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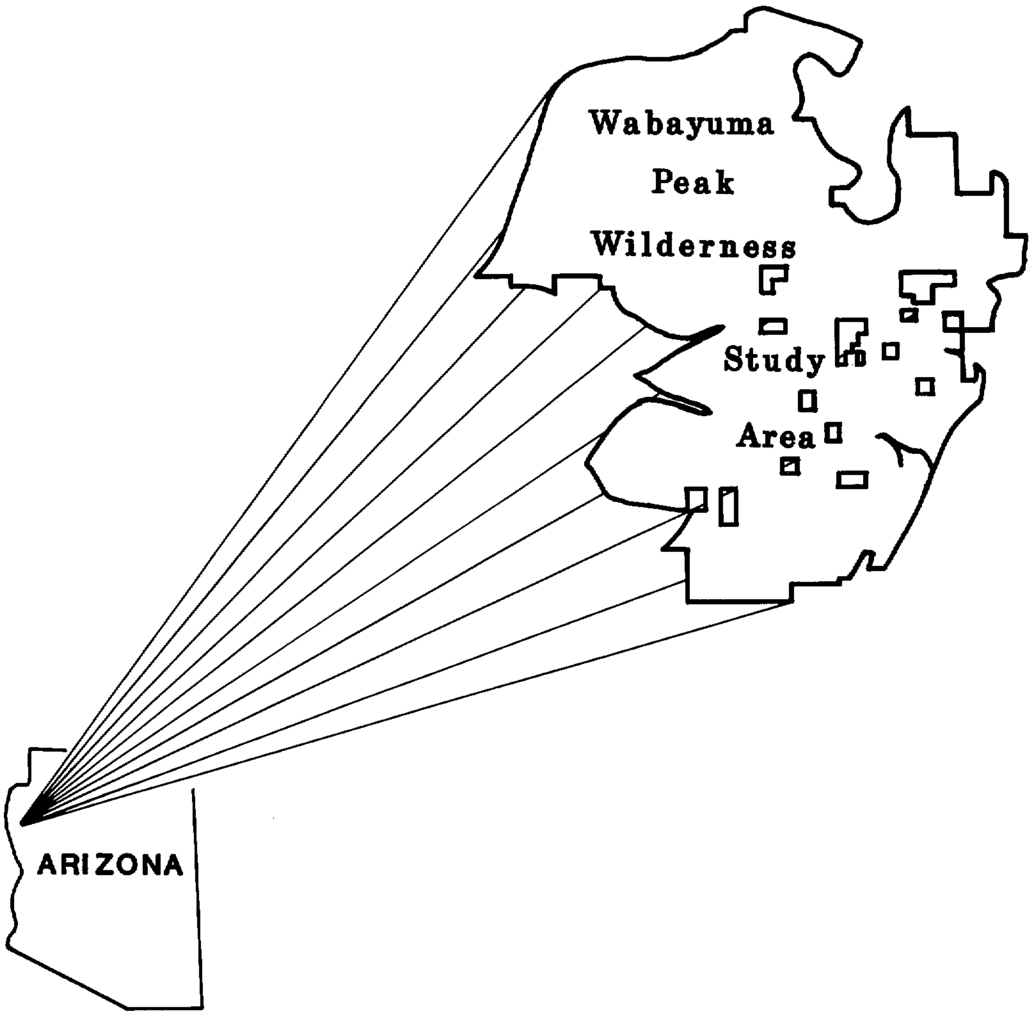
Mineral Land Assessment
Open File Report/1988

Mineral Resources of the Wabayuma Peak Wilderness Study Area (AZ-020-037/043), Mohave County, Arizona



BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

MINERAL RESOURCES OF THE WABAYUMA PEAK WILDERNESS STUDY AREA (AZ-020-037/043), MOHAVE COUNTY, ARIZONA

by

Mark L. Chatman

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1988

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Intermountain Field Operations Center
Denver, Colorado

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald P. Hodel, Secretary

BUREAU OF MINES
David S. Brown, Acting Director

PREFACE

The Federal Land Policy and Management Act of 1976 (Public Law 94-579) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Wabayuma Peak Wilderness Study Area (AZ-020-037/043), Mohave County, Arizona.

This open-file report summarizes the results of a Bureau of Mines wilderness study. The report is preliminary and has not been edited or reviewed for conformity with the Bureau of Mines editorial standards. This study was conducted by personnel from the Branch of Mineral Land Assessment (MLA), Intermountain Field Operations Center, P.O. Box 25086, Denver Federal Center, Denver, CO 80225.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

°	degree
$	dollar
ft	foot
in.	inch
mi	mile
ppb	part per billion
ppm	part per million
%	percent
lb	pound
lb/ft^3	pound per cubic foot
ton	short ton (2,000 lbs)
STU	short ton unit, equivalence of 1% grade of a mineral substance (1 short ton of 1% ore contains 1 STU = 20 lbs)
sq mi	square mile
oz/ton	troy ounce per short ton

MINERAL RESOURCES OF THE WABAYUMA PEAK WILDERNESS STUDY AREA (AZ-020-037/043), MOHAVE COUNTY, ARIZONA

by

Mark L. Chatman, Bureau of Mines

SUMMARY

The Bureau of Mines appraised the mineral resources of the Wabayuma Peak Wilderness Study Area (AZ-020-037/043), which comprises 42,650 acres in Mohave County, Arizona. The mineral resource evaluation was requested by the Bureau of Land Management and authorized by the Federal Land Policy and Management Act of 1976 (Public Law 94-579). Mines, prospects, and mineralized structures in or near the area were examined by Bureau personnel. The field study required 46 employee-days in January and February 1987.

The Wabayuma Peak study area is underlain by a complex Precambrian-age rock sequence, primarily granite, gneiss, and phyllite. The area is adjacent to the Cedar Valley base-metal sulfide mining district and the Boriana tungsten mining district. The six groups of mining claims staked in the study area are for base-metal sulfides, tungsten, and pegmatite minerals. Oil and gas leases cover 5,800 acres, but no hydrocarbon resources are known, and the USGS has rated the petroleum potential of the area as zero.

There apparently has been no mineral production from the study area. Resource blocks of the Antler Mine copper-zinc massive sulfide deposit, estimated previously, adjoin the Wabayuma Peak study area along the southern boundary. They contain indicated subeconomic resources of 350,000 to 400,000 tons with 3.0% copper, 6.5% zinc, and 3.0% lead--all outside of the study area. Drilling shows the Antler deposit extends for at least 300 ft into the southern part of the study area. This extension contains an inferred subeconomic resource with a minimum of 2,000 tons at grades of 1% to 4% copper

and 1% to 2% zinc. Part of the study area, known as "the Bulge", has geologic characteristics indicative of other massive sulfide occurrences similar to the Antler deposit, but subsurface exploration is needed for verification. Occurrences of base and precious metals in quartz veins, and occurrences of mica, feldspar, beryl, stone, and sand and gravel are present but are not resources because of their quality and/or grade.

INTRODUCTION

In January and February of 1987, the Bureau of Mines, in a cooperative program with the U.S. Geological Survey (USGS), studied the mineral resources of the Wabayuma Peak Wilderness Study Area, Mohave County, Arizona, on lands administered by the U.S. Bureau of Land Management (BLM). The Bureau surveys and studies mines, prospects, and mineralized areas to appraise reserves and subeconomic resources. The USGS assesses the potential for undiscovered mineral resources based on regional geological, geochemical, and geophysical surveys. This report presents the results of the Bureau of Mines study. The USGS will publish the results of their studies separately, and a joint USGS-Bureau report, to be published by the USGS, will integrate and summarize the results of both surveys.

Geographic setting

The Wabayuma Peak study area, part of the Basin and Range physiographic province in northwest Arizona, comprises a rugged tract of the Hualapai Mountains that is about 10.5-mi wide and 11.5-mi long. Elevations range from a high of 7,601 ft on Wabayuma Peak, to a low of about 2,480 ft where the Sacramento Valley meets the Hualapais to the west. The area is bounded on the north by Walnut Creek, on the east and south by Boriana Canyon and Mackenzie Wash, and on the west by Sacramento Valley (fig. 1).

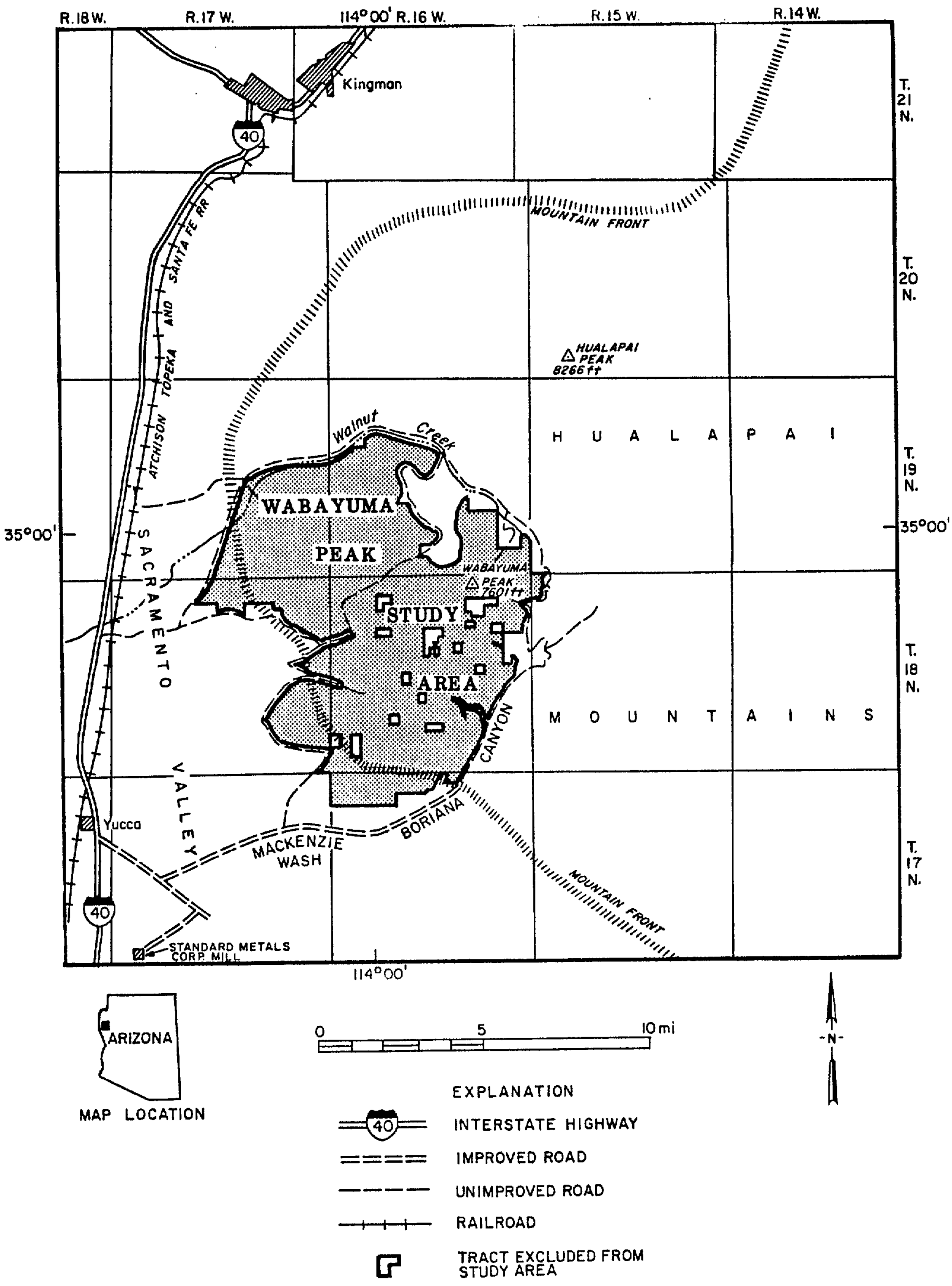

Figure 1.--Index map of Wabayuma Peak Wilderness Study Area, Mohave County, Arizona.

The area is accessible by unpaved roads which commence at the southern Yucca, and Old Trails interchanges of Interstate 40, and then follow the area perimeter. Old prospect roads traverse parts of the interior in six places. Yucca, Arizona, the nearest town, is 7 mi to the southwest. The Atchison, Topeka, and Santa Fe rail line follows the same route as Interstate 40 from Kingman, Arizona, into eastern California.

Previous studies

Geologic mapping of the Hualapai Range (Lee, 1908, pl. 1) and a geologic map of Mohave County, Arizona (Wilson and Moore, 1959), both include the total study area acreage, but on scales no larger than 1:375,000. Studies of the northward extension of the Antler Mine copper-zinc sulfide deposit entailed some work on the study area between the Antler Mine and "the Bulge", including: mapping and evaluation of lithologic origins (More, 1980); mapping and speculation on resource potential (Still, 1974); and drilling of four core holes near the southern boundary of the study area (Raabe, 1981, p. 15). Petroleum potential was evaluated by the U.S. Geological Survey (Ryder, 1983, p. C-18).

Methods of investigation

The Bureau's mineral survey consisted of a literature search for data relative to mining, minerals, and geology, discussions with individuals holding mining claims and mineral patents, examination of BLM mining claim records, and a field investigation. The field investigation consisted of examination and sampling of mine and prospect sites in and near the area, and reconnaissance for additional mineralized sites. A total of 129 samples was collected, including rock samples (104), stream-sediment samples (20), and panned-concentrate samples (5). Sampled localities are shown on plate 1. Forty-six employee-days were expended on field work.

Analytical work was done by Chemex Labs, Inc., Sparks, Nevada. Analysis for mercury and silver was by atomic absorption spectrophotometry (AA). Gold analysis was by fire assay with a neutron activation finish; the inductively coupled plasma (ICP) method was used to test for the other elements. Lower detection limits for each element are listed in Appendix A. Complete analytical results are available from the Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO.

Geologic setting

This summary of the geology is provided to enhance understanding of the minerals section. The Wabayuma Peak study area was mapped previously as Precambrian granite and gneiss with small, scattered Laramide intrusions (Wilson and Moore, 1959). Observations in this field study show that the core of the Hualapai Mountains, within the study area, is composed of pink, orthoclase-rich granite gneiss which contains hornblende gneiss layers. These rocks do not contain prospect workings or evidence of mineral resources.

The northwest quadrant of the study area and small sections along the western side of the study area are underlain by strongly foliated biotite gneiss and amphibolite, apparently in fault contact with the granite gneiss to the east. These foliated rocks have massive layers of felsic-rich pegmatites, as much as 12 ft thick, which are both concordant and strongly discordant to foliation and give these rocks a distinctive appearance. Quartz veins in the rocks along Walnut Creek contain small amounts of copper and gold. Other quartz veins in this strata contain small amounts of tungsten.

The most strongly mineralized rocks are along Boriana Canyon. Two stratabound Precambrian massive sulfide deposits known in the canyon were mined for copper and zinc. One of these, the Antler deposit, extends for at least 300 ft inside the study area. The quartz-biotite gneiss host of the Antler deposit and surrounding hornblende gneiss occupy about 1 sq mi in the southeastern part of the study area known as "the Bulge" (pl. 1); other massive sulfide deposits may be present there. Phyllitic rocks in Boriana Canyon were mined for tungsten-bearing quartz veins about 3/4 mi east of the study area boundary, at the Boriana Mine. These phyllitic rocks crop out along the eastern border of the study area to the south of the mine, but occupy only a few acres of the study area surface. Altered granite, thought to be the tungsten source, occupies the east-central part of the study area.

MINING ACTIVITY

No appreciable mineral production from within the study area is apparent. Numerous small adits, pits, and shafts along Boriana Canyon were excavated in search of extensions of the Cedar Valley district massive sulfide ores and the Boriana district tungsten-bearing veins. A few of those excavations lie within the study area boundary (pl. 1, figs. 2, 5). Another area of prospecting is along Walnut Creek, to the north, where some pits and a few deep shafts follow gold- and copper-bearing quartz veins (pl. 1, fig. 7).

The Cedar Valley (Hualapai) copper-zinc sulfide mining district includes the Antler and Copper World Mines. Extensions of the district include small prospect excavations in the southeastern part of the study area, and other prospects on the east side of Boriana Canyon (pl. 1, fig. 2) (Keith and others, 1983, map). The Antler claim was located on oxidized copper ore with 5% to 12% copper in 1879 (Romslo, 1948, p. 3). A total of about 136,000 tons of sulfide ore was produced through sporadic mining at the Antler and Copper World Mines from the 1890's to 1970; the bulk of production came between 1943 and 1954, and between 1966 and 1970 (Forrester, 1963, pl. 1; Soule', 1966, p. 11; Still, 1974, table 1).

The Antler Mine has been developed with over 6,600 ft of drifting on eight underground levels accessed by a 650-ft-deep shaft, inclined to the west (fig. 3). Mining on level 7, about 460 ft below the surface, has included northward drifting to within 100 ft of the study area boundary (fig. 4) (Still, 1974, pl. 37, fig. 4). The mine lies mostly within the Antler claim, patented in 1894 (mineral survey no. 903) (Stringham, 1946, p. 3), which is adjoined to the north by the study area. Adjoining the Antler patent are eight unpatented mining claims--two of them and part of a third are within the study area; the claims are held by Standard Metals Corp., New York City. Other base-metal mining claims are within 1 mi of the study area (ANT group, Stray Horse group, Putter group) (pl. 1), but none of these have known surface evidence of mineralization.

The Antler deposit yielded 78,251 tons of copper-zinc sulfide ore, including 34,236 tons in 1970, the last year of operation. Average grades were 2.9% copper, and 6.2% zinc, with minor lead (1%), silver (1 oz/ton), and gold (0.01 oz/ton). In the last year of mining, ore was processed in Standard Metals' 300-ton-per-day concentrator, south of Yucca (fig. 1) (Still, 1974, p. 3). Some concentrates were shipped to Japan; others were refined domestically. In earlier years, some concentrating was done on the Antler property. In the 1940's, ore was shipped to Bisbee, Arizona, for beneficiation (Romslo, 1948, p. 4).

Indicated reserves below level 5 were estimated in 1974 to be 350,000 to 400,000 tons with 3.0% copper, 6.5% zinc, 3.0% lead, 1.2 oz silver/ton, and 0.01 oz gold/ton (Still, 1974, p. i, tables 1, 2). They adjoin the study area, but are outside of the boundary. The most optimistic speculation indicates that the deposit might ultimately contain as much as 4 to 5 million tons of minable sulfides (Gilmour, 1975, p. 5).

The Boriana tungsten mining district, idle since 1957, is adjacent to the study area along Boriana Canyon. One working of the district, a small adit on the Loki claims (fig. 5), lies within the study area boundary. Total production from the district was 120,413 short ton units of WO_3 (tungsten trioxide)[1/], with about 98% coming from wolframite- and scheelite-bearing quartz veins in phyllitic rock at the Boriana Mine (Chapman, 1943, p. 3-4; Hobbs, 1944, p. 254-255; Dale, 1961, p. 73, 84, 87). None of the production came from inside the Wabayuma Peak study area. Throughout most of the study area, there are no phyllitic tungsten host rocks or mineralized structures. Production, reserves, workings, and geology of the district are summarized in Appendix B.

Current leases and claims

Current oil and gas leases cover scattered parts of the study area totalling 5,800 acres (pl. 1). There is no record of oil or gas drilling, shows, or production in or near the area (O'Sullivan, 1969a, p. 73; Peirce and others, 1970, pl. 14). The study area has been assigned a "zero" potential for petroleum on a scale of "medium", "low", "low to zero", and "zero" (Ryder, 1983, p. C-18). High metamorphic gradients characterize the region, and water well drilling records show a lack of potential source rocks (O'Sullivan, 1969b, p. 82).

1/ Equal to about 2.4 million lbs of tungsten trioxide, based on 20 lbs WO_3 per short ton unit (STU) of WO_3 (Jensen and Bateman, 1981, p. 435).

Mining claims in the study area include the Sparkle, Lizzard, and RC lode groups in the northwest quadrant; the Loki group, west of the Boriana tungsten mining district; part of the Antler group--restaked claims surrounding the Antler Mine; and one claim of the Boriana group around Boriana Mine (pl. 1).

Surface and mineral ownership

The 42,650 acres of the Wabayuma Peak study area enclose about 1,320 acres of privately owned land, in 14 separate parcels, which have been excluded from "wilderness study area" status. According to BLM Arizona State Office records of January 1987, mineral rights for only about 18,160 acres of the study area (42%) are under Federal ownership; mineral rights on the remaining acreage are privately-owned.

APPRAISAL OF SITES EXAMINED

Copper and zinc in massive sulfide deposits are known in the study area vicinity; in addition, there are tungsten-bearing quartz veins and small quartz veins with minor copper sulfides and gold. The Antler copper-zinc massive sulfide deposit extends from the Antler Mine into the study area; within the study area boundary are 2,000 tons of inferred subeconomic copper-zinc resources. "The Bulge" area, inside the Wabayuma Peak study area, has geologic characteristics indicative of other massive sulfide occurrences but subsurface exploration is needed for verification of any subsurface deposits. Several industrial minerals and rock products are present, but are not economically significant.

Copper, zinc, and other metals in massive sulfide deposits

Copper and zinc sulfides, along with small amounts of lead sulfides, and silver and gold, are found in Boriana Canyon at the Antler Mine, on the east side of the canyon at the Copper World Mine, and at several prospects south of the Copper World deposit. Deposits are of the Precambrian volcanogenic massive-sulfide type which are thought to form near fumeroles during subaqueous volcanic activity (Hutchinson, 1973, p. 1223). Significant remobilization of metals along faults is evident at the Copper World Mine and occurrences to the south.

The Antler deposit

The Antler Mine was inaccessible in 1987; workings are filled with toxic hydrogen-sulfide gas and power facilities to operate the hoist are lacking. The following descriptions are drawn from previous consultation work, as referenced. At the Antler Mine a tabular massive sulfide deposit strikes N. 20° to 30° E. over the 2,000 ft strike length and dips steeply to the northwest about 70°. En echelon folding has deformed the body with commensurate thickening and attenuation of the mineralized zone. Thickened zones represent "ore shoots" which rake north 50° at the northern end of the deposit, but rake southward at the south end, indicating a later, overall arching of the entire deposit. The lower extent of the deposit has not been reached, either by drifting or core drilling. The deposit extends to at least 650 ft in depth, but the total depth extent is not known. It is continuous along strike for at least 300 ft into the southernmost part of the study area but the actual total length of this extension is not known. (See Still, 1974, p. i, 9, 13, fig. 4, pls. 14, 18; Gilmour, 1975, p. 5.)

Resources

The economically significant part of the mineralized zone is at the north end of the deposit, adjacent to the study area, where the deposit is intercepted increasingly farther north at each successively lower level due to the northward rake of the body. Two post-ore high-angle faults offset the northern part of the deposit to the northwest for a maximum distance of 60 to 70 ft, while at depth, below level 5, two distinct mineralized zones are known; this is due to complex folding and rotational faulting. All indicated reserves defined by Still (1974, fig. 4) lie in the northern part of the deposit; reserve blocks adjoin the study area along the southern boundary, but are outside of the study area. The reserves[2/] amount to 350,000 to 400,000 tons of 3.0% copper, 6.5% zinc, and 3.0% lead. (See Still, 1974, p. i, 5, 13-17, pls. 14, 15, tables 1, 2.)

Pyrrhotite, chalcopyrite, sphalerite, some pyrite, and minor galena are the sulfide minerals present; they encase a core of fibrous silicates (tremolite, anthophyllite, actinolite) and massive chlorite, and are concentrated to the extent that 30- to 40-ft-wide stoping was possible. The overall host rock is quartz-biotite gneiss but wallrock adjacent to the sulfides is highly siliceous, pegmatitic rock composed of quartz, feldspar, and magnetite. At the south end of the deposit, similar lithologies and mineralogies are present, but the deposit thins considerably (1 to 6 ft). Nevertheless, some ore was stoped in the southern part of the deposit on levels 4 and 5 (Still, 1974, p. 11, 13, 14, 19).

Extension into Wabayuma Peak study area

Sampling by Standard Metals Corp. along the northernmost drift of the Antler Mine, on level 7, showed continuity of the copper and zinc minerals to

2/ Due to market conditions, none could be classed as reserves in 1987. Tonnages remain valid if classed as indicated subeconomic resources. Resource terminology is defined in U.S. Bureau of Mines and U.S. Geological Survey (1980).

within 120 ft south of the Wabayuma Peak boundary (fig. 3, tables 2A-B, 5). Highest overall metal concentrations in rock chip samples were 6.3% Cu and 4.7% Zn, with 0.9% Pb, and 1.3 oz Ag/ton (table 2B, no. 203A), detected in an 8-ft long sample from level 7. That particular sample had $236/ton in contained copper, zinc, lead, and silver, based on "high" commodity prices reported in Appendix D (and $6.67/oz silver). Drill core samples contained up to 9.9% copper and 14.0% zinc; maximum combined copper and zinc in any one sample was 18.4% in a hole that bottomed about 150 ft south of the current Wabayuma Peak study area boundary (table 2A, hole 18).

Surface core drilling by Standard Metals Corp. (fig. 4) verified that the deposit extends north into the Wabayuma Peak study area. In hole B-3, maximum concentrations encountered included a 1-ft interval of 7.5% Cu and 2.4% Zn at 1,120 ft, and 2 ft of 6.4% Cu and 8.9% Zn at 1,139 ft (table 3). Combined, this mineral zone has a total of 10 ft of 4% copper and 1% zinc. Holes 9 and 11 intercepted a second (eastern) mineral zone. In hole 9, the maximum concentrations were 1.4 ft of 0.1% Cu and 1.7% Zn at 604 ft. In hole 11, as much as 1.8 ft of 3.0% Cu and 6% Zn were intercepted at 671 ft (table 3). In total, this eastern mineralized zone averages 4.5 ft of 1% Cu and 2% Zn.

The extension of the Antler deposit within the Wabayuma Peak study area is estimated to contain a minimum of 2,000 tons of inferred subeconomic resources[3/] with grades of 1% to 4% copper and 1% to 2% zinc (see Appendix C for methodology). The tonnage is considered a minimum because it is based on remote drill intercepts on the outskirts of the Antler deposit. Seventy-five

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3/ Resource categories defined in U.S. Bureau of Mines and U.S. Geological Survey (1980).

percent of the resources within the study area boundary are in the western mineral zone, defined approximately by the position of hole B-3 (fig. 4). These resources are about 1,130 ft deep. The remaining resources within the study area are about 175 ft to the east in the mineral zone defined approximately by the position of holes 9 and 11 (fig. 4). These resources are about 650 ft deep.

Economics

The 2,000 tons of inferred subeconomic copper-zinc resources from the Antler deposit extension (within the study area boundary) are far too low a tonnage to be developed alone at current (1987) prices. Their economic viability is linked to the adjoining 350,000 to 400,000 tons of identified subeconomic resources from the main part of the Antler deposit that are adjacent, but outside of the study area boundary to the south.

The 1987 increase in copper prices improved the economic viability of these main Antler deposit resources. In response to closing of major U.S. operations and unreliable suppliers in Africa, copper increased from the $0.75/lb price range in mid 1987 to $1.40/lb by the end of December. Using late 1987 "high" prices for copper, zinc, and lead (Appendix D), rock from the main part of the Antler deposit (outside of the study area, but adjoining the southern boundary) could show a net return from refining of $8 per ton of ore mined[4/]. The total net value of the deposit (again, outside but adjoining the

4/ Based on $57/ton mining and milling costs [Raabe's (1981, p. 4) figure of $50/ton adjusted for inflation]; concentrator recoveries equal to those reported at the Standard Metals mill, when operating; use of three smelters (one each for copper, zinc, and lead), necessitated by the current industry conditions; net smelter returns of $51/ton for copper, $14/ton for zinc, and $0/ton for lead (lead treatment charges will outstrip refinery payments by about $3/ton).

study area boundary) could therefore be about $2.5 million. Capital expenditures needed to refurbish the mine would reduce this net value considerably. Major parts of the infrastructure must be rebuilt or replaced. The condition of the mining levels is unknown; flooding and other deterioration are likely.

Even if some net value were to remain after capital expenditures, the current volatility of the copper market must be considered as a negative factor. If copper prices were to drop from their very high levels of late 1987, the deposit would lose all semblance of economic viability. Copper production is expected to increase worldwide in 1988 (J. L. Jolly, U.S. Bureau of Mines Commodity Specialist for Copper, Washington, D.C., 1988, oral commun.), an event that will likely drive down copper prices. The entire main part of the Antler deposit, therefore, remains classed as subeconomic.

The Bulge area

The Antler deposit is geologically comparable to economically important Canadian Precambrian volcanogenic massive-sulfide deposits (Gilmour, 1969, p. 4) which notably occur in clusters of several deposits (10 or more) that represent former volcanic centers in a narrow stratigraphic interval (Sangster, 1972, p. 5, 9). Only two deposits are known in the Boriana Valley--the Antler and the Copper World. Others may be present, particularly in a part of the study area known as "the Bulge" (fig. 6). The Bulge is underlain by Antler deposit host rocks (quartz-biotite gneiss) and surrounding hornblende gneiss. Where the outcrop area of these rocks widens considerably, the site was named the Bulge (pl. 1, fig. 2). About 1 sq mi of the study area is underlain by these rocks, which are interpreted as volcanogenic (Still, 1974, p. 6; More, 1980, p. 110-111).

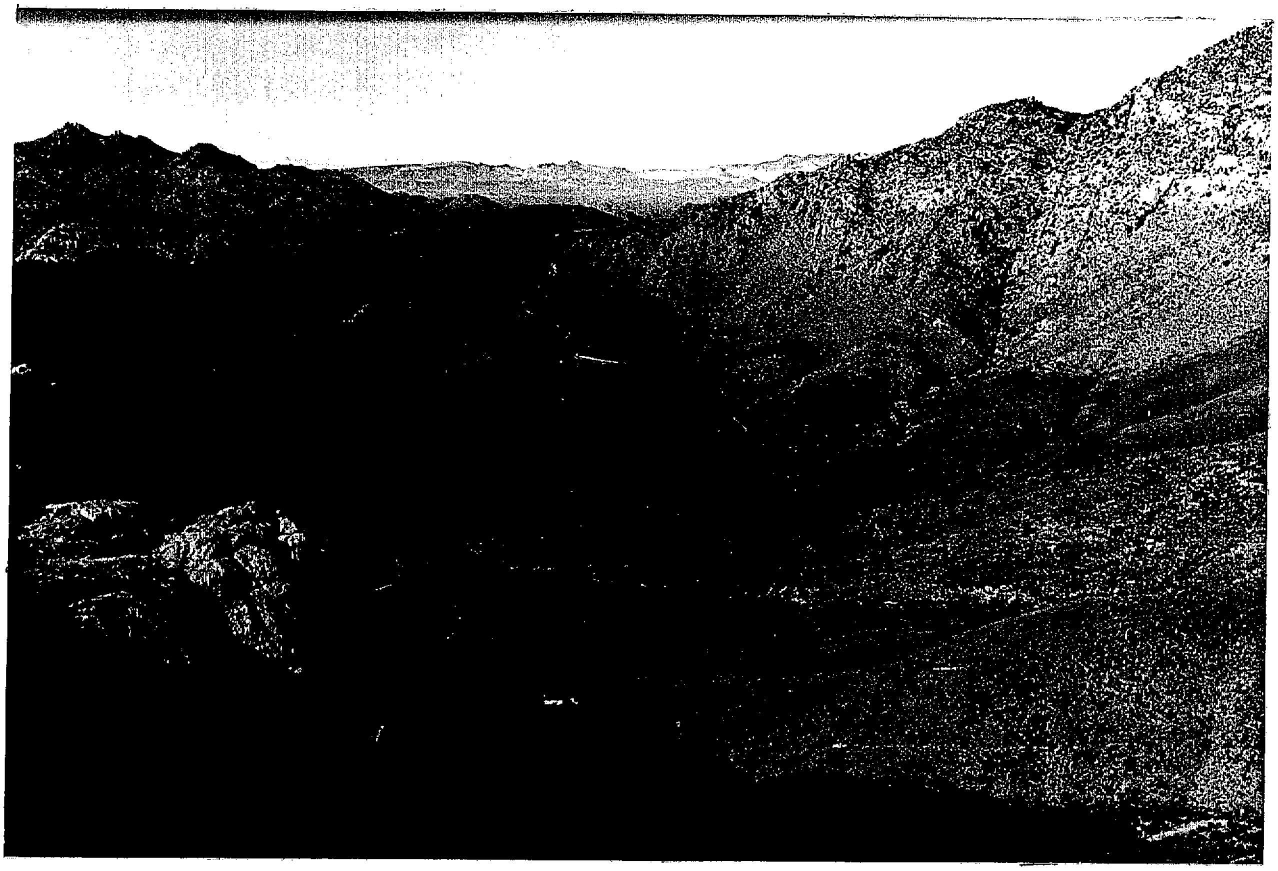

Figure 6.--The Bulge area (lower mountains with prospect roads in mid photo), seen looking west, from the site of the Copper World Mine. View is about 1 1/2 mi across.

Several key mineralogic and lithologic indicators of sulfide mineralization in a volcanogenic sequence of rocks have been reported in the Bulge. These indicators include: 1) small exposures of supergene copper oxides; 2) fibrous silicate (some copper-oxide stained) and garnetiferous zones like those encountered at or near the Antler Mine deposit; 3) thin "iron formations", ferruginous quartzitic rock that could be analogous to original siliceous sinter in the volcanogenic model; and 4) zones of cordierite-anthophyllite schists, occasionally with chlorite, that are analogous to chloride-rich metamorphosed equivalents of fumerolic extrusions in the volcanogenic model. Presence of these characteristics has resulted in the Bulge area being cited as a "prime target" for future minerals exploration because of possibilities that new deposits similar to the Antler Mine deposit may be found at depth. (See Still, 1974, p. 8; More, 1980, p. 75-77, 128.)

A 1974 Standard Metals Corp. report states that core drilling should be considered in the Bulge (Still, 1974, p. 30), which was covered at the time by 69 unpatented mining claims held by the corporation. No drilling has taken place (More, 1980, p. 128) and Standard Metals Corp. was forced to relinquish those mining claims in 1985 as a cost-cutting measure while the corporation was undergoing a Chapter 11 reorganization (Richard Rankin, comptroller, New York City, 1986, oral commun.; Art Still, geologist, Tucson, Arizona, 1986, oral commun.).

Stream-sediment samples collected from the Bulge in this Bureau survey were devoid of base-metal concentrations higher than normal for the rock type in the area (table 1). The mercury anomalies (on the order of 2,000 ppb Hg) reported by Still (1974, p. 30) in geochemical sampling over the Antler deposit were not found in the Bulge. Bureau samples there from quartz-biotite and hornblende gneiss source rocks generally did not contain more than 50 ppb Hg (20 to 30 ppb Hg is considered background). A show of copper mineralization (near sample locality 69) and a copper-zinc-bearing pegmatite (table 1, nos. 73, 74) were found.

Other Boriana Valley massive(?)-sulfide occurrences

The Copper World Mine, inactive since 1970, is the only other known sulfide deposit in Boriana Valley that is apparently of the massive-sulfide type. Fault control of this deposit dominates in the zones already mined, and remobilization of the apparent original massive sulfide deposit along the fault is suggested for this occurrence and possibly for others that are to the south (see Appendix E). Total Copper World Mine production of copper and zinc ores, about 58,000 tons, was derived from a mineralized zone that continues for 900 ft along strike and to at least 700 ft in depth from the surface. Identified resources on the order of 10,000 to 20,000 tons may remain, but their minability may be hampered by bad ground--the ore zone is heavily faulted and sheared. Mineralized rock in the mined areas is controlled along a N. 35° to 45° E. striking, vertical fault.

The fracture that controls mineral location does not extend into the study area. However, other, subparallel faults in granitic rock, equivalent to Copper World Mine wallrock, are found to the south and west of the mine, and within 0.2 mi of the Wabayuma Peak study area (fig. 2, nos. 101, 108). Excavations on these subparallel faults are confined to a few short adits and shallow shafts and pits (fig. 2, nos. 100-108). In two of the samples from the pits (table 1, nos. 101, 104), copper concentrations exceeded 1%. However, the granitic host rock does not extend into any part of the Wabayuma Peak study area.

Laramide-age quartz veins with copper sulfides and gold

Sulfide-bearing quartz veins in biotite gneiss and amphibolite occur along Walnut Creek in the northwesternmost part of the study area. Veins are exposed in several shallow pits, and in shafts as much as 60 ft deep (fig. 7, nos. 18-26). No appreciable production is apparent. Samples show a maximum copper concentration of 5,810 ppm (0.58%). All samples also contained gold--as much as 5,570 ppb (0.16 oz/ton) (table 5, no. 21). Average gold content was lower; four samples of vein quartz and one of gossan average 0.07 oz/ton. No resources can be identified because none of the veins have appreciable strike length; none are longer than 35 ft. The apparent metal source is the Laramide igneous intrusions that are common north of the study area.

Tungsten

No tungsten resources were identified in the Wabayuma Peak study area. There are two areas of tungsten occurrences: 1) the Boriana district in Boriana Canyon; and 2) small occurrences near Walnut Creek.

The Boriana tungsten mining district, idle for 30 years, is characterized by wolframite- and scheelite-bearing quartz veins in phyllitic rock. Total production was in excess of 120,000 short ton units of WO_3 (see Appendix B). The phyllitic tungsten host rock occupies a few acres of the study area along the southeastern side (figs. 2, 5), but ore zones and mineralized structures of the district do not extend into the study area. This lack of host rocks and structures severely limits possibilities for finding tungsten resources inside the study area. No tungsten was detected in phyllitic rocks there (tables 1, 4). Quartz veins within 0.2 mi, on structures that apparently do not continue into the study area, do contain as much as 1,970 ppm W (fig. 2, nos. 110-113) but this concentration is only about 25% of ore grade for operating, underground mines exploiting vein-type tungsten deposits (Anstett and others, 1985, p. 8). Altered granite, thought to be the tungsten source (Kerr, 1946, p. 102-104), occupies about 2 sq mi of the study area along the east-central border, but samples of that rock are barren of tungsten (table 4, nos. 50-55).

A small, quartz-vein-hosted tungsten occurrence, called the Ophir area, is in the northwest quadrant of the study area. A 1959 report of the site described scheelite in sparse, narrow, discontinuous quartz veins, striking N. 40° to 45° E., and dipping 50° to 70° NW. Biotite gneiss and amphibolite host the occurrence. Workings were limited to a few shallow surface cuts (Dale, 1961, p. 89). Examination of these in 1987 disclosed only one shallow pit with no observable tungsten mineralization. Sampling in the area detected tungsten in only 3 of 10 samples; tungsten concentrations detected did not exceed 270 ppm W in vein quartz, or 70 ppm W in panned concentrates of stream gravels (table 6, nos. 28-37). Two unpatented mining claims of the RC group currently cover some of the area. No resources were identified at the site.

The Lentz Black Rock tungsten claims are immediately north of the study area along Walnut Creek (pl. 1, nos. 1-3). The occurrence is of the same variety as in the Ophir area but appears to be of higher grade. The veins reportedly strike N. 60° E. and dip 55° NW., and production in the late 1950's was 15 tons of ore from shallow pits that yielded 1,200 lbs of 60% WO_3 (Dale, 1961, p. 88). Examination in 1987 revealed numerous shallow trenches, now sloughed in. Rock was exposed in only one pit. Three samples were collected (table 6, nos. 1-3), and one showed 590 ppm W. There is no evidence of tungsten continuity into the study area, but if some is present, resources that might exist would be small.

A sample of a Tertiary volcanic plug by Walnut Creek contained 140 ppm tungsten (table 5, no. 15), suggesting that related intrusions at depth may be the tungsten source for the Ophir and Lentz Black Rock occurrences. An economic evaluation of this possible tungsten source would entail subsurface exploration. Such endeavor is not recommended, because veins at the Ophir and Lentz Black Rock areas are low grade. Ore grades at underground vein-type tungsten mines are 0.5% to 1.5% WO_3 (Anstett and others, 1985, p. 10-19), or about 10 times greater than tungsten concentrations at either the Ophir or Lentz Black Rock areas.

Mica, feldspar, beryl, stone, and sand and gravel

Nonmetallic minerals and commodities in and near the study area include mica, feldspar, beryl, stone, and sand and gravel, but no identified resources are present. Precambrian gneisses contain some pegmatites, particularly in the northwest part of the study area. Lode claims staked south of Walnut Creek on large quartz-albite-orthoclase pegmatites (Lizzard and Sparkle groups) are devoid of prospect excavations. They contain very little mica. Nearby, a shallow prospect pit exposes a 2-in.- to 4-in.-wide pegmatite vein with microcline feldspar and 5% biotite. The vein, traceable along strike for 40 ft (fig. 7, no. 12), is not a resource. Other pegmatites contain small quantities of muscovite. An example is the reported Mica Ace occurrence (Elevatorski, 1978, p. 44); no appreciable amounts of mica were observed there (pl. 1). The M & C mica claim, circa 1967, was staked on the study area boundary (sec. 4, T. 18 N., R. 17 W.) where small books of muscovite, as much as 1 in. across, are in a northeast-striking quartz vein. There are no excavations or evidence of production at this site. Limited production of sheet mica, ground mica, and scrap mica was realized from pegmatites in the

Hualapai Mountains in the 1940's and 1950's during mining at the Mica Giant and Mica Hill (Merlo) Mines (Moore, 1969, p. 401-402), 4 to 6 mi northeast of the study area.

Small quantities of beryl occur in the Boriana district quartz veins; occurrences are discontinuous, sporadic, and confined to the outer edges of the veins. Seven samples were collected at the Bull Canyon Mine but only one, a dump sample, contained detectable beryllium oxide (BeO), with 0.02% BeO (Dale, 1961, p. 85-87, 89). Beryl is in the Boriana Mine dump, which contains about 100,000 tons of rock, but concentrations do not exceed 0.005% BeO (unpub. U.S. Bureau of Mines file data, 1959). Beryl-bearing pegmatite properties in the U.S. have BeO grades of 0.04% to 1.0%; none are currently (1987) operating. Economic beryllium oxide sources in North America are epithermal(?)-type deposits of the mineral bertrandite, a beryllium silicate. Grades are in the range of 0.6% to 0.85% BeO (U.S. Bureau of Mines, 1987a, p. 21; 1987b, p. 50).

Study area rock units have applications as basic rock products such as crushed stone but none have been quarried. Commercial utilization of this material is unlikely, as trucking to any market area is usually uneconomical over distances beyond about 8 or 10 mi. Kingman, Arizona, is about 20 mi away by road and the rail head at Yucca, Arizona, is about 14 mi away. Large sources of similar rock, already crushed, are present near the study area. The dump of the Boriana Mine contains an estimated 100,000-plus tons of rock (unpub. U.S. Bureau of Mines file data, 1959), much of it crushed phyllitic rock and quartzite. Small amounts have been used as local road fill along the Boriana Canyon road. Another large tonnage of crushed quartzitic rock is at the Antler Mine dump; the amount may exceed 10,000 tons.

The only sand and gravel accumulations are along the northern part of the study area in the Walnut Creek drainage. The occurrences are of insufficient tonnage for resource consideration. Materials from sand to boulder size are present, a mix that is economically deleterious. Large quantities of better-sorted material may be present in the Sacramento Valley, outside and west of the study area.

RECOMMENDATIONS FOR ADDITIONAL WORK

An effort should be made to fully define that part of the Antler deposit that is in the Wabayuma Peak study area. Ordinarily, geophysical methods would be recommended, but the Antler deposit is notably unresponsive to electromagnetic surveying as it does not represent a good conductor (Art Still, geologist, Tucson, AZ, 1987, oral commun.). Other alternatives are deep drilling from inside the study area boundary, or drifting northward on level 7 of the Antler Mine, combined with shorter drilling intervals (length). Such work would represent considerable expense relative to the current value of the metals sought. Drifting on level 7 would be the most economically expedient approach, as production revenues traditionally subsidize exploration costs. Overall, though, these revenues would be small due to market conditions.

The Bulge area should also be considered as a site for possible massive sulfide occurrences, based on the presence of favorable indicators cited previously. It is recommended that geophysical prospecting that includes electrical surveys be undertaken on the Bulge area, perhaps coupled with drilling of a few favorable sites, if any are encountered. Electrical surveys are recommended here because they were used effectively on the Copper World deposit (Silman, 1966, p. 6-9; Steve Tima, owner, Phoenix, AZ, unpublished data). The work will resolve some of the speculative aspects that now exist concerning the Bulge area. Additional exploration work may define another deposit in the range of 500,000 tons--equal to reserves plus production from the Antler deposit--which may represent a valuable resource.

CONCLUSIONS

Within the Wabayuma Peak study area are 2,000 tons of inferred subeconomic resources at grades of 1% to 4% copper, and 1% to 2% zinc, a tonnage too low for independent development. These resources are an extension of the main Antler copper-zinc sulfide deposit that is continuous from the Antler Mine into the study area. Resources remaining at the main Antler deposit are all outside of the study area but adjoin the area boundary to the south; they amount to 350,000 to 400,000 tons with 3.0% copper, 6.5% zinc, and 3.0% lead. The late 1987 jump in copper prices to about $1.40 per lb suggest a possible net return of $8 per ton from the main Antler deposit and a net total value of $2.5 million. However, necessary capital expenditures would be large, and no semblance of economic viability could be maintained should copper prices drop again. The entire deposit, therefore, remains subeconomic. The Bulge area has indicators of genetically related copper-zinc occurrences, but this cannot be confirmed without subsurface exploration.

Although the area is adjacent to a major tungsten district (the Boriana), there appears to be little evidence for tungsten resources, due to the absence of the tungsten host rock and structures from most of the study area. Other, small tungsten occurrences in the north part of the study area are too small and too low in grade for consideration as resources. There are occurrences of gold- and copper-sulfide-bearing quartz veins, and occurrences of mica, feldspar, beryl, stone, and sand and gravel in the study area. None represent resources due to their small size and/or relatively low quality. Oil and gas possibilities are rated zero, given the present understanding of the subsurface, although about 5,800 acres of the study area are leased for oil and gas.

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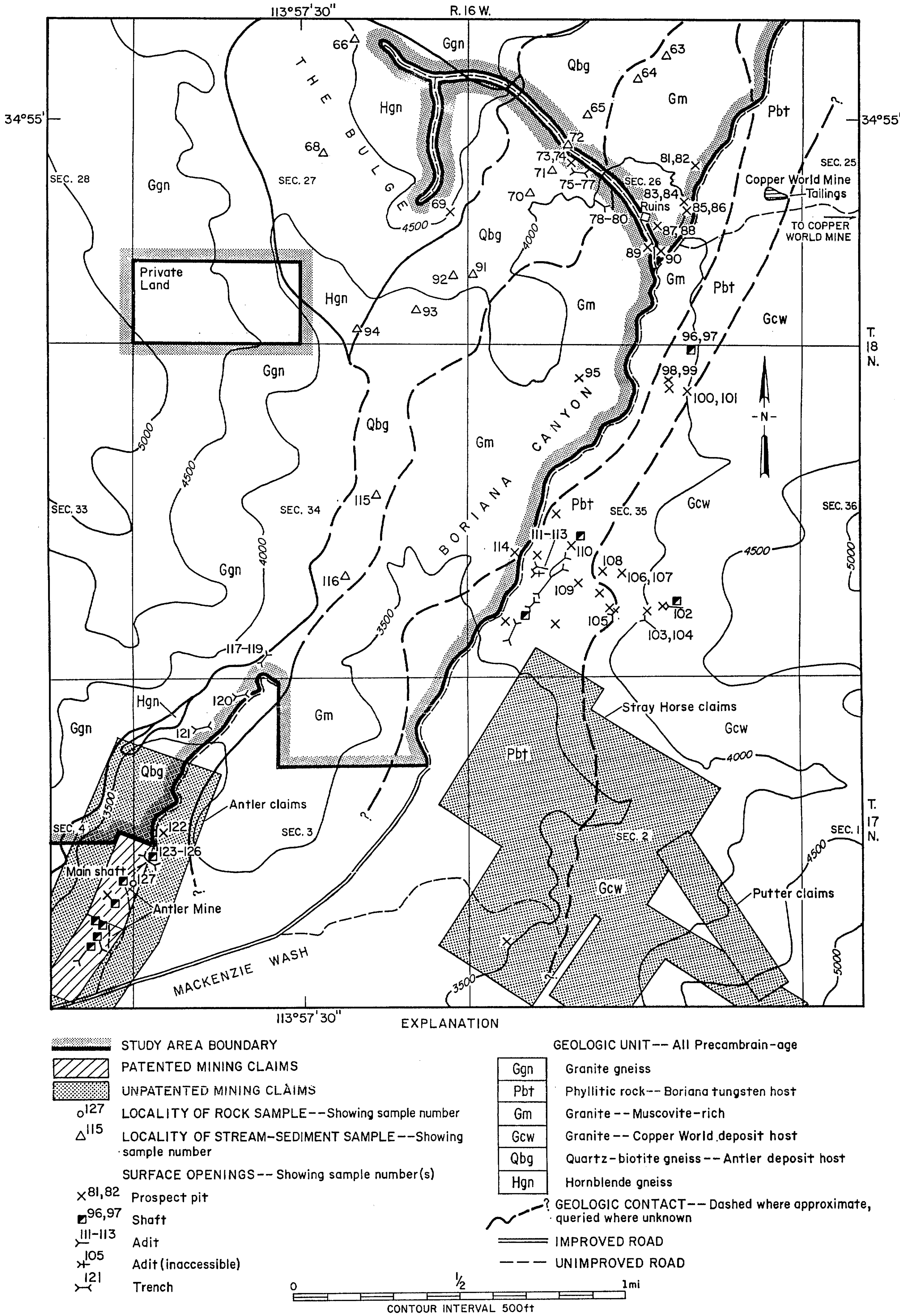


Figure 2.--Mines and prospects in lower Boriana Canyon, including the Antler Mine and prospects for extensions of the Copper World and Boriana deposits. Shown are sample localities 63-66, 68-127. Analytical data on table 1.

Table 1.--Sample data to accompany figure 2 (lower Boriana Canyon mines and prospects).

[Abbreviations used: S, stream sediment sample, -80 mesh; ---, not detected; xx, not applicable; >, greater than. All samples analyzed for Mo, none detected above 8 ppm, except sample 111; Pb and Zn below 100 ppm not reported. Note: samples 61, 62, 67, and 128 shown on plate 1 only.]

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm unless noted)	W (ppm unless noted)	Other (ppm unless noted)	Description
61	S	---	30	---	xx	Sediments derived from the Bulge.
62	S	---	17	---	xx	Do.
63	S	---	24	---	xx	Do.
64	S	---	14	---	xx	Do.
65	S	---	19	---	xx	Do.
66	S	---	12	---	xx	Do.
67	S	---	10	---	xx	Do.
68	S	---	17	---	Zn, 149	Do.
69	grab	---	12	---	xx	Hornblende gneiss near show of hydrous copper.
70	S	2	20	---	xx	Sediments derived from the Bulge.
71	S	---	14	---	xx	Do.
72	S	---	8	---	xx	Do.
73	chip, 8 in.	814	526	---	Ag, 2; Pb, 240; Zn, 249.	Pegmatite dike, strikes N. 70° E., dips 75° NW.

Table 1.--Sample data to accompany figure 2 (lower Boriana Canyon mines and prospects)--Continued

Sample		Analytical data				Description
No.	Type and/or length	Au (ppb)	Cu (ppm unless noted)	W (ppm unless noted)	Other (ppm unless noted)	
74	chip, 2 ft	1,160	558	---	Pb, 150; Zn, 338.	Quartz-biotite gneiss, adjacent sample 73, heavy limonite stain.
75	chip, 1 ft	3	---	---	xx	Breccia, mafic, strikes N. 40° W.; in 29-ft-long trench.
76	chip, 6 in.	2	5	---	xx	Pegmatite dike, strikes N. 40° W.; adjacent sample 75.
77	chip, 2 ft	---	4	---	xx	Quartz-biotite gneiss wall rock; adjacent sample 75.
78	chip, 3 in.	5	2	---	xx	Fault zone, strikes N. 25° E., dips 16° NW.; filled with clay, bedrock fragments; exposed in 12-ft-long adit.
79	chip, 2 ft	---	2	---	xx	Pegmatite pod; adjacent sample 78.
80	grab	---	13	---	xx	Quartz-biotite gneiss wall rock; adjacent sample 78.
81	chip, 1 ft	---	---	---	xx	Pegmatite pod in granitic rock.
82	chip, 1 ft	---	26	---	xx	Quartz vein, strikes N. 80° W., dips vertical; adjacent sample 81.
83	grab	---	---	---	xx	Pegmatite pod in granitic rock.
84	chip, 1 ft	---	8	---	xx	Granite; adjacent sample 83.

Table 1.--Sample data to accompany figure 2 (lower Boriana Canyon mines and prospects)--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm unless noted)	W (ppm unless noted)	Other (ppm unless noted)	Description
85	chip, 8 in.	---	8	---	xx	Quartz vein strikes N. 50° E., dips vertical, in granite.
86	chip, 2 ft	---	---	---	xx	Pegmatite pod; adjacent sample 85.
87	chip, 3 ft	9	---	---	xx	Pegmatite dike in granite, strikes N. 60° W., dips 65° NE.; muscovite; in 11 x 22 x 10 ft-deep pit.
88	chip, 3 ft	---	6	---	xx	Granite; adjacent sample 87.
89	chip, 2 ft	2	---	---	xx	Pegmatite dike in granite, strikes due N., dips vertical.
90	chip, 7 ft	---	---	---	xx	Pegmatite pod in granitic rock.
91	S	---	8	---	xx	Sediments derived from the Bulge.
92	S	---	25	---	xx	Do.
93	S	---	31	---	xx	Do.
94	S	---	13	---	Zn, 920	Do.
95	chip, 1 ft	---	6	---	xx	Pegmatite dike in granitic rock, strikes N. 10° W., dip not apparent; muscovite.
96	grab	---	48	---	xx	Phyllite, limonite-stained; from dump of shaft (debris-filled at 12 ft).

Table 1.--Sample data to accompany figure 2 (lower Boriana Canyon mines and prospects)--Continued

Sample		Analytical data				
		Au	Cu	W	Other	
No.	Type and/or length	(ppb)	(ppm unless noted)			Description
97	grab	---	80	---	Ag, 1	Quartz nodules in phyllite; from same dump as sample 96; largest nodules in shaft wall, 6 x 3 in., conformable to phyllite foliation; shaft cuts fault striking N. 50° E., dipping 75° NW.
98	chip, 7 ft	---	669	---	Hg, 280 ppb	Breccia in phyllite, strikes N. 20° E., dips vertical; quartz, feldspar, limonite stain.
99	chip, 2 ft	---	49	---	xx	Phyllite, altered; adjacent sample 98.
100	chip, 3 ft	---	329	---	xx	Phyllite in fault zone enclosed by granite that hosts Copper World deposit; fault strikes N. 50° E., dips 55° SE.
101	grab	31	>1%	---	Ag, 3; Hg, 530 ppb; Pb, 185.	Granite, Copper World deposit host; muscovite-rich, malachite and limonite stain; minor fluorite; from dump.
102	chip, 2 ft	---	911	---	xx	Fault zone, strikes N. 50° W., dips 74° NE.; in Copper World deposit granite; chloritic, minor malachite; 27-ft-long adit trends N. 85° E.
103	chip, 8 ft	---	2,400	---	xx	Fault zone, strikes N. 60° W., dips 70° NE.; chloritic; in Copper World deposit granite; 15-ft-long adit trends S. 60° E.
104	grab	29	>1%	---	xx	Granite, Copper World deposit host; adjacent sample 103; fractured, muscovite rich; malachite, azurite, fluorite, chlorite.

Table 1.--Sample data to accompany figure 2 (lower Boriana Canyon mines and prospects)--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm unless noted)	W (ppm unless noted)	Other (ppm unless noted)	Description
105	chip, 3 ft	---	16	---	Ti, 1.4%	Mafic rock, aphanitic, feldspar phenocrysts; along contact of Boriana-type phyllite and Copper World deposit granite.
106	grab	11	6,310	---	Pb, 100	Granite, Copper World deposit host; malachite; from dump of 12-ft-deep open cut.
107	grab	6	1,480	---	Zn, 181	Phyllite, Boriana-type; enclosed by Copper World deposit granite; from dump.
108	grab	7	8,000	---	xx	Granite, Copper World deposit host; fine-grained; malachite, azurite, quartz veinlets; from dump.
109	chip, 2.5 ft	7	1,320	---	xx	Quartz vein, strikes N. 40° W., dips 79° SE., in Boriana-type phyllite/quartzite; azurite, malachite.
110	select	4	8,320	1,970	Ag, 4	Phyllite, Boriana-type; malachite blebs on foliation planes; chalcopyrite, wolframite.
111	select	4,350	3,650	60	Ag, 39; Hg, 770 ppb; Mo, 242; Pb, 1,800.	Phyllite, Boriana-type, with quartz veinlets, azurite, malachite, limonite, wolframite; from dump; adit trends S. 40° E. for at least 100 ft and has bad air (H_2S gas).
112	chip, 4 in.	11	32	---	xx	Quartz lens, gray, at adit portal.

Table 1.--Sample data to accompany figure 2 (lower Boriana Canyon mines and prospects)--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm unless noted)	W (ppm unless noted)	Other (ppm unless noted)	Description
113	grab	2	19	---	xx	Phyllite, Boriana-type; bedrock at adit portal.
114	select	28	5	---	xx	Vein quartz, float; occurs in Boriana-type phyllite.
115	S	---	15	---	xx	Sediments derived from Antler deposit host rocks.
116	S	---	27	---	xx	Do.
117	chip, 3.5 ft	---	2	---	xx	Quartz-biotite gneiss with limonite blebs; 35-ft-long trench.
118	chip, 4 in.	---	17	---	xx	Pegmatite dike, horizontal; adjacent sample 117.
119	select	---	2	---	xx	Quartz-biotite gneiss, limonite-stained; from dump.
120	chip, 22 ft	---	3	---	xx	Quartz-biotite gneiss; in 40-ft-long trench.
121	chip, 10 ft	---	3	---	xx	Quartz-biotite gneiss, cut by epidote veinlets; limonite blebs; in 50-ft-long trench.
122	grab	35	124	---	xx	Chlorite schist, limonite-stained; mica-rich; garnet.
123	chip, 2 ft	169	6,870	---	Ag, 17; Pb, 790; Zn, 1,785.	Fault strikes N. 18° E., dips 47° NW.; gouge, limonite, chlorite, hematite; in 60-ft-long trench.

Table 1.--Sample data to accompany figure 2 (lower Boriana Canyon mines and prospects)--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm unless noted)	W	Other	Description
124	chip, 3 ft	3	4,600	---	Ag, 2; Pb, 195; Zn, 9,510.	Schist, mica-chlorite; adjacent sample 123.
125	chip, 3 ft	2	4,570	---	Ag, 2; Pb, 105; Zn, 1,930.	Quartz-biotite gneiss; malachite, limonite on fractures; hanging wall adjacent sample 123.
126	chip, 1.5 ft	262	7,710	---	Ag, 17; Pb, 275; Zn, 1,485.	Quartz pod; 7% limonite, hematite; adjacent sample 123.
127	grab	9	21	---	Zn, 115	Gneiss, gray; 95% quartz, 5% biotite; from Antler Mine dump.
128	grab	---	2	---	xx	Granite gneiss; major component of mountain range core.

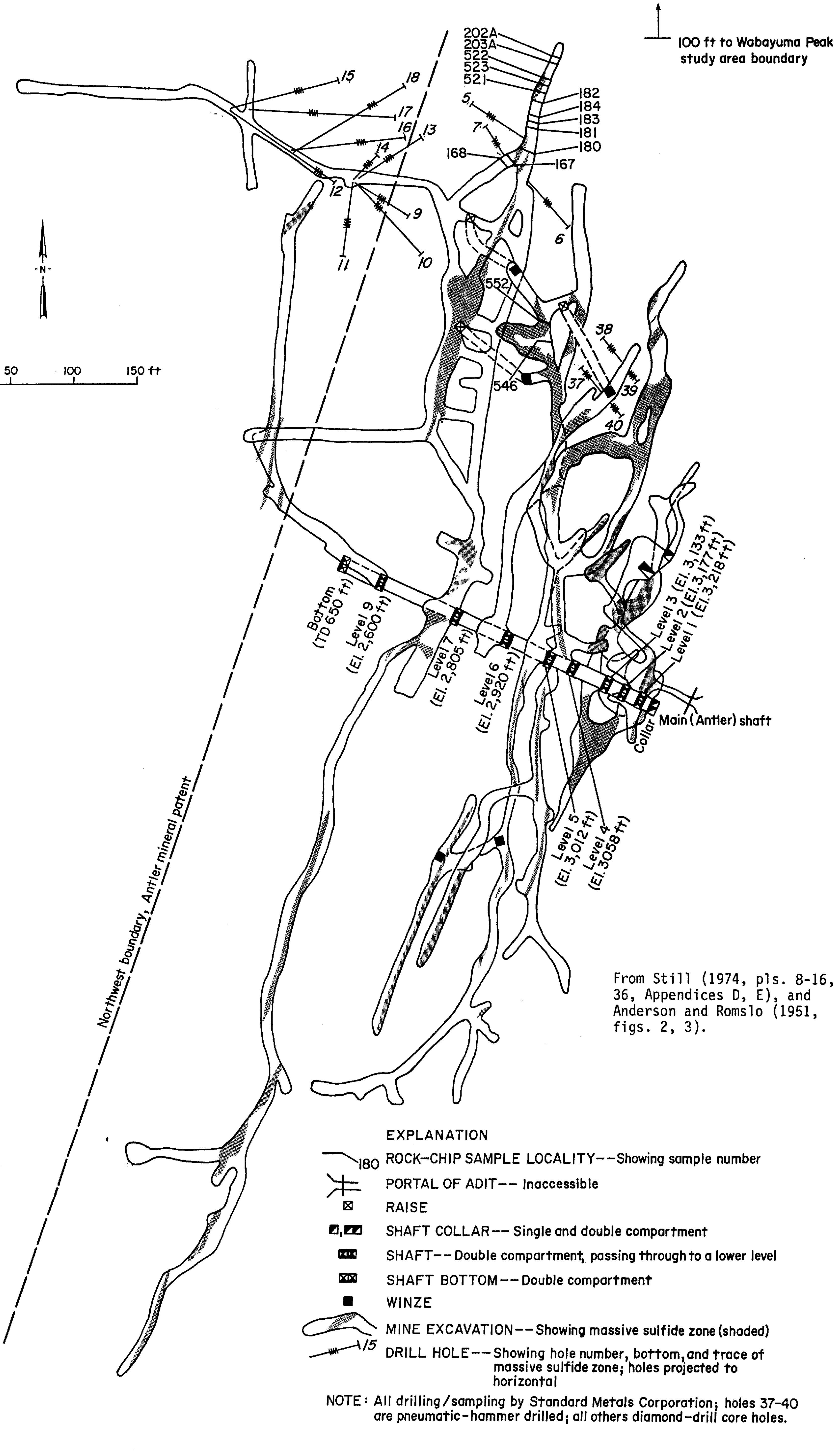


Figure 3.--Main underground workings, Antler Mine. Analytical data on tables 2A, 2B.

Table 2A.--Assays of mineralized intervals from underground drilling, levels 5 and 7, in the Antler Mine.

[Drill hole localities shown on figure 3. Data from Still (1974, Appendices D, E). Drilling/assays by Standard Metals Corp. Abbreviations used: tr, trace; ---, not detected.]

Hole no.	Interval-Ft		Analytical data Au (oz/ton)	Ag (oz/ton)	Pb (%)	Cu (%)	Zn (%)
5	0.0 - 5.0	(5.0)	0.010	3.6	0.1	2.0	3.2
	5.0 - 7.0	(2.0)	---	.1	.1	.2	1.4
	7.0 - 8.0	(1.0)	tr	.1	.1	.2	3.5
6	0.0 - 4.0	(4.0)	.007	.2	.1	.7	2.0
	4.0 - 10.0	(6.0)	tr	.4	.1	3.4	3.7
7			No Mineralization				
9	70.0 - 75.0	(5.0)		.30	.40	.50	.60
	75.0 - 76.6	(1.6)	.010	3.00	3.90	.85	2.50
	76.6 - 76.9	(0.3)	---	.80	.80	.85	1.10
	76.9 - 77.2	(0.3)	---	.80	.80	.85	1.10
	77.2 - 78.0	(0.8)	---	.80	.80	.85	1.10
	78.0 - 80.3	(2.3)	.010	3.30	4.20	.70	6.20
	94.2 - 95.2	(1.0)	.010	1.80	1.40	1.90	11.00
	95.2 - 95.7	(0.5)	---	.80	.60	1.70	6.70
10	76.0 - 80.0	(4.0)	.013	.40	.30	2.60	1.90
	80.0 - 81.0	(1.0)	.007	.20	.50	.50	3.40
	81.0 - 83.5	(2.5)	.005	.90	.30	3.70	2.00
	83.5 - 84.0	(0.5)	.005	.70	1.40	1.50	10.60
	84.0 - 86.0	(2.0)	.025	1.60	1.40	3.60	8.70
	86.0 - 87.7	(1.7)	.007	1.40	1.60	1.60	7.20
	87.7 - 88.7	(1.0)	.008	1.40	.60	.70	1.20
	88.7 - 91.0	(2.3)	---	.05	1.60	.50	2.20
	91.0 - 92.3	(1.3)	---	.30	.20	.90	.70
	92.3 - 93.7	(1.4)	.005	.90	.70	.90	.20
	93.7 - 95.0	(1.3)	---	.05	1.10	.20	2.00
	95.0 - 98.0	(3.0)	---	---	.40	.30	.20
	98.0 - 103.0	(5.0)	---	.05	.70	.20	.80
11	156.0 - 161.0	(5.0)	.015	.40	.30	3.10	2.00
	161.0 - 163.0	(2.0)	---	.40	.30	.20	.20
	163.0 - 167.0	(4.0)	---	.30	.30	.30	.20
	167.0 - 171.0	(4.0)	.005	.30	.50	.80	1.40

Table 2A.--Assays of mineralized intervals from underground drilling, levels 5 and 7, in the Antler Mine.

Hole no.	Interval-Ft		Analytical data Au	Ag	Pb	Cu	Zn
			oz/ton		%		
12	209.0 - 211.0	(2.0)	---	0.05	0.20	0.20	1.10
	211.0 - 213.0	(2.0)	0.005	.50	.30	1.70	1.00
	213.0 - 214.0	(1.0)	.007	.30	.20	.75	1.10
	214.0 - 216.2	(2.2)	.008	.70	.50	.50	1.70
	216.2 - 218.0	(1.8)	.005	1.10	.70	.30	7.60
	218.0 - 223.0	(5.0)	---	.60	.30	.45	6.20
	223.0 - 224.5	(1.5)	.004	.30	.10	.60	4.50
13	67.0 - 68.0	(1.0)	.005	.50	1.00	.60	13.50
	68.0 - 69.0	(1.0)	.005	6.00	8.20	.30	13.00
	69.0 - 70.0	(1.0)	.005	1.00	1.40	.10	9.40
	70.0 - 75.0	(5.0)	.005	1.90	3.00	.20	11.30
	75.0 - 79.8	(4.8)	.010	2.40	3.70	.25	8.20
	79.8 - 86.0	(6.2)	.005	1.00	1.30	.55	6.70
	86.0 - 91.0	(5.0)	---	.40	.40	.45	3.50
	91.0 - 93.7	(2.7)	---	---	.40	.10	.50
	93.7 - 96.0	(2.3)	---	.05	.10	.30	.30
	110.0 - 113.0	(3.0)	---	.60	.50	1.60	2.50
14	109.0 - 113.0	(4.0)	.005	.90	.60	3.70	10.30
	113.0 - 117.0	(4.0)	.010	.90	.70	3.00	9.30
	117.0 - 121.0	(4.0)	.010	1.20	1.10	3.10	8.50
	121.0 - 122.0	(1.0)	.005	.40	.20	2.00	3.30
15	196.6 - 200.2	(3.6)	.015	3.10	4.20	1.70	4.30
	200.2 - 201.7	(1.5)	.025	3.70	4.30	.20	3.30
	201.7 - 206.0	(4.3)	.005	.30	.20	.50	1.00
	206.0 - 214.0	(8.0)	---	.10	.20	.60	1.40
	214.0 - 216.0	(2.0)	.030	1.20	1.60	.60	.80
	216.0 - 217.2	(1.2)	.030	1.20	1.60	.60	.80
	217.2 - 220.0	(2.8)	.030	2.40	2.50	2.70	3.20
16	118.0 - 120.0	(2.0)	.010	4.10	5.20	1.10	21.20
	120.0 - 122.0	(2.0)	.020	1.10	1.30	5.30	14.00
	122.0 - 124.0	(2.0)	.010	1.50	1.20	5.50	9.50
	124.0 - 125.4	(1.4)	.012	1.50	1.40	4.30	13.00
	125.4 - 126.0	(0.6)	.020	1.78	1.95	2.80	12.15
	126.0 - 130.0	(4.0)	.010	1.80	2.00	1.40	11.80
	130.0 - 134.5	(4.5)	.010	1.50	1.70	2.60	11.40
	134.5 - 135.0	(0.5)	.030	1.70	2.20	1.10	1.00
17	191.0 - 196.0	(5.0)	.005	.80	.80	1.40	2.00
	196.0 - 201.0	(5.0)	.015	3.60	5.30	.50	2.60
	201.0 - 206.0	(5.0)	.007	.80	1.00	1.20	.80
	206.0 - 211.5	(5.5)	.007	.80	1.20	.90	1.00
	211.5 - 216.0	(4.5)	.005	.60	.40	1.60	4.80

Table 2A.--Assays of mineralized intervals from underground drilling, levels 5 and 7, in the Antler Mine.

Hole no.	Interval-Ft		Au (oz/ton)	Ag (oz/ton)	Pb (%)	Cu (%)	Zn (%)
18	124.0 - 127.0	(3.0)	0.010	2.40	2.70	3.60	14.00
	127.0 - 132.0	(5.0)	.012	1.50	1.50	2.00	14.00
	132.0 - 138.0	(6.0)	.012	2.10	3.10	.80	12.80
	138.0 - 142.0	(4.0)	---	.50	.70	.80	4.40
	142.0 - 145.0	(3.0)	.005	.90	1.30	1.00	6.00
	145.0 - 160.0	(15.0)	.008	.60	.50	.40	1.10
	160.0 - 162.0	(2.0)	---	.50	.60	2.00	6.00
	162.0 - 164.0	(2.0)	.025	.90	.80	7.90	9.00
	164.0 - 166.0	(2.0)	.015	.70	.40	8.20	10.20
	166.0 - 169.0	(3.0)	.065	1.60	.60	9.90	8.40
	169.0 - 174.8	(5.8)	---	.10	.50	1.20	3.50
	174.8 - 176.0	(1.2)	.010	.40	.60	3.10	7.20
	176.0 - 178.2	(2.2)	.005	.40	.30	1.50	4.90
37	0.0 - 4.0	(4.0)	.007	.2	.1	.7	2.0
	4.0 - 8.0	(4.0)	tr	.1	.1	tr	.1
	8.0 - 12.0	(4.0)	.008	.2	.1	tr	.2
	12.0 - 16.0	(4.0)	.005	.2	.1	tr	.1
	16.0 - 24.0	(8.0)	.005	.2	.1	.3	.1
	24.0 - 32.0	(8.0)	tr	tr	.1	.3	.2
	32.0 - 40.0	(8.0)	tr	tr	.1	tr	.1
38	0.0 - 6.0	(6.0)	tr	.1	.1	.4	.3
	6.0 - 13.0	(7.0)	tr	tr	tr	.1	.2
	13.0 - 19.0	(6.0)	tr	tr	.1	.1	.1
	19.0 - 25.0	(6.0)	tr	tr	.1	tr	.1
39	0.0 - 5.0	(5.0)	tr	tr	.1	1.0	4.1
	5.0 - 9.0	(4.0)	tr	tr	tr	.1	.2
	9.0 - 13.0	(4.0)	tr	.2	.1	.2	.2
	13.0 - 15.0	(2.0)	tr	tr	.1	tr	.1
40	0.0 - 7.0	(7.0)	.008	.2	tr	.3	.5
	7.0 - 10.0	(3.0)	.012	.3	.1	1.9	.6
	10.0 - 12.0	(2.0)	.013	.1	tr	1.4	1.0
	12.0 - 16.0	(4.0)	.005	.2	.1	.1	.2
	16.0 - 21.0	(5.0)	tr	tr	.1	.1	.4
	21.0 - 25.0	(4.0)	tr	.1	tr	.1	.3

Table 2B.--Assays of rock-chip samples collected from levels 6-7 in the Antler Mine (see figure 3).

[Assays by Standard Metals Corp. Data from Still (1974, Appendices D, E). Abbreviation used: ---, not detected.]

Sample		Analytical data				
		Au	Ag	Pb	Cu	Zn
No.	Width (ft)	oz/t		%		
167	8.0	0.012	1.4	1.3	2.5	6.2
168	7.0	.010	1.2	1.2	.5	5.7
180	8.0	.012	1.2	1.3	1.2	7.1
181	8.0	---	.1	.1	.1	.2
182	8.0	.004	.1	.1	.1	1.4
183	8.0	---	.3	.1	1.0	2.4
184	8.0	.006	.2	.2	.2	2.4
202A	7.0	---	.2	.2	.3	5.2
203A	8.0	.007	1.3	.9	6.3	4.7
521	9.0	.005	1.0	1.6	.3	6.5
522	8.0	---	.1	.1	.1	2.1
523	9.0	---	.2	.1	.4	2.7
546	7.0	.012	1.9	.7	9.7	4.8
552	5.0	.008	1.5	1.0	7.8	7.2

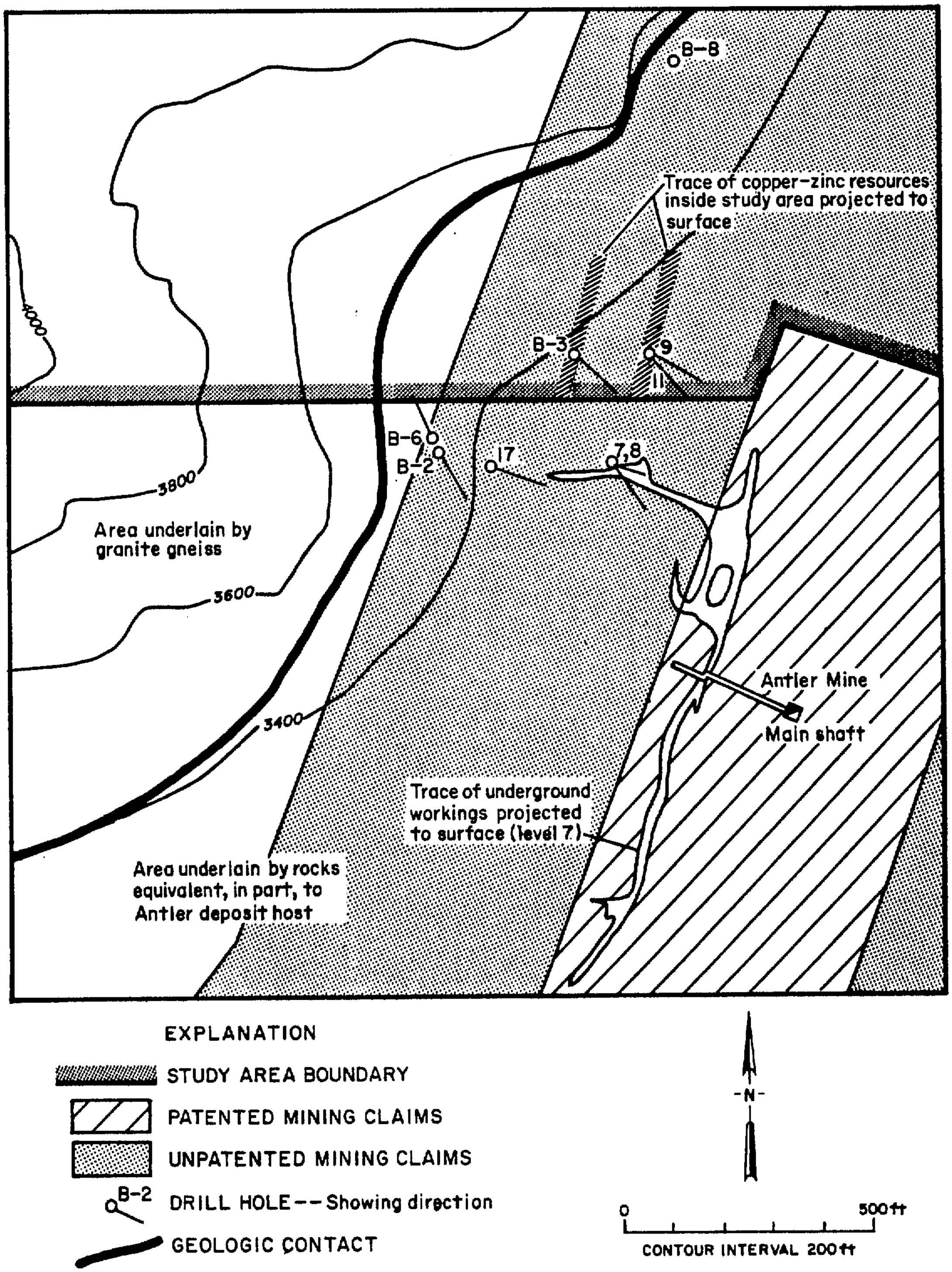


Figure 4.--Antler Mine area, showing northernmost extent of level 7 workings and surface drill hole sites in and near Wabayuma Peak Wilderness Study Area. Drill logs in table 3. Base adapted from Still (1974, pl. 37). Additional data from notes, A. R. Still (1/20/75).

Table 3.--Assays of mineralized intervals from surface core drill holes in or near Wabayuma Peak study area.

[Drill hole localities shown on figure 4. Data from Raabe (1981, p. 14-15), and Still (1974, Appendices D, E). Drill assays by Standard Metals Corp. Note: * indicates drilling inside the Wabayuma Peak study area. Abbreviations used: ---, not detected; tr, trace.]

			Analytical data				
			Au	Ag	Pb	Cu	Zn
Hole no.	Interval-Ft		oz/t		%		
B-2	1429.0 - 1431.0	(2.0)	0.006	1.25	2.40	1.10	14.00
	1431.0 - 1433.0	(2.0)	.011	.50	.58	3.10	18.50
	1433.0 - 1435.0	(2.0)	.007	1.85	2.00	3.30	11.00
	1435.0 - 1437.0	(2.0)	.007	2.23	2.40	.51	6.50
*B-3	1117.0 - 1119.0	(2.0)	---	1.40	1.55	.30	.47
	1119.0 - 1120.0	(1.0)	---	2.16	3.00	2.30	.59
	1120.0 - 1121.0	(1.0)	---	.69	.65	7.50	2.35
	1121.0 - 1122.0	(1.0)	---	.35	.40	1.60	.65
	1122.0 - 1124.0	(2.0)	---	.86	1.75	.10	.37
	1135.0 - 1137.0	(2.0)	---	.40	.60	.40	5.10
	1137.0 - 1139.0	(2.0)	---	2.20	2.60	6.70	6.30
	1139.0 - 1141.0	(2.0)	.010	.80	.60	6.40	8.90
	1141.0 - 1141.5	(0.5)	.010	2.40	2.20	7.40	3.40
	1141.5 - 1144.0	(2.5)	---	1.60	1.70	1.20	5.40
B-6	2012.0 - 2019.0	(7.0)	.014	1.46	1.05	2.10	2.70
	2042.0 - 2051.0	(9.0)	.003	.22	.16	.52	.22
	2051.0 - 2055.0	(4.0)	.016	1.05	.86	4.00	7.10
	2055.0 - 2057.0	(2.0)	.001	.05	.05	.20	.17
*B-8	No data available						

Table 3.--Assays of mineralized intervals from surface core drill holes in or near Wabayuma Peak study area--Continued

Hole no.	Interval-Ft		Analytical data Au (oz/t)	Ag (oz/t)	Pb (%)	Cu (%)	Zn (%)
7	573.0 - 577.5	(4.5)	0.005	0.1	---	0.327	0.4
	577.5 - 578.0	(0.5)	.005	.1	---	.806	.5
	578.0 - 581.5	(3.5)	.010	1.2	0.8	2.17	6.8
	581.5 - 585.2	(3.7)	.015	2.2	1.8	7.79	8.6
	640.1 - 642.3	(2.2)	.005	.1	---	.075	1.5
8	532.2 - 533.7	(1.5)	.020	3.4	2.4	7.43	9.4
	533.7 - 534.8	(1.1)	.010	2.8	2.6	7.32	7.1
	534.8 - 538.5	(3.7)	.010	.1	---	1.39	.8
	538.5 - 539.9	(1.4)	tr	.1	---	.126	1.5
	565.0 - 566.6	(1.6)	tr	.2	---	.214	7.9
	566.6 - 569.6	(3.0)	tr	.2	---	.277	1.6
	569.6 - 573.7	(4.1)	tr	.1	tr	.352	1.8
	573.7 - 576.3	(2.6)	.005	---	---	.756	1.2
	576.3 - 577.8	(1.5)	.010	1.0	1.2	1.70	4.8
	577.8 - 582.6	(4.8)	.015	1.0	1.0	1.66	7.9
	582.6 - 583.5	(0.9)	tr	---	---	.100	---
*9	600.5 - 602.5	(2.0)	tr	.1	tr	.075	1.6
	602.5 - 603.6	(1.1)	tr	---	.4	.075	1.1
	603.6 - 605.0	(1.4)	tr	---	.4	.100	1.7
*11	667.0 - 667.9	(0.9)	.055	---	.3	.970	1.0
	668.2 - 670.3	(2.1)	.010	---	.4	1.045	1.2
	670.8 - 672.6	(1.8)	.010	.1	.4	2.967	6.1
17	951.9 - 955.0	(3.1)	.010	.60	1.80	5.35	14.20
	955.0 - 957.7	(2.7)	.020	2.10	2.40	3.89	13.20

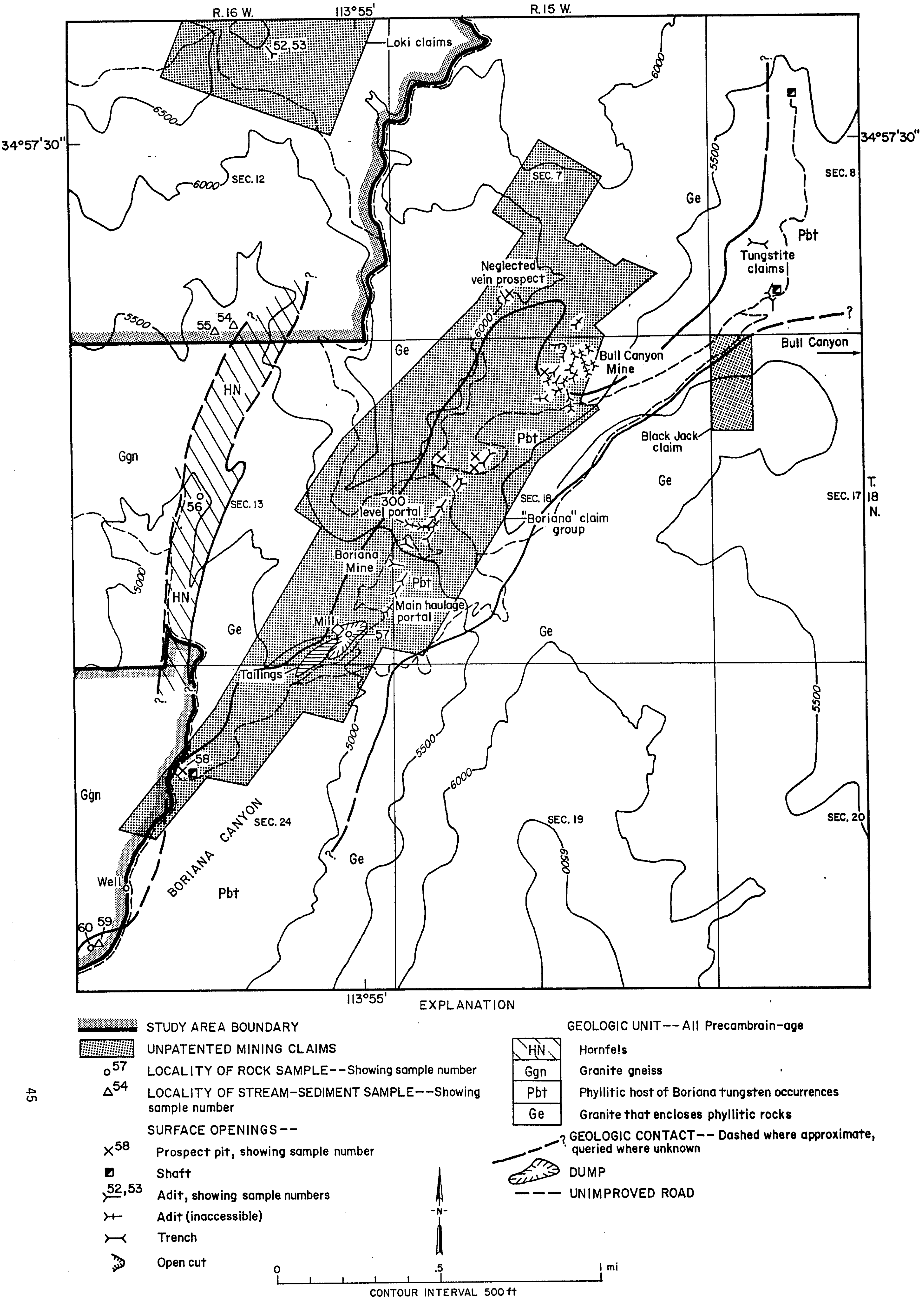


Figure 5.--Mines and prospects for tungsten in upper Boriana and Bull Canyons. Shown are sample localities 52-60. Analytical data on table 4.

Table 4.--Sample data to accompany figure 5 (upper Boriana and Bull Canyons mines and prospects).

[Abbreviations used: S, stream sediment sample; ---, not detected; xx, not applicable. All samples analyzed for Mo, none detected above 9 ppm; Pb and Zn below 100 ppm not listed. Note: samples 50, 51 shown on plate 1 only.]

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm)	W (ppm)	Other (ppm)	Description
50	grab	---	8	---	xx	Granite gneiss.
51	grab	16	35	---	xx	Granite, altered, muscovite rich; sericitized(?).
52	chip, 8 in.	45	990	---	Ag, 6; Pb, 640; Zn, 588.	Fracture, strikes N. 20° W., dips 70° NE.; chloritized; hematite; in adit.
53	chip, 6 in.	3	2,390	---	Ag, 2; Pb, 6,950; Zn, 1,235.	Talcose zone enclosing fracture (sample 52).
54	S	---	29	---	Zn, 129	Sediments derived from possible tungsten source rocks.
55	S	2	43	---	xx	Do.
56	grab	12	7	---	xx	Hornfels.
57	grab	6	327	50	Zn, 289	Phyllite and quartzite; from Boriana Mine dump.
58	chip, 2 ft	---	21	---	xx	Quartz veinlets in Boriana-type phyllite, strike N. 50° E., dip vertical; from small pit.
59	S	---	31	---	xx	Sediments derived from possible massive-sulfide host rocks.
60	select	2	22	---	xx	Vein quartz, float; blue-gray.

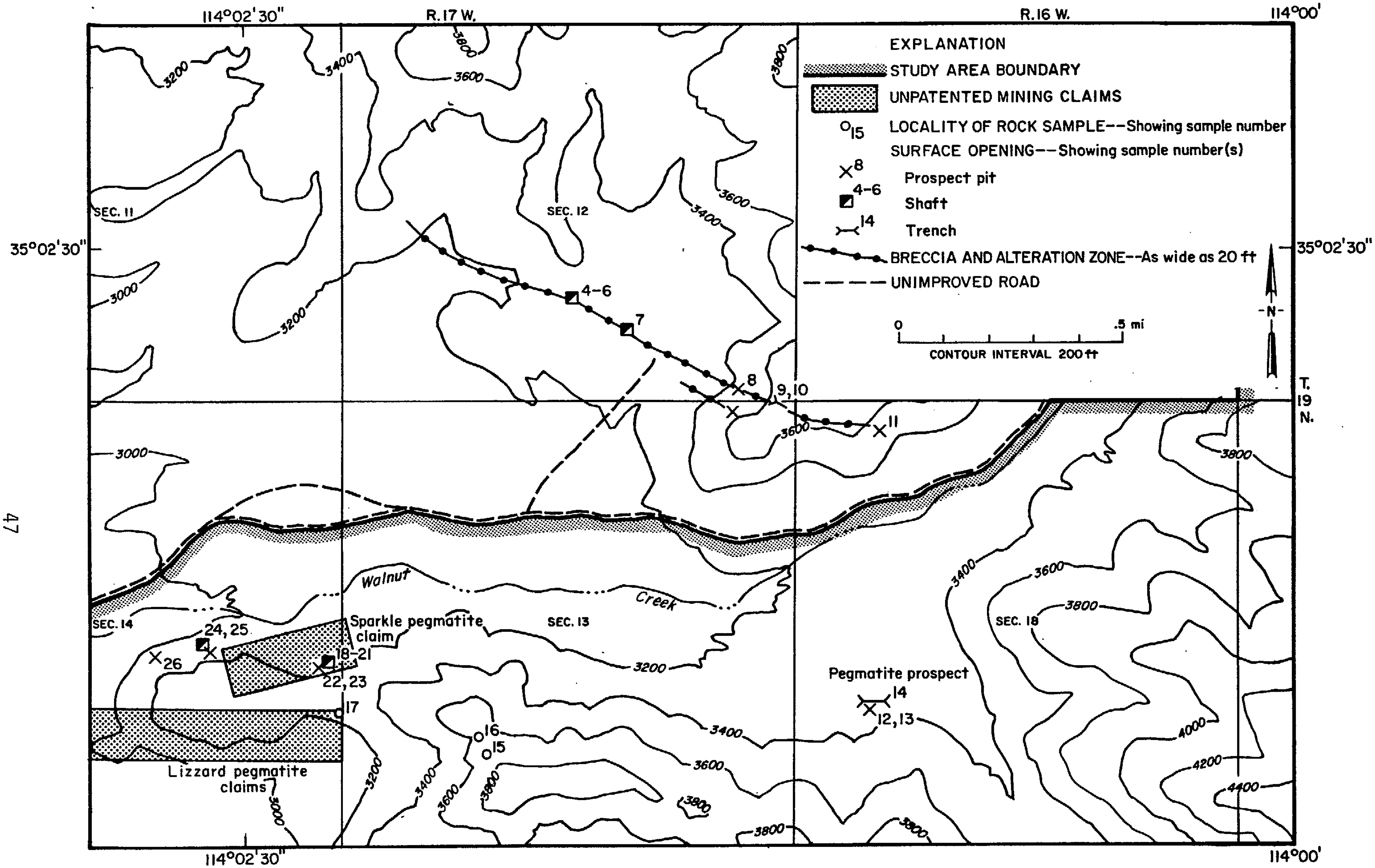


Figure 7.--Prospects along Walnut Creek. Shown are sample localities 4-26. Analytical data on table 5.

Table 5.--Sample data to accompany figure 7 (prospects along Walnut Creek).

[Abbreviations used: ---, not detected; xx, not applicable; all samples analyzed for Mo, none detected above 22 ppm except for sample 8.]

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm)	W (ppm)	Other (ppm)	Description
4	chip, 20 ft	---	8	---	xx	Altered zone in biotite gneiss, dips 70° NE.; outcrop; limonitic.
5	select	3	5	---	xx	Altered zone in biotite gneiss; limonitic; from dump by 100-ft-deep shaft.
6	select	---	3	---	xx	Biotite gneiss, minor chloritic alteration; from dump adjacent sample 5.
7	chip, 12 ft	6	23	80	xx	Altered zone in biotite gneiss; dips 70° NE.; minor brecciation (chert-filled) and white quartz veinlets; limonitic; near 30-ft-deep shaft, outcrop.
8	chip, 3.5 ft	---	29	30	Mo, 44	Altered zone, dips 85° NE.; brecciated and silicified, limonitic.
9	chip, 4 ft	---	19	40	Zn, 101	Silicified part of altered zone; at portal of 9-ft-long adit.
10	chip, 4 ft	---	8	---	xx	Silicified part of altered zone; from outcrop 10 ft north of sample 9; entire altered zone 70-ft-wide here.

Table 5.--Sample data to accompany figure 7 (prospects along Walnut Creek)--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm)	W (ppm)	Other (ppm)	Description
11	chip, 4 ft	---	7	---	xx	Altered zone, strikes N. 10° W., dips 80° SW.; limonitic, in 18 x 12 x 15-ft-deep open cut.
12	chip, 4 in.	28	6	---	Pb, 2,690, Zn, 246	Pegmatite vein, strikes N. 80° E., dips 30° NW.; 2-4 in. wide.
13	chip, 3 ft	9	24	---	Pb, 1,390, Zn, 1,050	Biotite gneiss bedrock; heavy limonite stain.
14	grab	24	26	---	Pb, 175; Zn, 165	Same rock type as sample 13; from shallow trench.
15	grab	---	95	140	xx	Dacite core of volcanic plug.
16	grab	---	21	---	xx	Rhyolitic zone of volcanic plug.
17	grab	---	6	---	xx	Pegmatite pod, 20 x 30 ft; albite, orthoclase, no mica.
18	select	117	620	---	Ag, 2	Biotite gneiss bedrock; limonite stain; from dump of 20-ft-deep inclined shaft.
19	select	23	637	---	xx	Pegmatite; orthoclase, albite; malachite stain; from dump.
20	select	4,040	1,635	---	Ag, 4	Quartz vein, strikes N. 50° E., dip not apparent; heavy limonite stain; from dump.
21	select	5,570	5,810	---	Ag, 6	Gossan; from dump.

Table 5.--Sample data to accompany figure 7 (prospects along Walnut Creek)--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm)	W (ppm)	Other (ppm)	Description
22	chip, 1 ft	517	903	---	Ag, 1; Zn, 157	Biotite gneiss, limonite stain; outcrop.
23	select	1,425	1,120	---	Ag, 2	Vein quartz and dense gossan; from dump of pit.
24	select	447	1,835	---	xx	Vein quartz, strikes N. 80° E., dips 35° NW.; to 1-ft-thick; from dump of 60-ft-deep shaft; heavy limonite stain, fractures.
25	grab	11	32	---	xx	Biotite gneiss bedrock; adjacent sample 24.
26	chip, 10 ft	737	2,040	---	Ag, 2	Quartz vein, strikes N. 80° E., dips 45° NW.; heavy limonite stain, fractures.

Table 6.--Sample data for Ophir tungsten area, and Walnut Creek area samples not shown on figure 7.

[Abbreviations used: P, panned-concentrate sample; ---, not detected; xx, not applicable. All samples analyzed for Mo, none detected above 3 ppm; Pb and Zn below 100 ppm not reported; see plate 1 for sample localities.]

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm)	W (ppm)	Other (ppm)	Description
1	chip, 3 ft	---	13	---	Zn, 152	Talus; biotite gneiss cemented by caliche.
2	chip, 7 ft	---	4	590	xx	Quartz-hornblende lens in biotite gneiss.
3	chip, 1 ft	---	17	---	xx	Biotite gneiss; adjacent sample 2.
27	grab	---	5	---	xx	Pegmatite, massive, as thick as 35 ft; albite, microcline, gray quartz.
28	chip, 4 ft	---	4	---	xx	Quartz vein, strikes N. 50° E., dip not apparent.
29	grab	---	7	270	xx	Vein quartz float near shallow pit.
30	chip, 2 ft	---	8	---	xx	Pegmatite dike, strikes N. 10° E., dips 70° NW.; traced for 110 ft along strike; albite, quartz, hematite.
31	P	---	6	---	xx	Sediments from possible tungsten source.
32	P	---	25	---	xx	Do.
33	select	---	23	---	xx	Vein quartz float.
34	P	---	13	70	xx	Sediments from possible tungsten source.
35	chip, 1.5 ft	---	25	10	xx	Quartz-veinlet zone in diorite, strikes N. 50° E., dips 60° NW.; parallels schistosity.

Table 6.--Sample data for Ophir tungsten area, and Walnut Creek area samples not shown on figure 7--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm)	W (ppm)	Other (ppm)	Description
36	P	---	7	---	xx	Sediments from possible tungsten source.
37	P	---	11	---	xx	Do.
38	chip, 4 ft	---	3	---	xx	Mafic dike, strikes N. 55° W., dips 75° NE.; in granite pluton.
39	chip, 1 ft	---	---	---	xx	Granite pluton; adjacent sample 38.
40	grab	2	7	---	xx	Granite; biotite, limonite stain.
41	chip, 4 in.	---	5	---	xx	Quartz vein, strikes N. 10° E., dips 85° NW.
42	chip, 3 in.	3	2	---	xx	Granite adjacent sample 41.
43	chip, 9 ft	---	3	---	xx	Quartz vein, strikes N. 72° E., dips 76° NW.; brecciated, silica cement.
44	chip, 10 ft	---	3	---	xx	Quartz vein, continuous with sample 43 vein.
45	chip, 12 ft	---	3	---	xx	Quartz vein, continuous with sample 43-44 vein.
46	grab	4	296	---	xx	Vein quartz, dump of 50-ft-deep shaft.
47	chip, 6 ft	10	659	---	xx	Quartz vein, strikes N. 16° W., dips 84° SW.; same vein as sample 46; 90 ft+ in length.

Table 6.--Sample data for Ophir tungsten area, and Walnut Creek area samples not shown on figure 7--Continued

Sample		Analytical data				
No.	Type and/or length	Au (ppb)	Cu (ppm)	W (ppm)	Other (ppm)	Description
48	grab	7	3,370	---	xx	Vein quartz; dump of 35-ft-deep shaft.
49	chip, 9 ft	3	36	---	xx	Siliceous shear, strikes N. 25° W.
129	grab	3	2	---	xx	Biotite gneiss, similar to bedrock along Walnut Creek; dominant foliation is N. 50° E., 80° NW.

Appendix A--Lower detection limits applicable to Wabayuma Peak sample analyses.

Element	Lower detection limit
Aluminum (Al)	0.01%
Barium (Ba)	1 ppm
Beryllium (Be)	.5 ppm
Bismuth (Bi)	2 ppm
Cadmium (Cd)	.5 ppm
Calcium (Ca)	.01%
Chromium (Cr)	1 ppm
Cobalt (Co)	1 ppm
Copper (Cu)	1 ppm
Gold (Au)	5 ppb
Iron (Fe)	.01%
Lead (Pb)	2 ppm
Magnesium (Mg)	.01%
Manganese (Mn)	1 ppm
Mercury (Hg)	5 ppb
Molybdenum (Mo)	1 ppm
Nickel (Ni)	1 ppm
Phosphorus (P)	10 ppm
Silver (Ag)	.2 ppm
Sodium (Na)	.01%
Strontium (Sr)	1 ppm
Titanium (Ti)	.01%
Tungsten (W)	10 ppm
Vanadium (V)	1 ppm
Zinc (Zn)	1 ppm

Appendix B--Summary of the Boriana tungsten mining district.

The Boriana district consists of the Boriana and Bull Canyon Mines, the Tungstite claims, Neglected Vein prospect, a working on the Loki claims, and several small pits, adits, and shafts which follow Boriana-type phyllitic rock southward down Boriana Canyon (figs. 2, 5, pl. 1) for a distance of 3.5 mi.

Economic concentrations of tungsten were found mainly in the Boriana Mine vein system--two composite lodes of quartz veins in phyllite, 90 to 135 ft apart, which contain wolframite and scheelite. Other minerals present include chalcopyrite, beryl, fluorite, chlorite, molybdenite, arsenopyrite, pyrite, and cuprotungstite; some gold and silver are present, in an unknown form (Wilson, 1941, p. 11-14; Kerr, 1946, p. 102-104; Dale, 1961, p. 75). Grades are 1% to 2% WO_3 (Hobbs, 1944, p. 257-258). Quartz veins between the two composite lodes have little tungsten (Dale, 1961, p. 75). Altered, partially sericitized granite that encloses the phyllitic rock is thought to be a volatile-rich cupola of the intruding igneous body which is the source of the tungsten (Hobbs, 1944, p. 257; Kerr, 1946, p. 102-104).

Boriana Mine

Mining at the Boriana, which explored the ore zone on 9 levels and 3 sublevels through 1,100 ft of depth and along more than 15,500 ft of horizontal underground workings, has delineated a consistent "ore shoot", defined by economic sections of the veins on all mine levels. This ore shoot rakes 35° north, or directly towards the altered, enclosing granite (Hobbs, 1944, p. 254; Kerr, 1946, p. 102-104). The Boriana Mine vein system itself strikes N. 30° to 40° E., conforming with phyllite foliation, over a distance of about 2/3 mi; the vein system dips SE. 75°, though it is vertical in some places (Hobbs, 1944, p. 251; Kerr, 1946, p. 64, 102-104). Neither the ore shoot nor the Boriana Mine vein system can be traced into the study area.

The Boriana Mine operated from 1915 to 1919, 1929 to 1937, 1939 to 1943, and 1951 to 1957. Operations were suspended in 1957, and previously, in 1919 because of falling metal prices. The shutdown in 1937 resulted from a fire which destroyed the mill, necessitating rebuilding. In 1943, as new ownership was sought, the mine was stripped of equipment and lay idle for several years (Dale, 1961, p. 73). Total production was about 118,100 short ton units (STU) of WO_3, with the vast majority having been produced from 1932 to 1942 (Hobbs, 1944, p. 249; Dale, 1961, p. 73). Milling of dump and gob material accounted for about 100 STU of WO_3 production in the early 1950's (Dale, 1961, p. 74); the remainder of the total was mine production. The Boriana was Arizona's leading tungsten producer in 1918, from 1933 to 1937, and one of the top producers from 1951 to 1956 (Dale, 1961, p. 64, 73). The Boriana area is covered by 31 unpatented mining claims (Hobbs, 1944, pl. 42), which are currently (1987) maintained (see pl. 1).

By-product copper from the Boriana Mine dump

An attempt was made during the late 1950's to produce copper concentrates while reprocessing Boriana Mine mill tailings for some of the remaining tungsten. The copper is present as chalcopyrite with quartz gangue and is spatially related to the quartz-tungstate veins in the mine. Copper concentrates, reportedly produced at the rate of about two tons per month, assayed 18% copper (Dale, 1961, p. 74); the total amount produced was probably in the range of 30 to 50 tons of concentrates. The Bureau conducted a beneficiation test for copper recovery with tailings that assayed 0.44% Cu (Clemmer, 1947). A 24.20% copper concentrate was produced through combined flotation and tabling, while tabling alone produced a 13.57% copper concentrate.

Other workings in the district

At the Bull Canyon Mine (Robinette prospect, Iguana claims), tungsten-bearing quartz veins were mined intermittently from the altered granite tungsten source rocks, starting in 1937, and ending in 1956. Mining was very near the adjacent phyllitic rocks (Chapman, 1943, p. 4; Dale, 1961, p. 84; Kerr, 1946, p. 104). The quartz veins can be traced continuously from the phyllitic rocks into the granite, where their strike alters to N. 50° to 60° E. Dip remains steep and to the southeast. Mineralogy is the same as at the Boriana Mine (Dale, 1961, p. 84-85), though Kerr's (1946, p. 104-105) observation of disseminated scheelite in the intrusive granite is noted as evidence for some direct magmatic crystallization. By the 1940's, six adits with a total of 1,350 to 1,400 ft of horizontal workings had been driven--most of the mine production, which totalled 2,176 STU of WO_3, or less than 2% of the total for the district, was realized from these adits (Chapman, 1943, map; Dale, 1961, p. 84-85). The Bull Canyon Mine area is covered by seven unpatented mining claims (Hobbs, 1944, pl. 42), most of which are currently (1987) maintained (see pl. 1). Many of the claims overlap Boriana Mine claims.

In the early 1950's, small production commenced from the Tungstite claims, where thin tungsten-bearing quartz veins were mined from altered phyllite near the granite contact (Dale, 1961, p. 87-88). Veins strike N. 40° E. at the south end of the claim area, but this alters to N. 10° E. to the north (Rubly and Bromfield, 1951, p. 2). Dip is 80° to the south. A 90-ft-deep shaft was reportedly sunk on the property, revealing a 3- to 6-ft-wide vein assaying 4.08% to 5.39% WO_3. Reported production was 137 STU of WO_3 (Dale, 1961, p. 87-88). There were originally 16 unpatented mining claims in the Tungstite group (Rubly and Bromfield, 1951, p. 2), but only one is currently (1987) maintained--it is known as the Black Jack claim (pl. 1).

Reserves

Reserve estimates for the district, which date from about 30 years ago, are about 1,000 STU of WO_3 indicated[1/] in veins, 47,000 STU of WO_3 inferred[1/] in veins, and 2,800 STU of WO_3 measured[1/] in dump material. Grades estimated are 0.3% to 1.5% WO_3. All reserves are at the Boriana and Bull Canyon Mines (Dale, 1959a; Dale, 1959b; Hobbs, 1944, p. 258; Rubly and Bromfield, 1951, p. 2). No part of these deposits could be considered reserves in the current (1987) depressed metals market; tonnages remain valid currently if reclassified as subeconomic resources[1/] rather than reserves.

Most workings which would expose productive veins in the Boriana district are now caved and the few that remain accessible are contaminated with toxic hydrogen sulfide gas, developed from weathering of sulfide minerals in the veins. The Boriana Mine has been flooded to the main haulage (500) level since some time in the 1950's. Detailed mapping of the Boriana Mine underground workings is in Hobbs (1944, pl. 44-46); those of the Bull Canyon Mine are shown in Chapman (1943, map).

1/ Resource and reserve classifications are defined in U.S. Bureau of Mines and U.S. Geological Survey (1980, p. 1-3).

Appendix C--Resource estimation methodology for the Antler deposit extension inside Wabayuma Peak study area.

Occurrence description

Two mineral zones, about 175 ft apart, are inside the study area. The position of the western zone is defined approximately by the position of hole B-3 and the eastern zone is defined approximately by holes 9 and 11 (fig. 4). The western zone is composed of an upper part, about 1,120-ft deep that is 3-ft thick, and a lower part, about 1,140-ft deep that is 7-ft thick, according to drill data from Standard Metals Corp. (table 3). The eastern zone is composed of about 4.5 ft of mineralized rock that was intercepted at 600 ft in depth in hole 9 and at 660 ft in hole 11.

Assumptions

The mineral zones are assumed to be: 1) linear, slab-like bodies that are; 2) continuous between the southern study area boundary (where Still's resource block adjoins) and the drill sites of holes B-3, 9, and 11; and, 3) have a width equal to their respective thicknesses. These mineral zones were then projected to the north for double their strike length of 100 ft, where thicknesses and widths were assumed to be unchanged. The eastern mineral zone was intercepted at different depths in holes 9 and 11; the variance is probably due to faulting.

If there is unrecognized discontinuity in the mineral zones, such as that induced by faulting or cessation of mineralization, the resource estimates could be too high and the assumed geometry of the occurrences would be incorrect. The assumption that thickness equals width could be in considerable error. Widths could greatly exceed thicknesses, leaving resource estimates far too low. Data on grades and thicknesses of the mineral zones is of minimal accuracy, because of the small number of drill holes. As the Antler

Mine is inaccessible, no additional data could be gathered underground. No drilling could be done to supplement this Bureau study. Factoring in the true inclination angles of the drill holes will change depth of the occurrences, perhaps by several feet; the angles are not known.

Calculation constants

Density used for rock in the mineral zones is 175 lbs/ft^3, based on 93.65% of the mineral zone being composed of rock with a 2.7 specific gravity, and 6.35% of the mineral zone being composed of sulfides with a combined specific gravity of 4.5. Combined in proportion, these numbers yield an overall specific gravity of 2.8, or 175 lbs/ft^3. The sulfides-to-rock ratio is based on Standard Metals Corp. drill data. In hole B-3, the upper mineral zone is considered to be 7 ft thick (from drill logs) and 7 ft wide (assumed), while the lower mineral zone is 3 ft thick (and wide). The mineral zone intercepted in holes 9 and 11 is considered to be 4.5 ft thick (and wide).

Inferred subeconomic resource tonnages

Using the above parameters, the following tonnages were derived for that part of the Antler deposit inside the Wabayuma Peak study area:

Mineral zone	Tons (st)
B-3 (upper)	237
B-3 (lower)	1,286
9 & 11	531
Total	2,054

The final combined tonnage number used in this report is rounded to 2,000 tons.

Grades

Grades were averaged from the drill logs of mineral zones supplied by Standard Metals Corp. In hole B-3, the average is 3.8% copper and 1.2% zinc; in holes 9 and 11 the average is 1.2% copper and 2.1% zinc. The ranges of metal concentrations in the inferred subeconomic resources are therefore listed as 1% to 4% copper and 1% to 2% zinc.

Appendix D--Salient statistics for copper, zinc, and lead.

[Data from U.S. Bureau of Mines publications: Mineral Commodity Summaries 1987, and Minerals and Materials, a bimonthly survey (June/July 1987).]

Statistic category	Copper	Zinc	Lead
1987 price, per lb metal (January to July)	\$0.65 to \$0.80[1/]	\$0.42 to \$0.46	\$0.28 to \$0.42
U.S. consumption 1986 (primary metal, short tons)	2,392,000 tons	1,127,000 tons	1,213,000 tons
U.S. mine production 1986 (primary metal, short tons)	1,183,000 tons	209,000 tons	404,000 tons
Import reliance (approximate)	27%	74%	20%
Major import sources	Chile, Canada	Canada, Mexico, Honduras	Canada, Mexico, Peru
Government stockpiles (short tons)	22,000 tons (goal is 1,000,000 tons)	378,000 tons (goal is 1,426,000 tons	601,000 tons (goal is 1,000,000 tons

1/ Copper prices increased sharply in late 1987 to about \$1.40/lb, as reported in The Mining Record, vol. 98, No. 52, Dec. 30, 1987. This change was due to shut down of two major domestic properties, and unreliability of production from properties in Zambia.

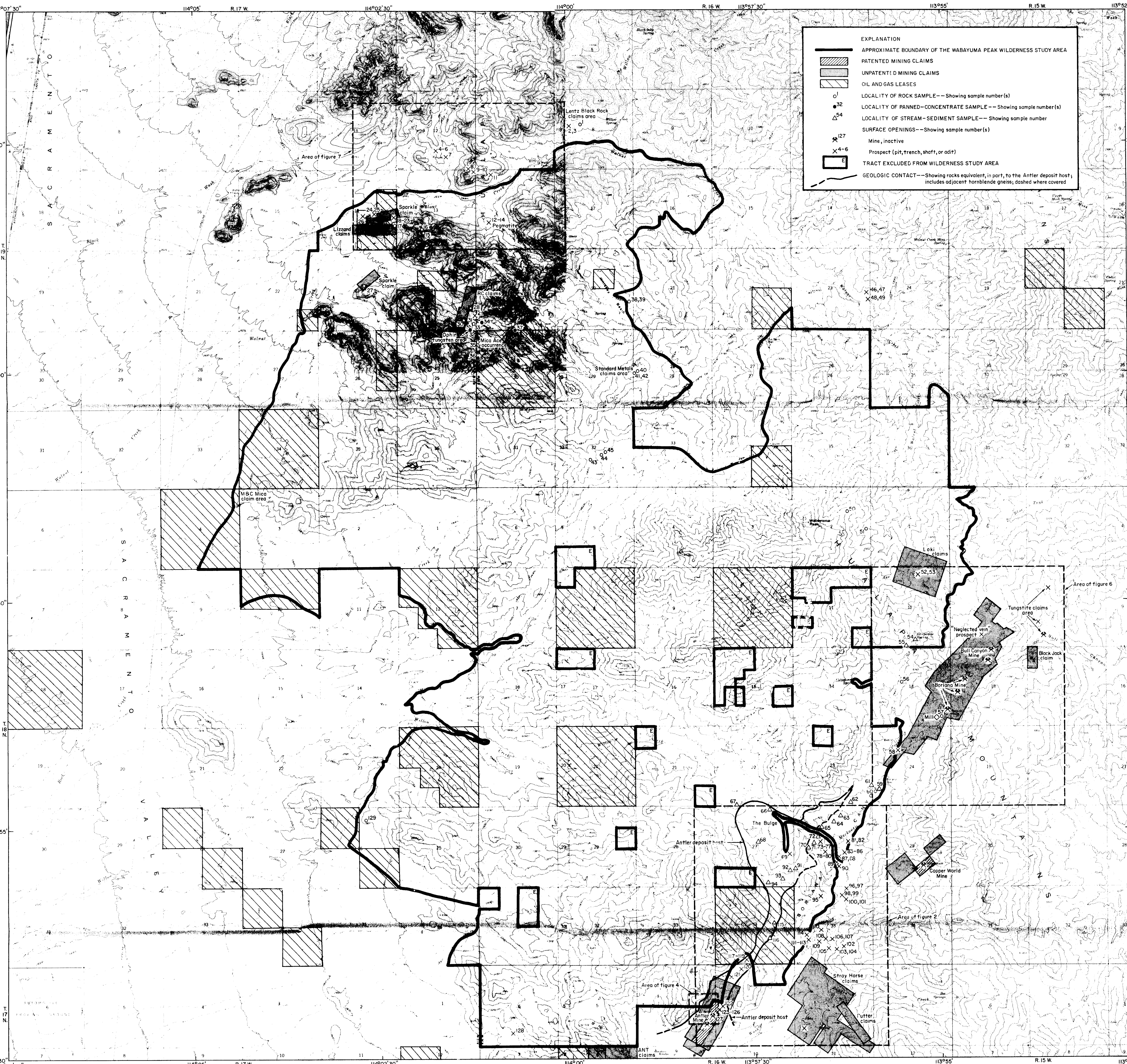
Appendix E--Summary of the Copper World Mine.

The Copper World Mine, a copper-zinc sulfide deposit in the Boriana Valley, was located in 1882 and patented in 1889 (Soule', 1966, p. 10); it has been inactive since 1970. The mine is mostly flooded now (1987), and the upper drifts are contaminated with hydrogen-sulfide gas and could not be entered. Reserve estimates from 1953 to the mid 1960's vary from 30,000 to 40,000 tons at grades from 3% to 3.8% copper and 7% to 13% zinc (Robinson and others, 1953, p. 5; Soule', 1966, p. 15; Forrester, 1966, p. 11); production since that time has been about 22,000 tons (the mine was idle from 1953 to 1966).

The Copper World deposit is strongly controlled by a N. 35° to N. 45° E. striking fault; the dip is vertical, but irregular. Movement along this fault caused pinch and swell of the mineralized zone, so that it varies from 1-in. to 10-ft wide (Silman, 1966, p. 3; Soule', 1966, p. 12). While the overall known extent of the deposit resembles replacement vein or fault-controlled veins types (Silman, 1966, p. 4), massive sphalerite and chalcopyrite were reported at the lowest level of the mine (unpublished data, Steve Tima, owner, Phoenix, AZ). This suggests that the deposit may be a massive sulfide body that was partially remobilized along the fault.

DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

OPEN FILE REPORT
MLA 5-88
PLATE 1



114°07'30" 114°05' R.17 W. 114°02'30" 114°00' R.16 W. 113°57'30" 113°55' R.15 W. 113°52'30"

Base from U.S. Geological Survey 1:24,000 Hualapai Peak, 1968; Kingman SE, 1967; Wabayuma Peak, 1967; Yucca NE, 1970.
Claim and oil and gas lease information from the Bureau of Land Management as of December 1986.

SCALE 1:36,000
CONTOUR INTERVAL 40 ft

MAP LOCATION

Field work completed in 1987 by Mark L. Chatman; assisted by Rodney E. Jeske.

MINE AND PROSPECT MAP OF THE WABAYUMA PEAK WILDERNESS STUDY AREA, MOHAVE COUNTY, ARIZONA

BY

MARK L. CHATMAN, U.S. BUREAU OF MINES

1988