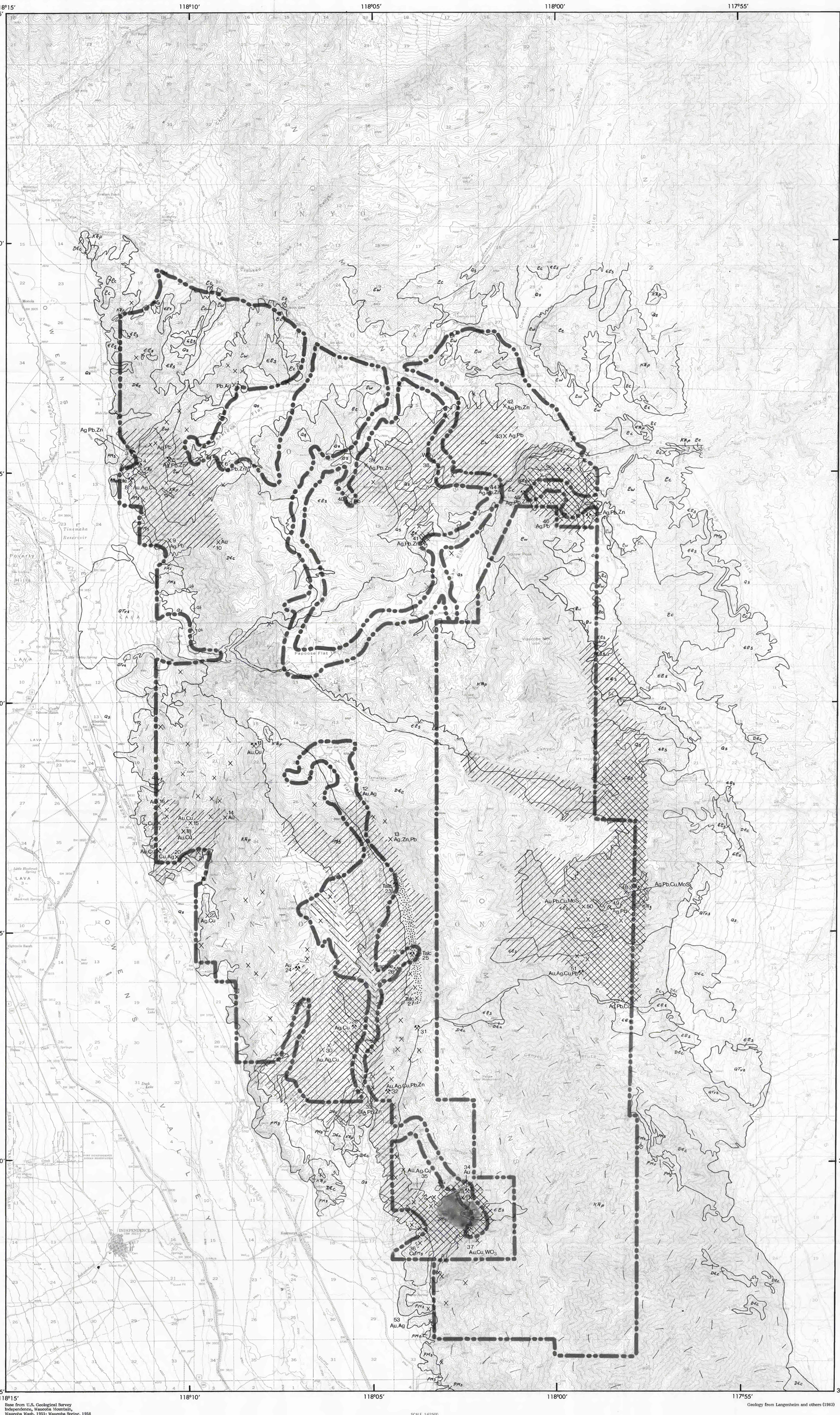

Base from U.S. Geological Survey
Independence, Waucoba Mountain,
Waucoba Wash, 1951; Waucoba Spring, 1958

SCALE 1:62500

CONTOUR INTERVAL 80 FEET
DASHED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology from Langenheim and others (1983)

EXPLANATION

AREAS WITH MINERAL RESOURCE POTENTIAL

High resource potential for gold and tungsten; moderate resource potential for silver, lead, zinc, and copper. Based on evaluation of existing mines and moderate geochemical anomalies of the metal suite Pb, Zn, Mo, Ag, Au, and Cu. Tungsten is in a skarn; other metals are vein deposits

Moderate resource potential for silver with associated lead, zinc, copper, and gold. Based on evaluation of existing mines and prospects and moderate geochemical anomalies of the metal suite Pb, Zn, Mo, and Ag. Vein deposits

Low resource potential for silver with associated lead, zinc, copper, and gold. Based on evaluation of existing mines and prospects and low geochemical anomalies of the metal suite Pb, Zn, Mo, and Ag. Vein deposits

Low resource potential for gold in placer deposits. Based on evaluation of existing properties

Moderate to low resource potential for talc and (or) graphite. Based on existing mines and prospects and geologic setting

MINE OR PROSPECT--Symbol indicates resource mined or present: Au, gold; Ag, silver; Cu, copper; Pb, lead; WO_3, tungsten trioxide; Zn, zinc. Number refers to tables 1, 2, and 3 of accompanying pamphlet

1 Au,Ag — Mine

2 Cu — Prospect

CORRELATION OF MAP UNITS

Qs	QUATERNARY
QTvs	QUATERNARY AND (OR) TERTIARY
Unconformity	
KTR p	CRETACEOUS, JURASSIC, AND (OR) TRIASSIC
PMs	PERMIAN, PENNSYLVANIAN, AND (OR) MISSISSIPPIAN
DEc	DEVONIAN, SILURIAN, ORDOVICIAN, AND (OR) CAMBRIAN
€Es	CAMBRIAN AND (OR) PROTEROZOIC
Ec	PROTEROZOIC
Ew	

DESCRIPTION OF MAP UNITS

Qs — SURFICIAL DEPOSITS (HOLOCENE AND PLEISTOCENE)--Unconsolidated to weakly consolidated sand, silt, gravel, and boulders

QTvs — VOLCANIC AND (OR) SEDIMENTARY ROCKS (QUATERNARY AND TERTIARY)--Lava flows, lahars, tuffs, and sedimentary rocks. Includes basalt, andesite, dacite, and rhyolite

KTR p — PLUTONIC ROCKS AND SMALL INTRUSIVE BODIES (CRETACEOUS, JURASSIC, AND (OR) TRIASSIC)--Medium- to coarse-grained mostly porphyritic granodiorite and quartz monzonite bodies and some diorite; granite and alaskite bodies. Includes the quartz monzonite of Papoose Flat, Tinemaha Granodiorite, Paiute Monument Quartz Monzonite, hornblende-augite monzonite of Joshua Flat, and the diorite of Marble Canyon

PMs — SILICEOUS SEDIMENTARY ROCKS (PERMIAN, PENNSYLVANIAN, AND MISSISSIPPIAN)--Sedimentary strata mostly siltstone, sandstone, and conglomerate. Some interbeds of dark limestone. Includes the Owens Valley Formation, Keeler Canyon Formation, Rest Spring Shale, and the Perdido Formation

DEc — CARBONATE AND SILICEOUS SEDIMENTARY ROCKS (DEVONIAN, SILURIAN, ORDOVICIAN, AND CAMBRIAN)--Sedimentary strata mostly limestone and dolomite with lesser amounts of shale, sandstone, and conglomerate. Includes the Lost Burro Formation, Sunday Canyon Formation, Vaughn Gulch Limestone, Hidden Valley Dolomite, Ely Springs Dolomite, Johnson Spring Formation, Barrel Spring Formation, Badger Flat Limestone, Al Rose Formation, Tamarack Canyon Dolomite, Lead Gulch Formation, Bonanza King Dolomite, Monola Formation, and the Mule Spring Limestone

€Es — SILICEOUS AND CARBONATE SEDIMENTARY ROCKS (CAMBRIAN AND PROTEROZOIC)--Sedimentary strata, mostly siltstone and sandstone with some limestone units. Includes the Saline Valley Formation, Harkless Formation, Poleta Formation, and the Campito Formation

Ec — CARBONATE AND SILICEOUS SEDIMENTARY ROCKS (PROTEROZOIC)--Sedimentary strata mostly dolomite and limestone with some siltstone and sandstone units as well. Includes the Deep Spring Formation and the Reed Dolomite

Ew — WYMAN FORMATION (PROTEROZOIC)--Sedimentary strata mostly sandstone and siltstone with some limestone and volcanic beds

CONTACT

APPROXIMATE BOUNDARY OF ROADLESS AREA

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. 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 resource potential survey of the Andrews Mountain (5063), Mazourka (A5064), and Paiute (B5064) Roadless Areas in the Inyo National Forest, Inyo County, California. These areas were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

SUMMARY

The principal metallic mineral resource in the three Inyo Mountains roadless areas (Andrews Mountain, Mazourka, and Paiute) is silver with lead, zinc, gold, tungsten, and copper, in that order, as lesser resources. Nonmetallic mineral resources include talc, graphite, and marble. Metallic mineralization is primarily in base-metal vein deposits, mostly peripheral to Mesozoic plutons, in silicic and carbonate metasedimentary rocks, and locally in the granitic rocks. The metal suite of lead, zinc, silver, and molybdenum with some copper, gold, and tungsten is found in anomalously high concentrations in stream-sediment and heavy-mineral-concentrate samples at many places in the region. Undefined limits of alteration and mineralization and unexposed parts of known structures in existing mines suggest that undiscovered deposits probably exist.

The Andrews Mountain Roadless Area has a low resource potential for lead, zinc, and silver in an area east of Andrews Mountain.

The Mazourka Roadless Area has a high resource potential for gold and tungsten adjacent to the Betty Jumbo and Black Eagle mines (nos. 37 and 34, respectively), moderate resource potential for silver and copper near the Copper Empire group (no. 28), and moderate resource potential for silver with lead and zinc near Marble Canyon. There is a low resource potential for silver, lead, zinc, copper, and gold throughout most of Mazourka Canyon and at several localities along the west front of the range.

The Paiute Roadless Area has a moderate resource potential for silver, lead, and zinc in the area around Lead Canyon.

INTRODUCTION

The study area, which includes the Andrews Mountain, Mazourka, and Paiute Roadless Areas, is within the Inyo National Forest in the northern part of the Inyo Mountains, northeast and east of Independence, Calif. The three roadless areas cover about 11,800 acres, 82,200 acres, and 55,900 acres, respectively. The terrain is rugged and steep with relief of about 7,000 ft along the east side of the range. Elevations range from about 3,700 ft above sea level in Owens Valley to 11,123 ft above sea level at Waucoba Mountain.

GENERAL GEOLOGY

The rocks in the study area can be divided into major groups according to age and type: the oldest are upper Proterozoic to Permian sedimentary rocks, rocks of intermediate age are middle and late Mesozoic plutonic rocks, and the youngest are Cenozoic volcanic rocks and surficial deposits.

The upper Proterozoic to Permian strata represent sediments that accumulated in a shallow-water marine-shelf environment. The total aggregate thickness of these strata is at least 35,000 ft but no continuous section has been found that contains more than a fraction of this thickness. The sequence is largely conformable but hiatuses exist and are recognized by the absence of strata of various ages. The rocks are mostly clastic, types made of about equal amounts of quartzose (sandstone and shale) and carbonate (limestone and dolomite) types. Fossils are rare. In most of the region, metamorphism has affected the oldest group of rocks to some extent; they are almost everywhere tightly compacted, recemented, and partially recrystallized. Locally, a low-grade metamorphic mineral assemblage including andalusite, sericite, metamorphic biotite, coarsely crystalline calcite, and dolomite has developed. Primary stratification and sedimentary structures, however, are the dominant fabric of the rocks.

Mesozoic plutonic rocks make up about half of the pre-Cenozoic exposures in the study area and are regarded as satellitic parts of the Sierra Nevada batholith (Bateman and others, 1963; McKee and Nash, 1967; Ross, 1969). These plutons intrude and metamorphose the upper Proterozoic and Paleozoic sedimentary rocks of the region. They generally have steep and sharp contacts with the surrounding country rocks and contact metamorphic effects extend as far as 2 mi from the contacts. Most of the plutonic rock is granodiorite but there are significant quartz monzonite, monzonite, and diorite plutons as well.

Small remnants of late Cenozoic basalt, mainly lava flows and agglomerate, occur on the east side of the range near the mouth of Paiute Canyon and along the west front of the range west of Badger Flat. These basalts have been isolated from their sources by erosion--those on the east from the Saline Range and those on the west from vents in Owens Valley.

Sedimentary deposits of Cenozoic age fill the valleys adjacent to the Inyo Mountains and within the mountains shallow accumulations floor the major canyons and cap the higher alluviated areas. The oldest rocks are Tertiary deposits that occur in scattered areas along the east side of the range. Cemented breccia, made of fragments of the older units, occurs at high elevations and some fanglomerates occur along the east front of the mountains.

Structural features in the northern part of the Inyo Mountains represent at least three distinct periods of deformation. These structural episodes include: (1) deformation that took place before emplacement of the plutonic rocks, (2) deformation associated with emplacement of the plutonic rocks, and (3) basin and range faulting that is responsible for the present uplift of the Inyo Mountains. The type of structure and style of deformation associated with these periods contrasts strongly.

Preplutonic deformation (pre-Middle Jurassic) is characterized by many high-angle normal and reverse faults with offsets usually less than 1,000 ft and open north-trending folds. These structures both predate and postdate regional thrusting of the Last Chance thrust (Stewart and others, 1966), a large fault (upper-plate movement of at least 20 mi that thrust upper Proterozoic and lower Paleozoic rocks onto upper Paleozoic rocks).

Deformation associated with, or caused by, emplacement of the plutonic rocks during the middle and late Mesozoic affected almost all the upper Proterozoic and Paleozoic formations. This deformation is characterized by folds caused by forceful emplacement of the plutons and local metamorphic rock fabric caused by thermal and dynamic metamorphism. In general, the degree of deformation increases with proximity to the plutons, with very intense deformation typical of the pendants of strata at deep levels of the batholith and sharp contacts with relatively slight deformation at high intrusive levels.

Basin and range faulting in late Cenozoic time that caused uplift of the Inyo Mountains and downdropping of the adjacent valleys is characterized by steeply dipping normal faults. Along much of its length, the present range front coincides with the traces of high-angle fault surfaces. The large magnitude of this displacement is apparent along the west side of the range, where as much as 8,000 ft of relief separates the valley floor from the range crest and an additional 1,000 ft of fault scarp is buried by alluvium in Owens Valley (Ross, 1965). Numerous small scarps visible in the unconsolidated alluvium along the front of the range indicate that some faults are still active.

GEOCHEMICAL STUDIES

Samples of rock, stream sediment, and nonmagnetic heavy-mineral concentrates were analyzed for 31 elements using a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). All of the rock and stream-sediment samples were also reanalyzed for zinc by atomic-absorption spectrometry (Ward and others, 1969); selected samples were reanalyzed for gold by the same technique (Meier, 1980). Stream-sediment samples were also analyzed for uranium using a modification of the fluorometric method of Centanni and others (1956). Results of the analyses and their geochemical interpretation are included in Donahoe and others (1983).

Ten elements were selected from the samples of stream sediment and 11 from the samples of nonmagnetic heavy-mineral concentrate as possibly being related to hydrothermal alteration and (or) mineralization. An anomalous-value range and a threshold value (highest background value) for these elements were selected on the basis of a visual inspection of a frequency distribution plot. For the sediment and heavy-mineral concentrate samples, the anomalously high concentrations for each selected element were assigned to one of two or three concentration-range categories in order to better identify weakly, moderately, or strongly anomalous samples. Drainage basins with anomalous samples were assigned a numerical score based on the number of anomalous elements and their concentration (Donahoe and others, 1983). In general, the higher the anomaly score for a site, the more significant is that drainage basin in terms of mineral potential.

AEROMAGNETIC SURVEY

The largest aeromagnetic anomaly within the Andrews Mountain, Mazourka, and Paiute Roadless Areas occurs over the Pat Keyes pluton of the Hunter Mountain Quartz Monzonite in the southern part of the study area. Broad gradients along the east and west flanks of this anomaly are largely a result of the topography of the Inyo Mountains. This same anomaly extends north over most of the Paiute Monument Quartz Monzonite pluton and northwest over the Tinemaha Granodiorite pluton. Geologic mapping shows that the Tinemaha and the Paiute Monument plutons are separated by Paleozoic sedimentary rocks at the south end of Mazourka Canyon, but the aeromagnetic data clearly indicate that the two plutons are joined at shallow depth.

The shape of the anomaly over the Tinemaha Granodiorite indicates that its east boundary dips at a shallow angle to the east under the broad arcuate belt of Paleozoic sediments in the Mazourka Canyon and Badger Flat areas, areas where geochemical anomalies have been detected.

A magnetic anomaly closely coincides with the Marble Canyon pluton which is composed of diorite and intruded by monzonite of Joshua Flat. Although this pluton is most extensively exposed outside of the map area (McKee and Nelson, 1967), the magnetic anomaly suggests its southwestern contact dips to the southwest below Proterozoic sedimentary rocks and extends to near the boundary of the Paiute Roadless Area and therefore may have influenced mineralization of the sedimentary rocks further to the south.

A positive anomaly occurs approximately coincident with a mapped outcrop of the Proterozoic and Paleozoic silicic metasedimentary rocks located 2 mi west of Andrews Mountain. Elsewhere rocks of this type do not produce significant magnetic anomalies which suggests that the source of the anomaly west of Andrews Mountain is below the surface. Possibly the anomaly manifests a pluton intruded to a shallow depth in this region.

MINING HISTORY AND MINING DISTRICTS

Mexicans, in the 1800's, are credited with the first discovery of the mineral deposits located in the lower slopes of the Inyo Mountains.

In 1861, the Russ mining district was established, located southeast of Independence, Calif.; the first important discovery was not made until 1862 at the San Carlos mine (DeGroot, 1890; Ross, 1965), 4 mi northeast of Independence. Several other important gold-silver-copper deposits were discovered, within a 12-mi radius of Kearsarge Station, including the Black Eagle and Alice Quartz mines (nos. 34 and 4, respectively), and the Custer (Baxter) mine (no. 51). By 1890, stamp mills along the west range front at Chrysopolis, Willow Spring, the Reward mine, and the Montezuma mine (no. 3), had or were processing local ores. A smelter at Elna Station, near Big Pine, Calif., processed ore from the Montezuma mine.

With few exceptions, most lead and silver properties produced from 1880 to 1950. The three largest producers in the area were the Montezuma mine (no. 3), Blake mine (no. 5), and Custer (Baxter) mine (no. 51). Tungsten was produced from only the Betty Jumbo mine (no. 7). The most recently developed deposits include talc and graphite in Mazourka Canyon and marble near Tinemaha Reservoir. Table 1 (pamphlet) lists the recorded production from properties in the three Inyo Mountains roadless areas.

Production of placer gold from areas other than in Mazourka or Marble Canyon is unknown, and probably very minor. Mazourka Canyon yielded most of its gold from 1894 to 1912 and from 1927 to 1941. Reported production from 1898 to 1941 was 396.4 oz of gold and 30 oz of silver from 1,828 yd^3. Small-scale mining in this area continues, with local residents apparently recovering small amounts.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The northern part of the Inyo Mountains, an area that includes the Andrews Mountain, Mazourka, and Paiute Roadless Areas, has high, moderate, and low resource potential for several metallic elements and a moderate to low resource potential for the nonmetallic commodities talc, graphite, and marble. The metallic element for which there is a high resource potential is silver; gold, lead, and zinc associated with the silver have a moderate resource potential and scattered occurrences of copper and tungsten offer a low resource potential. One area in the southern part of the Mazourka Roadless Area has a high resource potential for gold and tungsten and a moderate resource potential for silver.

The large number of mines and prospects throughout the area and geochemical sampling that documents the presence of a number of elements, many of which indicate mineral suites and mineralizing systems, indicate relatively widespread alteration and mineralization. A suite of molybdenum, lead, zinc, and silver with local addition of copper, tungsten, and gold is found in anomalously high concentrations at many places. This group of elements, indicative of base-metal vein deposits formed by hydrothermal systems fits well with the geologic framework of the northern Inyo Mountains. Hydrothermal solutions associated with the large Mesozoic plutons of this region would find a suitable host for vein deposits in the much fractured and faulted Proterozoic and Paleozoic metasedimentary rocks that they intrude and locally in the plutons themselves. The general distribution of the molybdenum, lead, zinc, and silver enrichment is peripheral to or within the plutons. The base-metal veins are in a variety of rock types--some are in granitic rocks, some in carbonate units, but most seem to be in silicic metasedimentary rocks, shale, or quartzite. This may be due to the more fractured condition of the silicic rocks which develop more small fractures than the less brittle carbonate rocks. The relative density of large faults on a regional scale is about the same in all rock types. No particular structural features that have been mapped by standard geologic means seem to be preferentially mineralized or related to mineralization. The association of alteration and mineralization to silicic rocks seems to be controlled by smaller structures than those mapped.

Some small mineralized tactites occur near granitic contacts with carbonate rocks and contain tungsten, copper, a little gold, and, at one place, iron. None of the tactites are large and the contact zone is sharp and unmineralized in most places. Talc bodies form locally at the contact between granite and dolomite or even fairly far from the surface exposure of granite where the dolomite has been strongly metamorphosed.

Andrews Mountain Roadless Area.--Metallic mineral resource potential of the Andrews Mountain Roadless Area is low. A weak anomaly in molybdenum, zinc, copper, gold, and tungsten was detected in stream-sediment samples from one drainage west of Andrews Mountain (see map) and five mining properties show some resource potential, including one past producer near the area, the Squaw Flat mine (no. 41), with a small production of silver, gold, and lead (table 1 of accompanying pamphlet). An occurrence of low-grade scheelite on the Blue Crystal mos. 1-6 (no. 38) claim is in a small garnet-bearing tactite.

Mazourka Roadless Area.--The Mazourka Roadless Area has a high resource potential for gold and tungsten in the area adjacent to, and including the Black Eagle and Betty Jumbo mines (nos. 34 and 37, respectively) in the southern part of the area. There is a moderate resource potential for copper with some silver in the vicinity of the Copper Empire group (no. 28) near the mouth of Mazourka Canyon and a moderate resource potential for silver with lead and zinc in the northeastern part of the roadless area in the vicinity of Marble Canyon, the Narrows, and areas directly to the east of The Narrows. There is a low resource potential for silver, lead, zinc, copper, and gold throughout most of Mazourka Canyon, and at several other localities along the west front of the range. There is a moderate to low resource potential for talc and graphite in local areas on the east side of Mazourka Canyon about 5 mi from its mouth.

Evaluation of analyses of key metallic elements from stream sediments and panned heavy-mineral concentrates delineates five subareas within the roadless area that have significantly high anomalous amounts of the metal suite lead, zinc, molybdenum, and silver to warrant their classification as areas of moderate to low resource potential. Inspection of mines and prospects with accompanying assays of rock from the mines substantiates this subarea delineation and indicates greater than moderate resource potential at the Black Eagle and Betty Jumbo mines.

There are 39 mining properties in or near the Mazourka Roadless Area with some resource potential; 11 of these were past producers. The Betty Jumbo mine, Black Eagle mine, Silver Princess mos. 1-4 (Nancy Hanks), and the Copper Empire group are the most important of these mines. Resource estimates from these and other deposits in or near the area are in tables 2 and 3 of the accompanying pamphlet.

The Copper Empire group has seven mineralized areas along or near a 2-mi-long igneous-sedimentary rock contact. About 460,000 tons of indicated and inferred low-grade resources average 0.83 percent copper; this includes 69,000 tons that average 0.59 oz silver per ton. The Betty Jumbo mine has two scheelite-bearing tactite bodies; one at the east adit and one at the west adit. The east adit has had previous production and is nearly mined out, but the west adit has an indicated and inferred reserve of 52,000 tons averaging 0.70 percent tungsten trioxide. The Black Eagle mine has had a long history of past production and is fully developed. A small, demonstrated and inferred reserve of 12,000 tons averaging 0.21 oz per ton gold remains.

Graphite and marble mines in the area have produced a relatively small amount, compared to the amount of similar grade material left in place. Only a small amount of talc remains in present mines, but the possibility for discovering more is high. Resource estimates for these nonmetallic deposits are in table 3 of the pamphlet.

Placer gold is known from near the Mazourka Roadless Area in two localities--Marble Canyon in the northeast and the upper and middle parts of Mazourka Canyon. The Marble Canyon deposits, about 2 mi east of the roadless area, were discovered in 1934 (Dorsey, 1960) and have produced small amounts since this time.

Most of the known placer production from the upper and middle parts of Mazourka Canyon area probably comes from numerous gold-bearing quartz veins and veinlets nearby. Commonly, the gold is found still attached to quartz in these residual eluvial deposits. Local residents use small mechanized concentrators, working with limited available water. The unreported production is assumed to be small.

Paiute Roadless Area.--The Paiute Roadless Area has a moderate mineral resource potential for silver and associated lead and zinc in the area around Lead Canyon. This estimate is based on high anomalous values of lead, zinc, molybdenum, and silver from stream sediment and heavy-mineral concentrate as well as identified resources from several mines and prospects in or near the area. Although molybdenum is ubiquitous in samples from this area it is probably not in concentrations high enough or voluminous enough to be indicative of a potential for molybdenum resource.

There are six mining properties with identified resources, including one past producer, the Custer (Baxter) mine (no. 51), in or near the Paiute Roadless Area. Adjacent to the east edge of the area, the Bunker Hill and Blue Monster mines produced lead, silver, and zinc over a period of several decades. Properties with identified resources are listed in tables 2 and 3 of the pamphlet.

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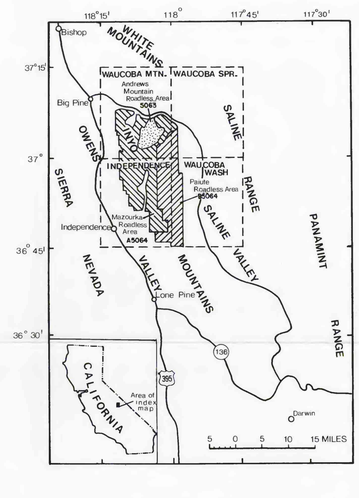

INDEX MAP SHOWING LOCATION OF THE ANDREWS MOUNTAIN, MAZOURKA, AND PAIUTE ROADLESS AREAS IN THE INYO MOUNTAINS

MINERAL RESOURCE POTENTIAL MAP OF THE ANDREWS MOUNTAIN, MAZOURKA, AND PAIUTE ROADLESS AREAS, INYO COUNTY, CALIFORNIA

By
Edwin H. McKee, James L. Donahoe, and Richard J. Blakeley
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U.S. Bureau of Mines

1983

Explanatory pamphlet accompanies map

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