Drill holes. **0.2**

57.5 Portal to Summit decline. Little is known about the early history of the Summit mines. The patented claims were most likely filed near the turn of the century. By 1920, the Summit adit was 487 ft long and the Apex was 205 ft long. Several shafts (as much as 260 ft deep) and prospect pits also developed the vein prior to 1920 (unpubl. report, G. H. Utter, 1920). There was some production in 1895, but total figures are not known. At least $25,000 worth of gold and silver was produced from these mines from 1895–1920 (unpubl. report, G. H. Utter, 1920). By 1964, the Apex adit was 300 ft long and the Summit adit was 500 ft long (Gillerman, 1964). In 1977, Summit Minerals, Inc. (Charles and Douglas Hanson) was formed and controlled the Summit group of mines. Several companies have examined the property over the years. The adits now connect. **0.3**

57.8 Drill holes. **0.1**

57.9 Cross Summit fault, exposed in road cut. Bank mine at 3:00.

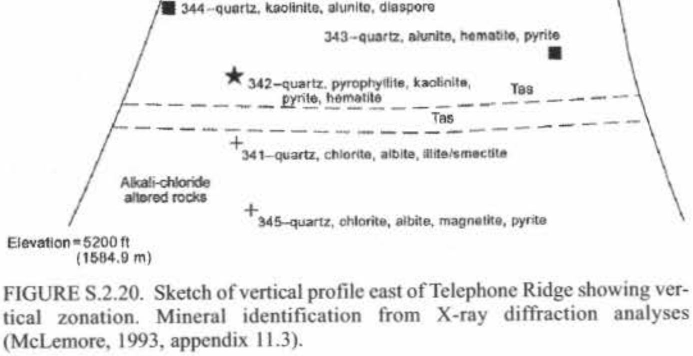

FIGURE S.2.20. Sketch of vertical profile east of Telephone Ridge showing vertical zonation. Mineral identification from X-ray diffraction analyses (McLemore, 1993, appendix 11.3).

In 1982–1984, Inspiration Mines Inc. examined and drilled along the Summit vein. Fifteen holes were drilled (McLemore, 1993, appendix 11.1.4). Reserves were calculated as 1,100,000 st in three separate ore shoots above the 5300-ft level (300 ft below the Summit adit level), with combined grades of 2.1 ppm Au and 157 ppm Ag. Part of one ore body contained 207,400 st of ore grading 2.6 ppm Au and 266 ppm Ag. Inspiration Minerals Inc. defined five additional ore shoots 400 ft below the Summit adit level that contained 121,500 st grading 2.7 ppm Ag. It is unknown how much, if any, of these reserves has been subsequently mined. These reserves occur over a strike length of over 1575 ft and average 6 ft thick with lower grades of ore surrounding the higher-grade deposits. Two or more veins are locally present (unpubl. report, Watts, Griffits, and McQuat, Inc., 1988).

In 1988, Nova Gold Resources Inc. began exploration of the Summit mine area. Biron Bay Resources, Ltd. became a partner in 1989 and up to 120 drill holes have been drilled since 1988 (McLemore, 1993, appendix 11.1.4). Reserves are estimated as 1,450,000 st of ore averaging 6.1 ppm Au and 352 ppm Ag (Petroleum and Mining Review, v. 14, 1992, p. 2). **0.2**

58.1 **Stop 6**, walk down to Bank mine. Examine acid-sulfate alteration and Bank vein north of the shaft and decline

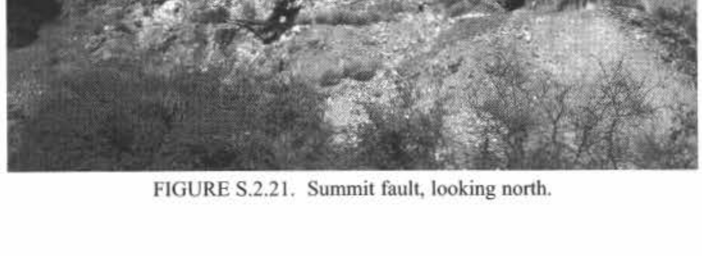

FIGURE S.2.21. Summit fault, looking north.

portal. The Bank (National Bank) mine operated in 1895 when two Smith brothers sank the shaft to 200 ft. A mill was built before 1900, but the mine and mill closed in 1900 and production is unknown. The Bank reopened in 1936–1937 when 100 st of ore averaging 8 ppm Au and 612 ppm Ag were produced (McLemore, 1993). The Bank is now 200 ft deep with levels at 75, 100, 150, and 200 ft.

An outcrop north of the shaft is typical of the Au-Ag veins along the Summit fault. Gold and silver in the Steeple Rock district are associated with banded (crustiform and coloform), rhythmically layered, and breccia quartz, although quartz veins displaying these textures may on occasion be barren of gold and silver. Banded and rhythmically layered quartz consists of hundreds of thin bands or layers of quartz interlayered with thin black bands or streaks of sulfides (pyrite, galena, chalcopyrite, and/or sphalerite). Bladed quartz, pseudomorphed after bladed calcite, forming a lattice texture is also common locally. The bladed texture is characteristic of geothermal systems and indicates that the quartz formed under boiling conditions.

The Summit fault offsets acid-sulfate alteration, which is exposed on the hills east of the Bank mine (Fig. S.2.22). The vein also cuts through the alteration (Fig. S.2.23).

Return to vehicles and continue north on dirt road. **0.1**

58.2 Sharp bend in road to right. Crossing Summit fault and acid-sulfate altered area. Continue around the bend. White outcrops along ridge at 1:00 are quartz veins filling the Norman King fault (Fig. S.2.22). **0.1**

58.3 Descend hill. Morenci tailings visible at 11:00. **0.5**

58.8 Road junction, **keep right**. Norman King mine ahead above arroyo. The Norman King mine was originally located as the Norman mine in 1883 by B. V. Steed and F. L. Heft. A patent plat was prepared in 1885 (mineral survey #515), but the patent application was never completed. Not much development occurred until the late 1800s, until Herbert Hoover worked in the area as a mining engineer. The Hoover Tunnel (also known as the Knutson adit) is named for him. O. V. Ward relocated the Norman claim as the Norman King mine in 1900. The Billali claim was also staked in the 1880s. **0.1**

58.9 Cross arroyo past Norman King mine. **0.4**

59.3 Road junction, **keep left.** Mohawk fluorite mine at 3:00. Saddleback Mountain at 9:00. **0.2**

59.5 **Turn left** at road junction and cross Bitter Creek and cattle guard. An east-west trending fault, the Bitter Creek fault, underlies Bitter Creek and offsets areas of acid-sulfate alteration and younger rhyolite dikes (Fig. S.2.23; McLemore, 1993; McLemore et al., this vol-

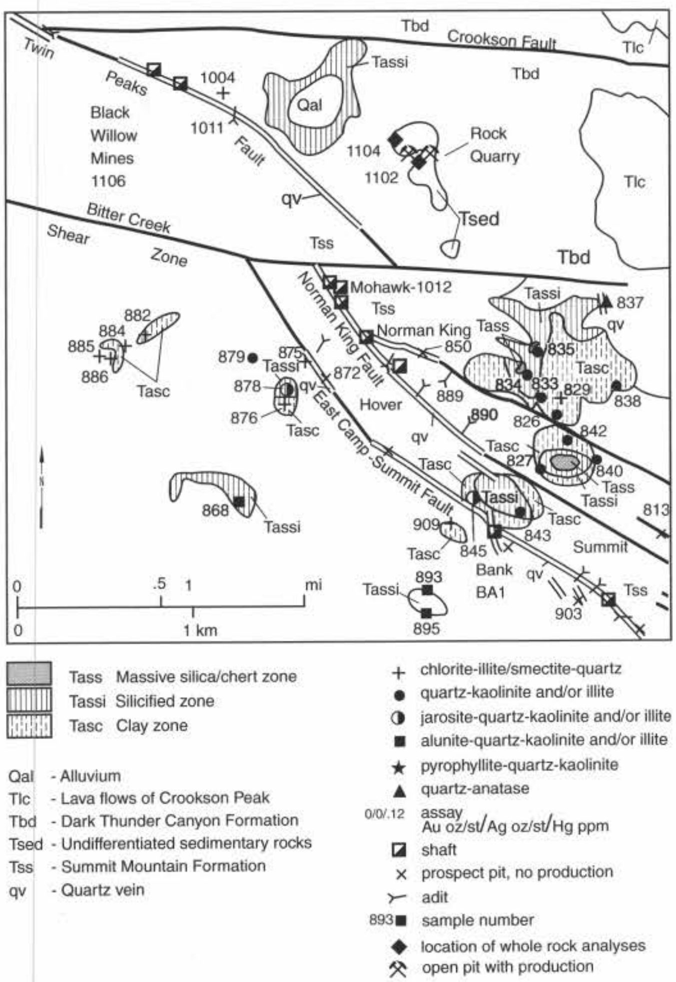

FIGURE S.2.22. Geology and alteration of the Summit and East Bitter Creek altered areas.

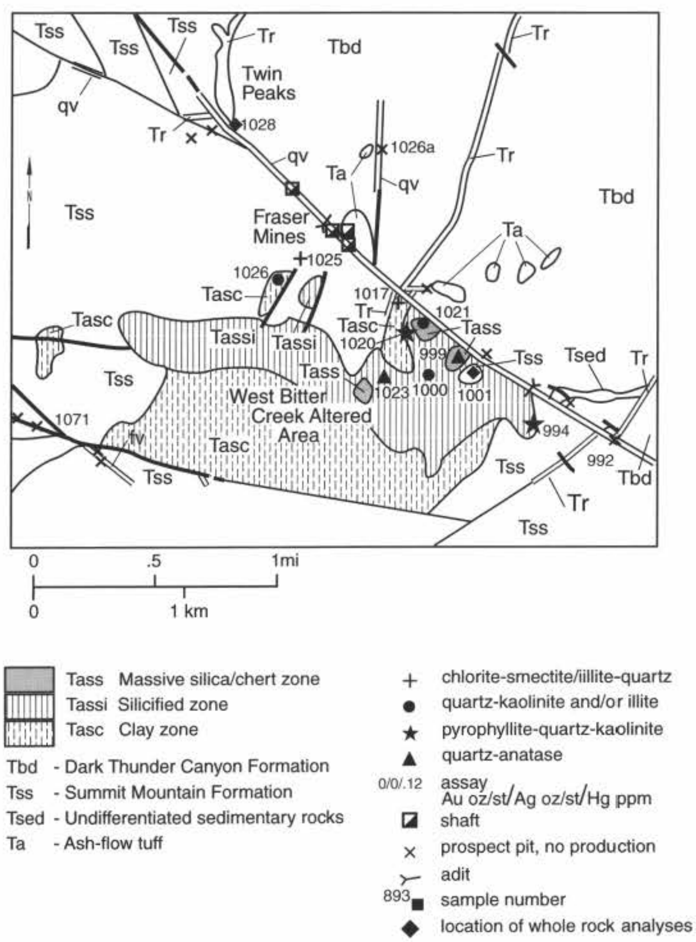

FIGURE S.2.23. Geology and alteration of the West Bitter Creek altered areas.

ume, p. 127). **0.2**
59.7 Mill foundations and tailings at 9:00. A sample of the tailings contained 17 ppm Ag. Ranch at 3:00 (Fig. S.2.24). **0.5**
60.2 Cross cattle guard. **0.4**
60.6 Road junction, **keep left**. Road to right to Apache Peak mine. **0.1**
60.7 Cattle guard. **0.6**
61.3 Area at 9:00 of red, gray, and white consists of acid-sulfate alteration. **0.1**
62.2 **Stop 7**. Examine sinter deposit on left representing a former hot-spring system. The material is soft, friable, unconsolidated, white–tan, and varies in texture from spongy to poorly indurated. It consists of gypsum, amorphous silica, and calcareous clay (McLemore, 1993). The maximum thickness is probably less than 26 ft. Examination of several samples failed to reveal any distinctive pollen for age determinations. **0.2**
62.4 Cross rhyolite dike and Bitter Creek. **0.4**
62.8 Cross acid-sulfate alteration. Silica zone forming prominent knobs at 9:00. **0.1**
62.9 Mine at 2:00. **0.3**
63.2 Cattle guard at New Mexico-Arizona border. **Keep to the right**. Road to the left to Saddleback Mountain and Goat Springs. **0.1**
63.3 Road cuts are in Quaternary alluvial fan deposits. Ascend to top of mesa. **0.6**
63.9 Road junction, **keep left**, past corral. Noah Mesa at 4:00 capped by Bloodgood Canyon Tuff. Morenci tailings at 2:00. **0.4**
64.3 Cattle guard. **0.8**
66.1 Cattle guard. **3.1**
67.4 Sharp bend in road to left. Descend hill through Quaternary alluvial fan, fluvial, and lake deposits. **4.0**
71.4 Cattle guard. **0.1**
71.5 Descend steep grade through light greenish-gray Quaternary lake beds. **0.4**
71.9 Cross cattle guard. Farms ahead. **0.8**
72.7 Cattle guard. **Turn left** onto paved AZ-75E. **0.2**
72.9 Cross bridge over Bitter Creek (past MP-390). **5.9**
78.8 Cross bridge over Sand Wash. **3.7**

FIGURE S.2.24. Mill foundations in Bitter Creek.

82.5 Carlisle Road on left, keep on AZ-75E. **0.6**
83.1 Virden Road on left, keep on AZ-75E. **0.4**
83.5 Cross bridge across Gila River and enter town of Duncan. **0.4**
83.8 Cross railroad tracks. **Turn left** onto US-70E. **1.1**
84.9 Leave Duncan and cross railroad tracks. **1.8**
86.7 Cross bridge and Railroad Wash. **2.3**
89.0 Weigh station at 9:00. **1.2**
90.2 Cross New Mexico-Arizona border into New Mexico. **4.1**
94.3 Junction with Virden Road (NM-92), continue on US-70. **21.6**
115.9 Junction with Redrock Road (NM-464), continue on US-70. **1.3**
117.2 Junction with US-90, continue on US-70E. **1.2**
118.4 Lordsburg city limit. **1.1**
119.5 Proceed under the railroad overpass to loop road to join Motel Drive. Continue east on Motel Drive to Main Street at flashing light. **0.2**
119.7 **Turn right** onto Main Street NM-494. **0.6**
120.3 I-10 overpass, continue on Main Street. **0.2**
120.6 Holiday Inn Express.
End of Supplemental Road Log.

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