Investigations of Molybdenum Deposits in the Conterminous United States 1942-60

By HAROLD KIRKEMO, C. A. ANDERSON, *and* S. C. CREASEY

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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Description and maps of many small mines and prospects, with sections by C. C. Albritton, Jr., W. S. Burbank, G. H. Espenshade, D. J. Fisher, E. N. Harshman, S. W. Hobbs, R. U. King, A. H. Koschmann, D. H. Kupfer, J. A. MacKallor, D. R. MacLaren, R. L. Miller, J. F. Robertson, C. P. Ross, H. K. Stager, D. B. Tatlock, Ogden Tweto, D. J. Varnes, and J. S. Vhay

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CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

TABLES

INVESTIGATIONS OF MOLYBDENUM DEPOSITS IN THE CONTERMINOUS UNITED STATES, 1942–60

By Harold Kirkemo, C. A. Anderson, and S. C. Creasey

ABSTRACT

Many of the molybdenum-bearing deposits in the conterminous United States were examined by geologists of the U.S. Geological Survey in the 18 years between 1942 and 1960. Geologic maps were made of some of them, a few deposits were systematically sampled, and others were studied contemporaneously with diamond-drill programs of the U.S. Bureau of Mines and the Reconstruction Finance Corporation and with exploration projects of Defense Minerals Exploration Administration and other agencies. Most of the deposits examined are in the Western States; two are in Maine, two in North Carolina, and two in Wisconsin. About half of the molybdenite deposits examined are quartz veins that include some pyrite and, less commonly, chalcopyrite. Stockworks of intersecting quartz veins, mineralized aplite dikes, and mineralized metamorphosed limestone (largely tactite) compose most of the remainder. Two breccia pipes containing chalcopyrite and molybdenite and one deposit in mineralized rhyolite breccia were examined. In general, the most important resources of molybdenum in the deposits described in this report are in the stockwork deposits and breccia pipes. Of the total domestic reserves of about 4 billion pounds of recoverable molybdenum, about three-fourths is in deposits that produce molybdenum as the principal product, as at Climax, Colo. The remaining reserves are in deposits, mainly porphyry copper deposits, that produce molybdenum as a byproduct.

INTRODUCTION

During World War II, molybdenum supplies became short because of the substitution of molybdenum for chromium, nickel, tungsten, and vanadium as an alloying element. At the request of the War Production Board, the Geological Survey investigated many molybdenite deposits in the conterminous United States to find those most promising for exploration and exploitation. Geologic maps were made of some of these deposits, and samples for assaying were systematically collected for a few. Some properties were diamond drilled by the U.S. Bureau of Mines and some by the Reconstruction Finance Corporation. The State of Colorado and the Colorado Metal Mining

Fund cooperated in the preparation of a report on one of the deposits in Colorado.

W. S. Burbank was in charge of the molybdenite investigations for the Geological Survey during World War II. Under Burbank's direction, C. A. Anderson initiated the field program in the Western States in September 1942 and was in charge of it until he left for other assignments in October 1943. He was assisted by D. H. Kupfer and, for short periods, by S. C. Creasey and M. W. Cox. Kupfer worked on the program from September 1942 until July 1944; during the last year, he worked independently, largely on the Copper Hill deposit in Arizona. Creasey joined the program in May 1943, and continued until it recessed in August 1944. He worked largely on deposits in the Pacific Northwest and was assisted for 2 months in 1943 by E. A. Scholz. During 1942 and 1943, C. C. Albritton, G. H. Espenshade, D. J. Fisher, S. W. Hobbs, A. H. Koschmann, R. L. Miller, C. P. Ross, Ogden Tweto, D. J. Varnes, and J. S. Vhay examined the molybdenite deposits they found while engaged in other studies; their reports have been incorporated in this paper.

Publication of reports on the molybdenite program conducted during World War II was postponed because of the assignment of personnel to projects considered more urgent.

With few exceptions, property owners or their agents guided Geological Survey personnel to the properties described in this report, and their familiarity with local problems facilitated the work immensely. Engineers with the U.S. Bureau of Mines furnished information and cooperated with the Geological Survey in the study of several deposits during the 1942–44 period. Their cooperation on many joint investigations since then is gratefully acknowledged. The staff of the Reconstruction Finance Corporation (RFC) also cooperated in the examination and sampling of some deposits in Arizona during World War II. A list of all the individuals who helped with this program would be too long to incorporate in this report, but the Geological Survey is grateful for their cordial and helpful assistance.

The Korean emergency that began in 1950 brought new shortages of minerals and metals for defense and essential civilian industries. The Geological Survey and the Bureau of Mines therefore resumed investigations of mineral deposits on behalf of Federal agencies authorized under the Defense Production Act of 1950 to assist in the search for minerals and metals. These investigations have continued under various authorizations since the Korean emergency ended. Among the agencies concerned were the Defense Minerals Administration (DMA), the Defense Materials Procurement Agency (DMPA), the Defense Minerals Exploration Administration

(DMEA) from 1951 to June 30, 1958, and, since September 11, 1958, the Office of Minerals Exploration (OME).

Many Federal geologists and mining engineers participated in the field investigations during and after the Korean emergency, particularly in the DMEA program, and unpublished reports resulting from these examinations have been summarized for this bulletin. The report covers nearly two decades of Geological Survey investigations of molybdenum deposits. The names of personnel whose reports have contributed information for this bulletin are given in the descriptions of the individual deposits.

A comprehensive report on the worldwide geologic occurrence, mineralogy, production, and bibliography of molybdenum is available in Vanderwilt's (1942) excellent work.

USE AND HISTORY OF MOLYBDENUM

Molybdenum is used chiefly in ferrous alloys, which consume 85 to 90 percent of the supply (McInnis, 1957, p. 1). Other uses include nonferrous alloys, chemical reagents, colors for pigments, catalysts in petroleum refining, lubricants, and high-temperature structural application (McInnis, 1957, p. 60–62).

During World War I (1914–18), the demand for molybdenum as a substitute for tungsten resulted in a total world production of about 5 million pounds (McInnis, 1957, p. 3). Peacetime uses of molybdenum slowly grew, and by the start of World War II, world production had increased to 34 million pounds annually. The war effort, however, required additional molybdenum, and it was supplied mostly by increased production at the Climax mine in Colorado, the leading molybdenum producer in the United States, and to a lesser extent by increased byproduct output from some of the porphyry copper mines. Domestic production increased to a maximum of more than 60 million pounds in 1943, the Climax mine providing 75 percent of the total (McInnis, 1957, p. 4). After World War II, the molybdenum market slumped, and the domestic production in 1946 was only 18 million pounds, the lowest in a decade. The outbreak of the Korean war created another heavy demand for molybdenum, and the supply became critical. In 1950, molybdenum was included in the National Strategic Stockpile List of Critical and Strategic Materials. In 1952, the U.S. Government announced an expansion goal of 58 million pounds annually of domestically produced molybdenum, and this goal was later raised to 70 million pounds for 1954. New sources of molybdenum in Canada and the United States helped to increase production, and in 1960 domestic production reached a high of 68.2 million pounds. (McInnis and Burke, 1961, p. 823).

Creasey (1957, p. 6) estimated the total U.S. molybdenum reserves (including Alaska) to be about 3 billion pounds. He also estimated that 94 percent of these reserves is contained in five deposits: Climax, Colorado; Utah Copper, Utah; San Manuel, Arizona; Morenci, Arizona; and Orange Hill, Alaska. More recent data on molybdenum reserves have been assembled by a panel for the Materials Advisory Board of the National Research Council (1959, p. 120), under the Chairmanship of Mr. Frank Coolbaugh of American Metals Climax, Inc. This panel estimated that the total U.S. molybdenum reserves contained about 4 billion pounds of recoverable molybdenum, which is about 68 percent of the free world reserves. Of the U.S. reserves, 78 percent is in deposits that produce molybdenum as the primary product, and 22 percent is in deposits that produce molybdenum as a byproduct, according to the panel's report.

GEOLOGICAL OCCURRENCES OF MOLYBDENUM

Molybdenite (MoS_2) and, to a minor extent, wulfenite ($PbMoO_4$) and powellite ($CaMoWO_4$) are the commercially important minerals of molybdenum. Ferrimolybdite (molybdite) ($Fe_2(MoO_4)_3 \cdot 8H_2O$) is an oxidation product of molybdenum-bearing minerals, but it has not been treated commercially.

In recent years practically no wulfenite has been mined, and during World War II the War Production Board considered only molybdenite as a commercial source of molybdenum. Therefore, the Geological Survey studied only molybdenite deposits during this period. All promising sources of molybdenum, however, were eligible for consideration under the exploration programs in effect since 1950.

Molybdenite is a lead-gray metallic mineral that characteristically occurs in thin, tabular, commonly hexagonal plates and, to a lesser extent, in rosettes. It has a perfect basal cleavage and is soft and flexible but not elastic. Superficially it resembles graphite, for which it is often mistaken.

Molybdenite is produced from three main types of deposits: (1) Those that contain molybdenite alone or as the chief economic mineral, (2) copper deposits that yield molybdenite as a byproduct, and (3) contact-metamorphic tungsten deposits that yield byproduct molybdenite or molybdenum from powellite. About two-thirds of the domestic supply of molybdenum normally comes from the first type of deposit, and the remaining third mainly from the second type.

The Climax deposit in Colorado is the largest known single concentration of molybdenite in the world. The molybdenite here occurs in a stockwork of small intersecting quartz veinlets surrounding a zone of silicified granite and schist. Numerous quartz-pyrite veinlets intersect the quartz-molybdenite veinlets, which are cut by seams of sericite. The pyritic veinlets contain small amounts of fine-grained topaz, huebnerite, chalcopyrite, and sphalerite (Butler and Vanderwilt, 1933, p. 227–229).

At Urad, Colo., branching and intersecting veins containing molybdenite are seemingly related to a large vein system.

The Questa molybdenite deposit in New Mexico is the only known vein deposit in the United States that has produced large quantities of molybdenite (Vanderwilt, 1942, p. 39). The ore consists of molybdenite, quartz, rhodochrosite, pyrite, and fluorite (Carpenter, 1960a, p. 85). The ore veins range from a few inches to several feet in width. Disseminated molybdenite is also widely dispersed in the wallrocks surrounding the veins.

Porphyry copper deposits usually contain some accessory molybdenite, which is recovered from several mines. These deposits generally are localized in fractured and mineralized zones that include silicic intrusive masses and some of the contiguous country rock. The chief primary minerals are quartz, pyrite, chalcopyrite, and molybdenite. Chalcocite replaces chalcopyrite and pyrite in the zone of supergene enrichment. The ratio of copper to molybdenum in the porphyry copper ores is estimated to average about 75:1; it ranges from about 20:1 to perhaps 200:1.

In mineralized breccia pipes, which are somewhat similar to the porphyry copper deposits, copper minerals and molybdenite generally occur in quartz gangue cementing the fragments that compose the pipe. From a deposit of this type at the Childs-Aldwinkle mine, Copper Creek, Ariz., about 7 million pounds of molybdenite and almost 6 million pounds of copper were produced from 1933 to 1939 (Kuhn, 1941, p. 529).

Many aplite and pegmatite dikes and masses, and quartz veins associated with them, contain small quantities of molybdenite, but conditions generally are not favorable for the recovery of large quantities of molybdenite. Some quartz veins contain large rosettes of molybdenite crystals that are valued highly as mineral specimens. In general, however, the molybdenite-bearing parts of these veins are podlike and do not have leads to other pods, and mining usually necessarily ends after the extraction of a single pod.

Small quantities of molybdenum are widely distributed in calcium-silicate rocks along the margins of granitic intrusive rocks and calcium-rich sedimentary rocks. Tungsten in scheelite ($CaWO_4$) is the chief economic mineral, and molybdenite or powellite ($CaMoWO_4$) may be a byproduct. The only domestic production from this type of deposit is from the Pine Creek tungsten mine in California, where molybdenum trioxide (MoO_3) is recovered from the powellite by chemical treatment, and molybdenite is separated by flotation (Bateman, 1956, p. 24). Fractures in the calcium-silicate rock control the deposition of the tungsten and molybdenum minerals, and at some deposits more than one generation of fractures are mineralized. At Pine Creek, the molybdenite is younger than the scheelite, and they are not coextensive.

DESCRIPTION OF DEPOSITS

The locations of the molybdenum deposits examined by the U.S. Geological Survey are shown on figure 1. The following descriptions of the deposits are arranged alphabetically by States; individual deposits are described under the counties in the States.

ARIZONA

MARICOPA COUNTY

ROWLEY OR RELIANCE MINE, by J. A. MacKallor

The Rowley (Reliance) mine is in the Painted Rock district approximately 27 miles west and north of Gila Bend, Ariz. It was accessible in 1952 by automobile from Gila Bend. The property is in secs. 24 and 25, T. 4 S., R. 8 W. on the western edge of the Painted Rock Mountains.

J. A. MacKallor, U.S. Geological Survey, and M. J. Elsing and W. T. Griswold, U.S. Bureau of Mines, visited the property in January 1952 for the DMA. The owner, Jack Rowley Fedrick, accompanied the examiners to the property.

The property was explored and developed by various companies during the period 1909–23. The workings in 1952 included a main inclined shaft (No. 1) 265 feet deep, an inclined shaft (the Jobes) 125 feet deep, and a vertical shaft 163 feet deep. The amount of drifting is unknown; perhaps as much as 1,850 feet was driven. The 125 level, the only level not under water in 1952, follows the vein for 370 feet. Both the No. 1 shaft and the Jobes shaft are in the Rowley vein. Reportedly some stoping was done in the workings from the Jobes shaft. A small mill comprising two concentrating tables and a Frue vanner operated for a time, and probably at least 2,000 tons was milled from 8,000 to 10,000 tons of vein material mined during the development work.

One small car of copper ore averaging 15 percent copper was shipped to a local smelter, and 30 tons of wulfenite concentrate, containing 18.26 percent of MoO_3, was shipped to a buyer in California. The amount of diamond drilling completed is not known. Most likely five or six vertical holes were drilled from points 260 to 600 feet east of the vein. Records show that the vein was intersected at depths of 260 and 340 feet below the collar of the main shaft in two holes drilled 260 and 375 feet, respectively, east of the shaft.

Flat-lying Tertiary andesite flows underlie the Jack Rowley claims and the adjoining San Carlos claims. A fault striking N. 30°–37° W., and dipping 37° to 50° E. cuts these rocks and extends about 4,000 feet across the claims. Mineralized segments of the fault comprise the Rowley vein, and one segment, about 800 feet long, is exposed on the Rowley claims. Mineralized segments are present also on the San Carlos claims. The Rowley vein consists of two distinct and adjoining veins in the same fault structure—a quartz vein in the footwall and a barite vein in the hanging wall.

The quartz vein has a fairly uniform width of about 5 feet in the main shaft and on the 125 level for a distance of about 370 feet. The footwall contains no fault gouge or breccia. A few widely spaced tight fractures cut the vein and extend a few feet into the andesite. The vein is massive; nowhere is it brecciated or greatly fractured. There is no gossan or leached zone in or near the vein and no evidence of a zone of enrichment at depth.

Massive quartz and a minor amount of jasper compose most of the vein material, but a small amount of specular hematite and sparse grains of pyrite are present. Some of the quartz is rust colored from small amounts of hematite and limonite that occur both as inclusions and as stains from weathering of iron minerals in the andesite. Several persistent bands of malachite and chrysocolla, 1 to 2½ inches thick, occur within the quartz. These minerals also occur for distances as much as 3 feet along isolated fractures that cut the vein and extend into the andesite. Small pockets of high-grade oxide copper ore and a small amount of chalcocite have been reported.

The barite vein in the hanging wall of the Rowley vein structure ranges from 15 to 30 feet in thickness. Its contact with the quartz vein in sharp and regular, whereas the hanging wall is very irregular. Gouge, 4 inches thick, separates the barite from a 3- to 4-foot zone of fractured and slightly brecciated andesite. Inclusions of andesite are present in the vein within 10 feet of the hanging wall. Barite usually occurs as masses of stringers parallel to the strike of the vein, although some of the stringers are contorted and even bend through an arc of 180°.

Galena is associated with the barite. One pod about 5 inches in diameter was seen, and reportedly pods of galena were once mined. Small amounts of calcite are also present.

Molybdenum minerals are present in both the quartz and barite veins near their common contact. Ferrimolybdite forms a thin partial coating on the walls of the main shaft from the surface to a depth of 50 feet. At a greater depth, small stringers containing minute crystals of wulfenite are present in the shaft walls. Some of the stringers cut through the narrow bands of malachite and chrysocolla.

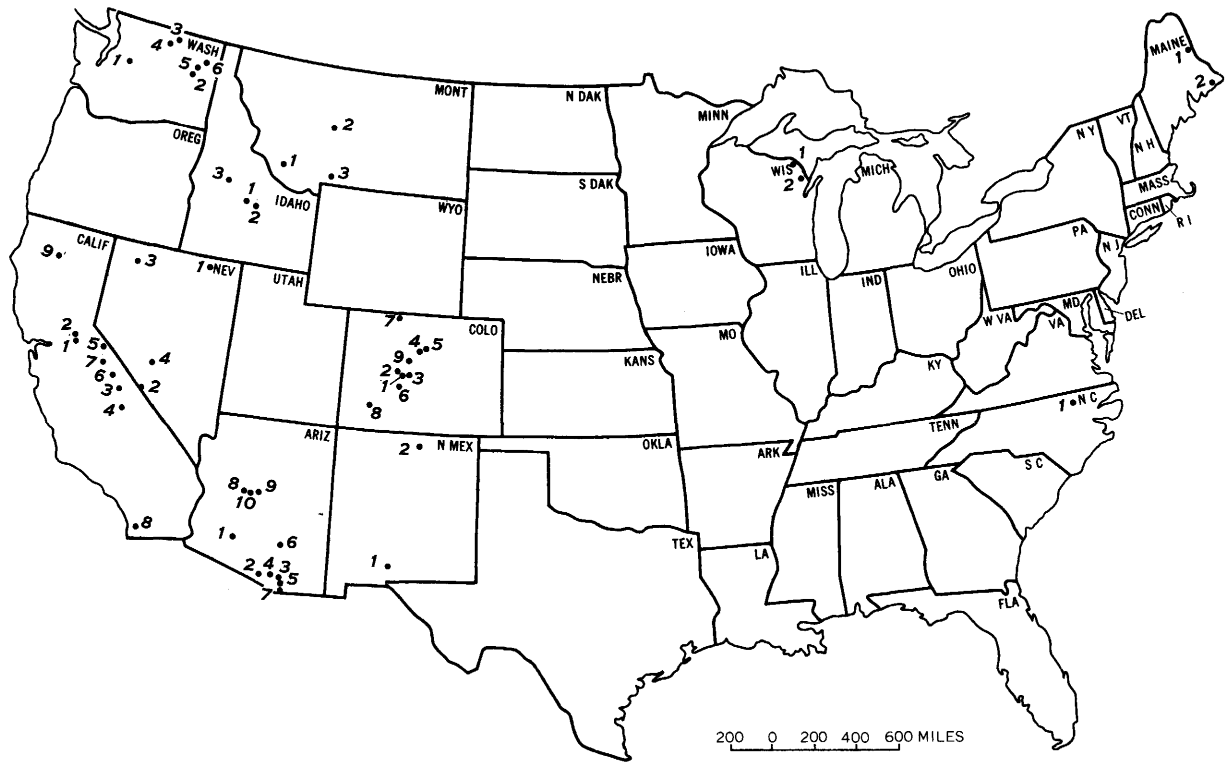

Figure 1.—Index map of the conterminous United States showing location of molybdenum deposits examined by U.S. Geological Survey 1942–60. Key to location on page E9.

Key to locations shown on figure 1

- Arizona:
  - Maricopa County:
    1. Rowley.
  - Pima County:
    2. Gold Bullion.
    3. Leader.
    4. New Years Eve.
  - Pima and Santa Cruz Counties:
    5. Sun Lode.
  - Pinal County:
    6. Rare Metals.
  - Santa Cruz County:
    7. Santo Nino.
  - Yavapai County:
    8. Copper Basin.
       Commercial.
       Copper Hill.
       Loma Prieta.
    9. Squaw Peak.
    10. Twin Ledge.
- California:
  - Calaveras County:
    1. White Horse and Bay Horse.
  - Eldorado County:
    2. Consumnes Copper.
  - Inyo County:
    3. Atkins.
    4. War Baby.
  - Mono County:
    5. Blue Speck.
    6. Laurel Creek.
    7. September.
  - San Diego County:
    8. Bour.
  - Shasta County:
    9. Boulder Creek.
- Colorado:
  - Chaffee County:
    1. Little Guy.
    2. Red Mountain.
    3. Wagner.
  - Clear Creek County:
    4. Urad.
  - Gilpin County:
    5. Wilma.
  - Gunnison County:
    6. Gold Hill.
  - Routt County:
    7. Foch, Copper Mask.
  - San Miguel County:
    8. Ophir Valley.
  - Summit County:
    9. D and G property.
- Idaho:
  - Custer County:
    1. Boulder Creek.
    2. Walton.
       White Mountain.
  - Valley County:
    3. Virginia-Beth.
- Maine:
  - Aroostook County:
    1. Henderson.
  - Washington County:
    2. Cooper.
- Montana:
  - Beaverhead County:
    1. Monaghan.
  - Cascade County:
    2. Big Ben.
       Hegener.
  - Park County:
    3. Emigrant Gulch.
- Nevada:
  - Elko County:
    1. Robinette.
  - Esmeralda County:
    2. Sorenson.
  - Humboldt County:
    3. Desert View.
  - Nye County:
    4. Hall.
- New Mexico:
  - Dona Ana County:
    1. Billie H. and Dona Loga.
  - Taos County:
    2. Questa (Moly).
- North Carolina:
  - Halifax County:
    1. Boy Scout-Jones.
       Moss-Richardson.
- Washington:
  - King County:
    1. Devils Canyon.
  - Lincoln County:
    2. Spokane.
  - Okanogan County:
    3. Bi-Metallic.
    4. Starr.
  - Stevens County:
    5. Deer Trail Monitor.
    6. Western Molybdenum.
- Wisconsin:
  - Florence County:
    1. Payant-Chrissman.
  - Marinette County:
    2. Camp Five.

On the 125 level, wulfenite occurs in patches and stringers of minute crystals and in clusters of large crystals along small fractures. A specimen containing a few crystals of vanadinite in association with wulfenite was found on the dump.

The quartz vein in the mineralized structure at the Rowley mine averages less than 1 percent copper, less than 1 ounce silver per ton, and a trace of gold. The barite vein contains less than 1 percent lead and less than 1 percent MoO_3.

PIMA COUNTY

GOLD BULLION MINE

The Gold Bullion mine is in the Baboquivari mining district, about 60 miles southwest of Tucson, Ariz. When Anderson and Kupfer examined it in December 1942, the property was accessible from State Highway 286 that connects Robles Junction and Sasabe. The mine is in sec. 2, T. 20 S., R. 7 E. on the north side of Weaver Canyon about 7 miles west of the highway.

In 1942 the property consisted of two claims, Banes 1 and Banes 2, owned by H. E. Heighton of Tucson. The property was originally prospected for gold, and between 1906 and 1910 an inclined shaft was sunk about 225 feet, connecting to two drifts (fig. 2). This shaft dips 70° N. for the first 52 feet and 44° N. for the last 173 feet. To the east, a second shaft connects to the upper level. An unknown amount of gold ore was shipped in 1913. Molybdenite occurred to

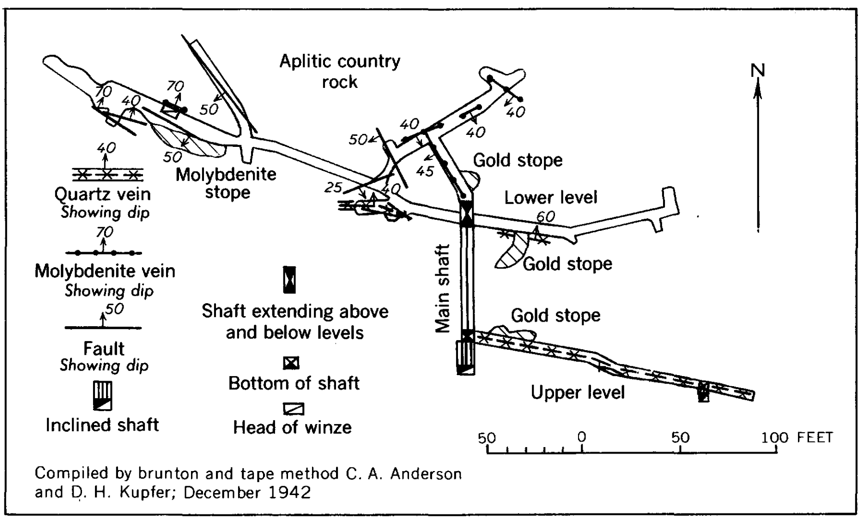

FIGURE 2.—Geologic map of the underground workings of the Gold Bullion mine, Pima County, Ariz.

the west of the shaft on the lower drift. In 1916 several hundred tons of high-grade molybdenite ore was mined from a stope 20 feet high, 40 feet long, and 6 to 10 feet wide. Apparently the material from this stope included all the minable molybdenite ore.

The country rock is an aplitic granite cut by quartz veins that have considerable range in size and trend. The vein on which the two shafts were sunk strikes N. 70° W. and dips 70° N. near the surface but flattens to 40° N. below the 55 level. The vein pinches and swells; it is 8 feet wide on the 55 level of the western shaft. Reportedly it contained the gold that encouraged the original exploration, but no molybdenite was observed.

Molybdenite is found only on the lower level in workings largely in the hanging wall of the main quartz vein. The molybdenite is associated with quartz that forms narrow veins as much as 1 inch wide and 15 feet long. Faulting after the deposition of the molybdenite crushed the quartz and smeared the molybdenite. The veins, which grade into narrow gouge zones, strike northwest and northeast.

Along the north wall of the molybdenite stope, a quartz-molybdenite vein locally is 3 inches wide. Reportedly it widens to 8 inches in the bottom of the winze (fig. 2).

The exposed veins containing molybdenite are widely separated and too low in grade to constitute minable ore. Nothing observed in the mine indicated any other high-grade pockets similar to the one mined from the molybdenite stope.

LEADER MINE

The Leader mine is in sec. 24, T. 18 S., R. 15 E., at the north end of the Santa Rita Mountains. An unknown amount of copper and about 13,000 pounds of molybdenite have been produced from the property, but the mine was inactive in January 1943.

Molybdenite occurs in limestone and garnet rock in the footwall of a low-angle fault; the hanging wall is granitic rock. The molybdenite occurs separately from chalcopyrite, the dominant copper mineral in the mine. The molybdenite is disseminated, forming scattered bunches or pockets of molybdenite-bearing rock. It also occurs in thin seams that commonly swell to small pockets as much as a foot long and several inches wide at intersections with other seams. The reserves of exposed molybdenite-bearing rock are small.

The report of Creasey and Quick (1955, p. 315–318, pl. 31) on the Leader mine contains a map of most of the underground workings. Much of the molybdenite observed in the mine is on the 40 level, shown on figure 3 of the present report. This level was omitted on plate 31 of the report by Creasey and Quick (1955) because of the scarcity of copper-bearing minerals.

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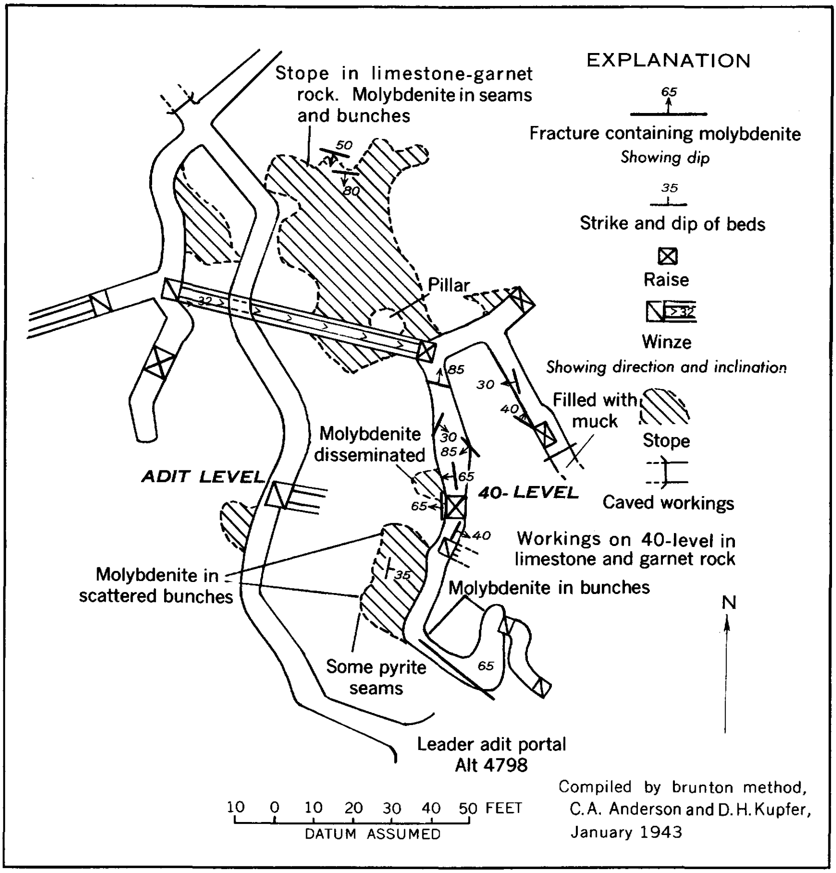

FIGURE 3.—Map of the 40 level and part of the portal level of the Leader mine, Pima County, Ariz.

NEW YEARS EVE MINE AND ESPERANZA CLAIMS

The New Years Eve mine is about 4 miles west of Twin Buttes in sec. 9, T. 18 S., R. 12 E. When examined in 1943 by Kupfer and Anderson, the property was owned by the Amargosa Molybdenum and Copper Corp., Dr. Samuel Isermann, president. More than 2,000 feet of underground workings was accessible for examination after the mine was unwatered with the aid of a loan from RFC.

In the mine, molybdenite is associated with chalcopyrite in a plug-like mass of quartz. Some high-grade bunches of molybdenite several inches in greatest dimension occur, but most of the molybdenite is erratically distributed in short disconnected veinlets.

The Esperanza claims are 1 mile to the southwest of the New Years Eve mine, and in 1943 they also were owned by the Amargosa Molybdenum and Copper Corp. Here the rocks have been brecciated and silicified. Chalcopyrite and molybdenite occur in the breccia as well as in narrow quartz veins cutting the altered rocks. In 1944, the U.S. Bureau of Mines drilled three holes totaling 1,461.5 feet. The core samples contained an average of 0.05 percent MoS_2 and 0.28 percent copper (Tainter, 1947). The U.S. Geological Survey placed maps of the Esperanza claims in open file (Anderson and Kupfer, 1945). These maps are not included in this report because J. R. Cooper of the Geological Survey was investigating the geology and mineral resources of the Twin Buttes quadrangle in 1960. His report will be much more comprehensive and will include all pertinent information relating to the molybdenite deposits in the quadrangle.

PIMA AND SANTA CRUZ COUNTIES

SUN LODE CLAIMS

The Sun Lode Molybdenum Co., owned by John A. Duffy and Chester A. Wynn, Chicago, Ill., leased and relocated several claims in Madera Canyon, two of which were examined by Anderson and Kupfer in April 1943. Madera Canyon, on the west slope of the Santa Rita Mountains, is accessible by a good road from Continental, Ariz., which is on U.S. Highway 89, 26 miles south of Tucson. The two prospects visited were Sun No. 1 claim near the center of sec. 35, T. 19 S., R. 14 E., in Pima County, and Sun No. 25 claim in sec. 2, T. 20 S., R. 14 E., in Santa Cruz County.

The longest adit, 250 feet, is on Sun No. 1 claim. It was driven in a southeasterly direction along a fault in which molybdenite-bearing quartz was found. Fifty feet above the adit at about its midway point, an opencut 49 feet long has been excavated along the same quartz vein as that in the adit.

The only other adit, 42 feet long, is on Sun No. 25 claim. It was driven due west along a vertical fault. A lens of quartz containing scattered crystals of molybdenite was found between 27 and 35 feet from the portal.

At these claims granitic rocks, ranging from diorite to granite, are most abundant, and they are cut by numerous aplitic dikes. In the northern part of Madera Canyon, quartz veins strike almost east but range from N. 70° W. to N. 80° E.; their dip is steep to the north. The veins range in width from 1 inch to more than 3 feet; marked changes in width occur along the strike. In general, the veins are spaced 30 to 100 feet apart. Younger faults virtually parallel the veins. Molybdenite occurs as tiny scattered crystals in short seams that are irregularly and sparsely distributed in the quartz veins. In general, molybdenite is more abundant where the quartz veins are widest.

The spotty distribution of the molybdenite in the observed veins will probably discourage their exploration.

PINAL COUNTY

RARE METALS DEPOSIT

The Rare Metals deposit, in sec. 8, T. 4 S., R. 13 E., is in Riverside No. 2 mining district, about 4 miles west of Kelvin and 1 mile south of the Gila River. In 1943, the deposit could be reached by a dirt road 2 miles long that connected to the Kelvin-Florence graded road, 2½ miles southwest of Kelvin.

Anderson and Kupfer examined the deposit in March 1943. The property was owned by the Riverside Mining Co., A. H. Johnson, Phoenix, president and manager. In 1942, the RFC granted a development loan of $5,000 to the company.

In 1943, the mine workings consisted of an 84-foot vertical shaft, an 80-foot crosscut extending N. 15° W. from the bottom of the shaft, and two drifts, 18 and 15 feet long extending west from the crosscut at 18 and 62 feet, respectively, northwest of the shaft. No ore had been produced at the time of the examination.

The country rock at the deposit is coarse-grained biotite granite that is cut by east- to northeast-trending quartz porphyry and aplite dikes as much as several feet wide. Quartz veins are exposed at the surface and in the underground workings, and irregular quartz masses are exposed northeast of the shaft. Southwest of the shaft, a quartz vein ranging from 1 inch to 2 feet in width strikes N. 70° E. and dips 80° N. In the underground workings, narrow quartz veins form zones 1 foot wide; the veins strike N. 75° E. and are vertical. Underground, some of these quartz veins contain pyrite, chalcopyrite, and traces of molybdenite. The surface exposures of quartz, however, are barren except for limonite and faint malachite stains.

Molybdenite occurs as thin seams in the fault gouge of two fault zones that strike east to northeast. These seams were too narrow and too far apart for profitable mining under 1959 prices for molybdenite.

SANTA CRUZ COUNTY

SANTO NIÑO MINE, by D. H. Kupfer

The Santo Niño mine and adjacent molybdenite prospects are in sec. 9, T. 24 S., R. 16 E., on the east slopes of the Patagonia Mountains in the Patagonia mining district. The properties are within 2 miles of the Mexican border and about 14 miles east of Nogales, Ariz.

Kupfer briefly visited these properties in December 1943. At the time of the visit, the Santo Niño group consisted of five patented claims owned by the Southern Copper Mining Co., New York. The early history of the mine is not known. Production from operations in 1918–31 and 1942–43 was about 20,000 tons of ore averaging 7 to 8 percent copper and about 1 percent MoS_2. The mine was not operating at the time of Kupfer's visit.

In 1943 the mine had been developed on about seven levels. The stoped area was about 200 feet long, more than 200 feet high, 30 to 40 feet wide on the stope level, and 5 to 6 feet wide in the upper levels. Few timbers were present in the lower workings and all the stopes and drifts were standing in good condition. Kupfer mapped three of the levels (pl. 1).

The country rock of the area is a fresh gray quartz monzonite with very conspicuous joints. The principal joints strike north to N. 10 W. and dip 60° to 70° W., and the secondary joints dip 0° to 10° N.

Prominent fractures, both mineralized and unmineralized, are found in the mine and on the surface above the mine. The fractures strike N. 45°–50° E. and dip 60° N. to vertical. Where mineralized, the fractures may contain pink, feldspathized quartz monzonite, light cream-colored aplite, or pyrite- and chalcopyrite-bearing vein quartz. Where unmineralized, the fractures contain as much as 5 feet of white or limonite-stained gouge and breccia. Striae on the slickensided surfaces indicate that the average overall movement was dip-slip although the direction of movement varied through about 30° of arc. Small irregularities on one slickensided surface suggest that the fault is a reverse fault.

The principal ore-bearing formation is a pink feldspar-rich medium-grained granitic rock. The contact between the pink feldspar rock and the gray quartz monzonite country rock is gradational and very irregular and suggests that the feldspar has replaced the quartz monzonite. The principal body of feldspathized rock is a roughly sheetlike body that averages only a few feet in width, strikes N. 10° W., and dips 70° W. It has been explored for a length of about 300 feet and a depth of more than 350 feet. The maximum thickness observed was about 20 feet, but pocketlike extensions or apophyses extend out from the main mass for more than twice that distance.

Chalcopyrite and pyrite are disseminated through most of the feldspathized rock and for several feet into the adjacent quartz monzonite. No significant chalcopyrite mineralization has been found below a point 40 feet above the haulage level (pl. 1) although the feldspathized rock extends below this point. Large and small vugs and pockets of massive and terminated quartz are scattered irregularly throughout the feldspathized rock.

Molybdenite is found principally in pockets and lenses that are as much as 10 feet in maximum dimension and are located at irregular intervals in the feldspathized rock. Observed molybdenite pockets were associated with conspicuous joints. The high-grade molybdenite is disseminated for 2 to 3 inches out into the rock surrounding the joints. Although not observed in place, some of the pockets of molybdenite were so rich that the ore (except for small amounts of chalcopyrite) appeared to the unaided eye to be pure molybdenite.

Chalcopyrite and molybdenite at Santo Niño are associated in a broad way, but they appear to be unrelated in detail. The chalcopyrite is widely disseminated over the whole deposit whereas the molybdenite occurs in small pockets which may or may not contain significant amounts of chalcopyrite. Copper reportedly has been found at the surface, but no molybdenite was reported less than 100 feet from the surface; selective leaching or alteration is thus indicated.

Although only a brief examination was made, the localization of the feldspathized rock and of the mineralization appears to be closely related to the north-south jointing and, secondarily, to the northeast fractures. The main ore body follows the trend of the joints, and the wider areas and apophyses tend to follow the fractures. The joints and fractures apparently provided the channels and openings that allowed access to the country rock and localized the deposition.

The ore body at the Santo Niño mine is virtually mined out, and efforts to find extensions or new ore bodies have been unrewarding. The ore bottoms 40 feet above the haulage level, but the feldspathized rock extends downward an unknown distance. About 500 feet of exploratory drifting and crosscutting on the haulage level failed to discover any ore.

A detailed examination of the working would probably reveal the structural controls that localized the Santo Niño ore body. If these controls were known, they could be used as guides for further explorations at the Santo Niño mine and at other molybdenite prospects in the vicinity (Schrader and Hill, 1910, 1915).

YAVAPAI COUNTY

COPPER BASIN DISTRICT

The center of the Copper Basin district is about 12 miles west of Prescott, Ariz., and 6 miles east of Skull Valley; graded gravel roads provide easy access from both places. The three deposits described here are in T. 13 N., R. 3 W.; the Copper Hill deposit is near the center of sec. 20; the Commercial mine, a half mile to the east, is on the boundary between secs. 20 and 21; and about one-quarter mile further to the southeast is the Loma Prieta mine in the SW¼ sec. 21.

The ore deposits and regional geology of Copper Basin were reported by W. P. Johnston [1] and by Johnston and Lowell (1961) based on studies made some years after the Geological Survey investigation.

[1] Johnston, W. P., 1955, Geology and ore deposits of the Copper Basin mining district, Yavapai County, Arizona: Utah Univ. unpub. Ph. D. thesis.

The summary in the following paragraphs is largely from their reports.

The Copper Basin deposits that contain the molybdenite are similar to the porphyry copper deposits common to the western and southwestern Basin and Range province. The deposits are related to a composite stock that includes five mappable facies ranging in composition from diorite to aplite. Johnston and Lowell (1961, p. 925) recognized 25 nearly vertical breccia pipes near the top of the composite stock. These pipes are circular or elliptical in horizontal plan. The fragments composing the breccia are cemented by quartz, orthoclase, and sulfide minerals. Both the Copper Hill and Loma Prieta deposits are part of this group of breccia pipes.

Johnston and Lowell (1961, p. 919) suggested that the composite stock is of Late Cretaceous(?) or early Tertiary(?) age whereas the main country rock consists of Precambrian gneiss and granitic rocks.

Preliminary studies were made in Copper Basin by Anderson and Kupfer in February 1943, and more extensive investigation of the Copper Hill and Loma Prieta deposits were made in the spring and summer of 1943. These deposits are adjacent to the Commercial mine.

COMMERCIAL MINE

The Commercial mine in Copper Basin was not studied by the Geological Survey, but a brief description is warranted because it has been the most productive deposit in the Basin and because it is similar in many aspects to the Copper Hill and Loma Prieta deposits. The Commercial mine, owned by Phelps Dodge Corp., was under lease to F. S. Schemmer, who was mining oxide copper ore at the time of our study in 1943. According to Johnston (p. 105–106; see footnote 1) production started in 1914; incomplete data to 1955 show that more than 150,000 tons of high-silica copper ore was produced.

The Commercial mine has been developed by shafts, adits, drifts, and crosscuts, all within the limits of a breccia pipe (Commercial pipe), which is about 600 feet in diameter at the surface (Johnston, p. 106; see footnote 1). Some molybdenite is exposed in the workings of the Commercial mine, but none was recovered because the high-silica oxidized ore was used for flux by the smelter. Much of the ore was shipped to the Phelps Dodge smelter at Clarkdale before it closed down in 1950. During 1959, Schemmer was shipping ore to the smelter at Douglas.

COPPER HILL MINE

In 1943, the Copper Hill mine, owned by Schemmer and J. E. Erickson, was under lease to the Copper Basin Molybdenum Co., a partnership of Vic Hale, Nick Duyn, and Fred Gibbs. The Copper Hill group of claims consisted of eight claims, held by location. They are bordered on the east by patented claims owned by the Phelps Dodge Corp.

The Copper Hill mine was located by John Jackson; a cross section drawn by Jackson, dated September 1907, indicates that much of the underground development was done in 1906. The cross section shows stopes near the surface west of the accessible workings; presumably oxidized copper ore was being mined in 1907. Additional development work was done in 1917–18. Copper carbonate ore has been mined from the adit level; from 1916 to 1918 1,800 tons of molybdenite ore was mined, 300 tons of which reportedly averaged about 5 percent MoS_2. Presumably that molybdenite ore came from the upper levels of the mine where higher grade molybdenite ore is exposed.

Anderson and Kupfer made a surface geologic map and sampled parts of the mine in March and April 1943. The RFC granted a loan to the Copper Basin Molybdenum Co. for diamond-drill exploration, and Kupfer logged and sampled the cores and sludges from May to October 1943.

The main shaft, more than 300 feet deep, was under water below the 130 level in March 1943, but it was unwatered in September to make the 300 level accessible. The most extensive workings are on the 130 level; they compromise an east-trending crosscut 330 feet long and two drifts that extend south from the crosscut. The west drift is 190 feet long, and the east drift was open for 70 feet in 1943. Above the west drift, workings are accessible from an old shaft and winze (fig. 4). The 44 level consists of a crosscut 90 feet long and a connecting 20-foot drift. A short level at 49 feet connects the 44 level to the winze that provides access to the 56 level, a drift 100 feet long (fig. 4). At the surface north of the old shaft, a north-trending inclined opencut 35 feet long passes into an adit 36 feet long. An adit level explores the ground above the eastern part of the 130 level.

The prevailing rock is a deeply weathered coarse-grained hornblende-quartz diorite intruded by fine-grained biotite-quartz diorite. Aplite dikes are numerous near Quartz Hill and Cross Hill, but poor exposures prohibited their representation on the geologic map. Rhyolite dikes and plugs intrude the coarse-grained quartz diorite north of Copper Hill, and south of this hill a quartz diorite porphyry dike, 30 to 50 feet wide, intrudes both the coarse- and fine-grained quartz diorite (fig. 5).

Both facies of quartz diorite locally have been brecciated, sericitized, and silicified. The alteration process has produced distinct zones, circular to elliptical in outline, some of which are breccia pipes. These zones are more resistant to erosion, and they form the summit areas of small hills; four are shown on figure 5. The Copper Hill pipe is about 400 feet in diameter.

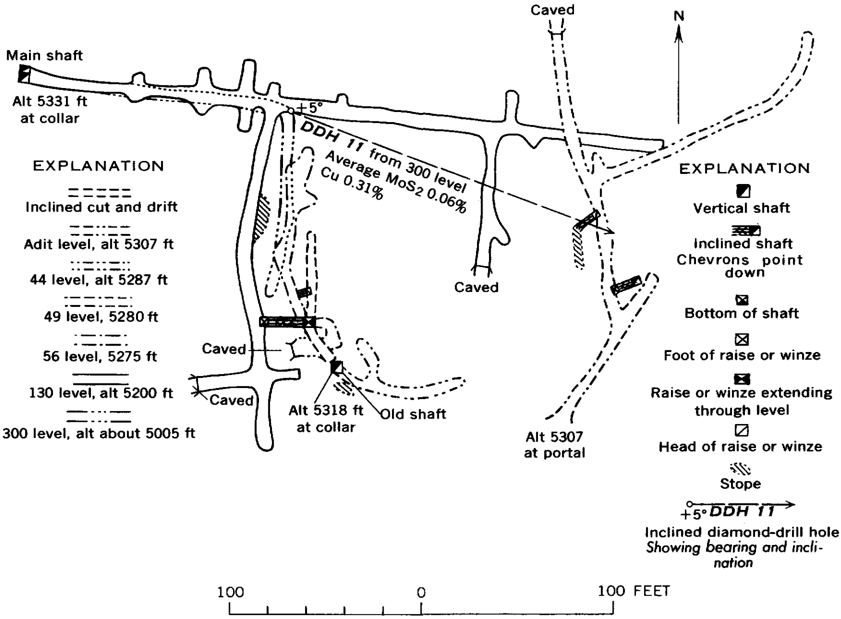

FIGURE 4.—Composite map of levels of the Copper Hill mine, Yavapai County, Ariz.

The workings of the Copper Hill mine are in the southern part of the circular area of brecciated and altered hornblende-quartz diorite. The breccia is cut by low-dipping quartz veins that contain small amounts of pyrite, chalcopyrite, and molybdenite.

Steeply dipping quartz seams cut the breccia and the low-dipping quartz veins, but the displacement is small. Chalcopyrite and molybdenite are more common in the steeply dipping quartz seams and in vein quartz that cements breccia fragments. Molybdenite occurs in finely divided veinlets cutting quartz or at the margin of the veins, whereas chalcopyrite is disseminated in the quartz.

Seams of brilliant yellow ferrimolybdite occur in the upper workings of the mine where molybdenite is more abundant than in the main part of the mine.

The breccia, well exposed in the underground workings, is composed of heterogeneous rock fragments. The western margin of the breccia on the 130-foot level (fig. 6) is a steep, west-dipping fault, but mineralized rock extends west and south of the fault, as shown by diamond-drill holes 7, 8, and 9 in the west drift on the 130 level (fig. 6; table 1). On the upper levels, the margin of the mineralized breccia is locally controlled by several faults, but at the face of the 56 level, breccia is in contact with massive quartz diorite without an intervening fault. On the 130 level west of the east drift, unmineralized quartz diorite is

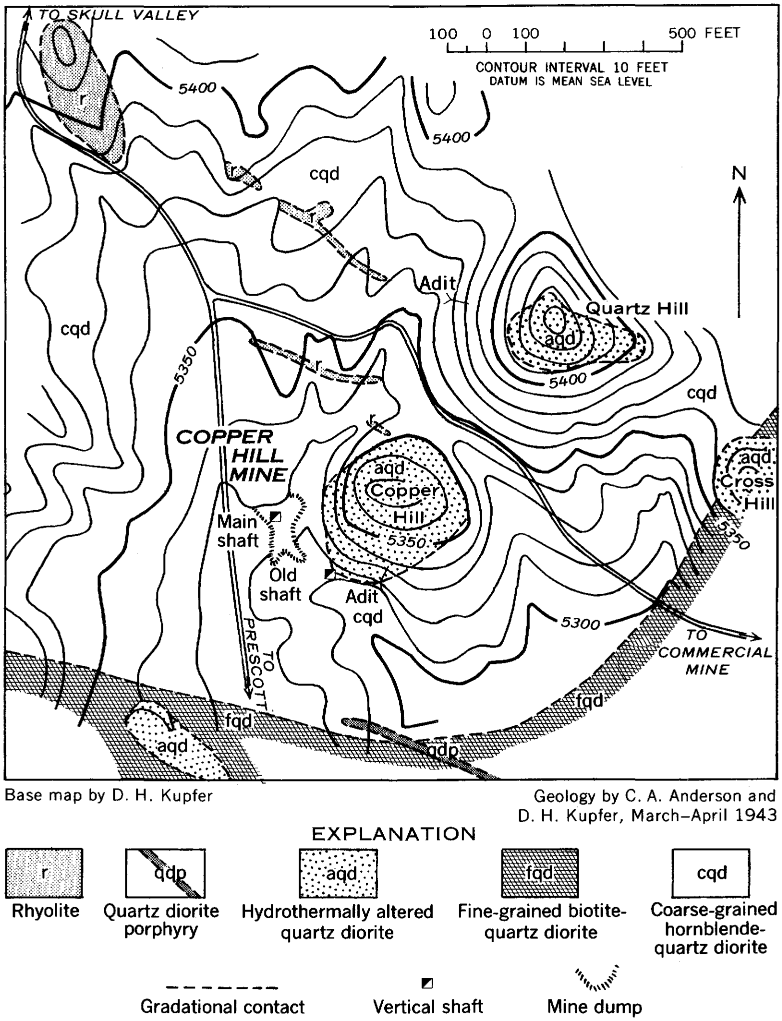

FIGURE 5.—Geologic map of the area around the Copper Hill mine, Yavapai County, Ariz.

separated from the mineralized breccia by a steep fault. Smears of molybdenite in the fault indicate post-mineralization movement. Diamond-drill hole 6 (fig. 6; table 1) proves that the barren quartz diorite on the 130 crosscut is lenticular, and thus supports the concept of a breccia pipe.

Fourteen horizontal channel samples, cut with a pneumatic chipper from the 130 level, yielded more than 100 pounds of rock per 10-foot sample length. The samples were broken and quartered into 20- to 30-pound samples that were assayed by the Union Assay Office, Salt Lake City, Utah, and by Hawley and Hawley, Douglas, Ariz. Samples were sent to the two assay offices to check on the grade; the returns were in close agreement. In cooperation with W. B. Maitland, supervising engineer, RFC, seven channel samples were cut with a single-jack and moil in the upper levels; these samples were assayed by Hawley and Hawley. Table 1 shows assays for 7 individual samples cut in the upper levels and for 1 sample on the 130 level and the average assays for 13 samples cut in two sections on the 130 level.

The drilling program, which started May 13, 1943, and ended September 21, 1943, provided additional information on the grade of the ore. Eleven holes totaling 1,475 feet were drilled. The core recovery of the first hole, which was drilled from the surface with an LM bit that makes a core seven-eighths inch in diameter, was low because the rocks in the ore zone are broken and because grease on the drill rods collected molybdenite and thus significantly reduced the molybdenite recovery. To check whether the diamond-drill cores yielded representative samples of the ore, three holes were drilled with AX and BX bits and grease-free rods on the 130 level in a mineralized zone whose grade had been determined previously from channel samples. Because assays of the cores agreed with those of the channel samples, the remaining seven holes were drilled with AX or BX bits and grease-free rods. The average assays of core samples from six holes drilled from the 130 level are shown in table 2. Diamond-drill Hole 11, drilled from the 300 level, and the average assays of drill-core samples obtained from it are shown on figure 4. Drill core samples were assayed by the Union Assay Office.

The assays indicate a rather uniform content of copper and molybdenite, considering the heterogeneity of the breccia pipe. The weighted average of the channel and drill-core samples from the 130 level is 0.22 percent MoS_2 and 0.45 percent Cu. Individual samples from the upper levels along the western margin, however, indicate that some areas have a higher molybdenite and copper content (fig. 6; table 2).

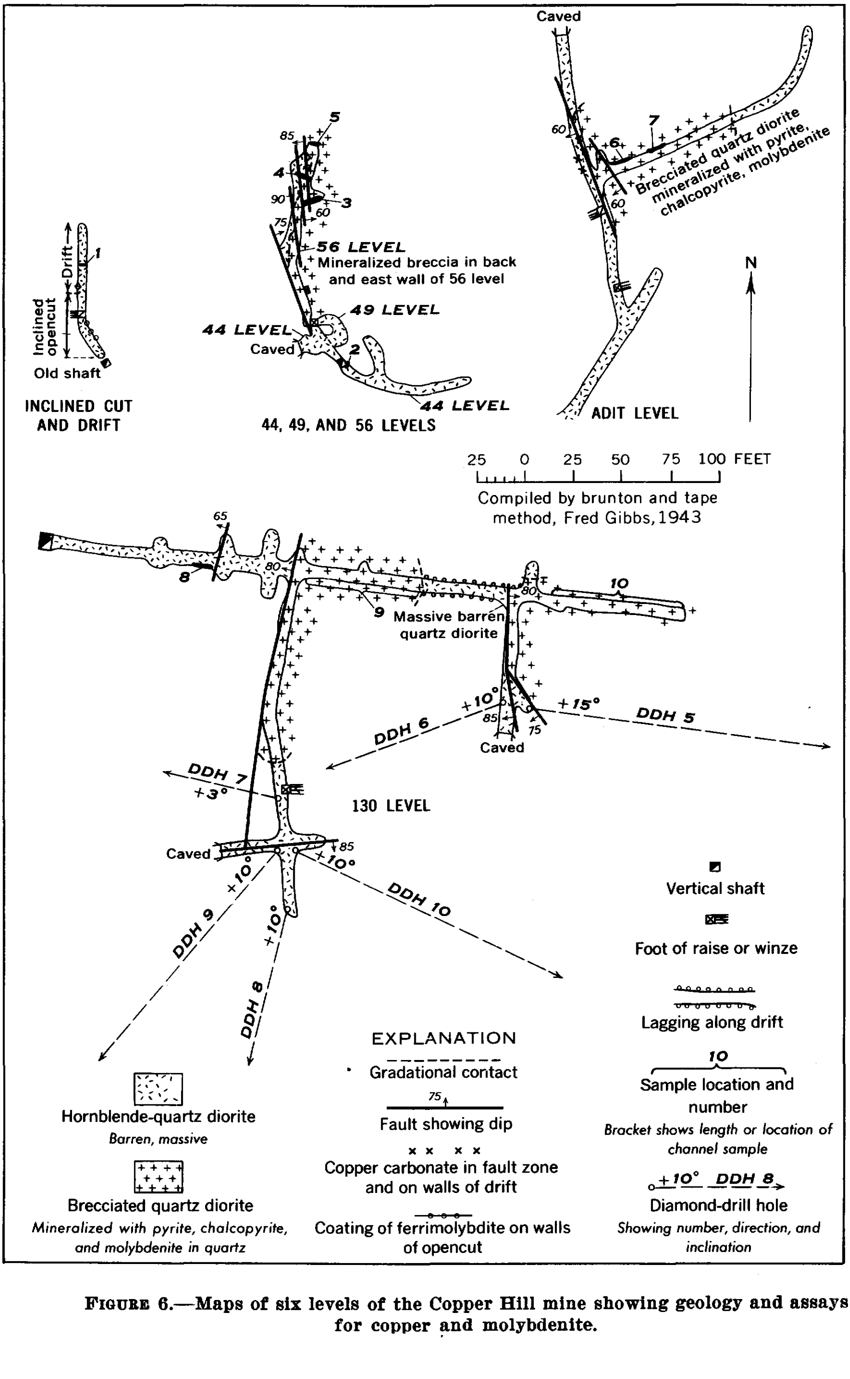

FIGURE 6.—Maps of six levels of the Copper Hill mine showing geology and assays for copper and molybdenite.

TABLE 1.—*Sample and assay data for the Copper Hill mine*

Number (fig. 6)	Length (feet)	MoS_2 (percent)	Copper (percent)
Channel samples			
1	3.5	0.46	2.90
2	3.5	2.01	3.37
3	9.9	.10	.89
4	7.4	.54	4.05
5	5.5	.79	1.36
6	10.0	.24	1.89
7	10.0	.22	.91
8	10.0	.26	.76
9 [1]	60.0	.22	.39
10 [2]	70.0	.22	.48
Drill-hole core samples			
5	------------	0.21	0.42
6	------------	.17	.63
7	------------	.30	.35
8	------------	.23	.35
9	60.0	.21	.47
10	------------	.14	.61

[1] Composite of 6 samples.
[2] Composite of 7 samples.

TABLE 2.—*Condensed logs of diamond-drill holes, Copper Hill mine*

By D. H. Kupfer

Drill hole 5

[130 level, east drift, 58 ft south of main crosscut; elevation at collar, 5,211 ft; drilling date, July 7–23, 1943; inclination, +15°; bearing, S. 81° E.; length, 166 ft]

Interval (feet)

0–18 Breccia, noticeably low in quartz; several local spots very rich in molybdenite and chalcopyrite.

18–62 Barren hornblende diorite; much of the hornblende altered to biotite, but no other appreciable alteration. Low core recovery. Broken and crushed core indicates probable fault from 56 to 62 feet.

62–70 Silicified breccia above average grade in molybdenite; some chalcopyrite.

70–100 Silicified breccia containing moderate amounts of chalcopyrite and molybdenite.

100–142 Silicified quartz diorite, somewhat mineralized; many quartz veinlets; parts of rock unaltered.

142–166 Hornblende-quartz diorite unaltered except slightly, near fractures.

TABLE 2.—*Condensed logs of diamond-drill holes, Copper Hill mine*—Continued

Drill hole 6

[130 level, east drift, 53 ft south of main crosscut; elevation at collar, 5,210 ft; drilling date, July 23–26, 1943; inclination, +10°; bearing, S. 70° W.; length, 101 ft]

Interval (feet)	
0–27	Poorly mineralized quartz diorite; hornblende altered to biotite. Core badly broken, and recovery low. Rock both crushed and kaolinized, probably related to faulting.
27–55	Silicified breccia; molybdenite disseminated but low grade; chalcopyrite above average grade.
55–101	Silicified breccia; molybdenite, and chalcopyrite abundant; much free quartz.

Drill hole 7

[130 level, west drift, 115 ft south of main crosscut; elevation at collar, 5,210 ft; drilling date, July 31–August 1, 1943; inclination, +3°; bearing, N. 77° W.; length, 60 ft]

Interval (feet)	
0–20	Silicified breccia containing abundant molybdenite and some chalcopyrite.
20–27	Hornblende-quartz diorite cut by numerous mineralized quartz veins.
27–60	Hornblende-quartz diorite, hornblende almost unaltered; sulfide minerals confined to a few narrow seams.

Drill hole 8

[130 level, west drift, 175 ft south of main crosscut; elevation at collar, 5,209 ft; drilling date, August 4–7, 1943; inclination, +10°; bearing, S. 14° W.; length, 83 ft]

Interval (feet)	
0–7	Silicified breccia with abundant quartz; molybdenite abundant, copper sparse.
7–29	Quartz diorite cut by quartz veins carrying molybdenite and chalcopyrite.
29–70	Hornblende locally altered to biotite; some slightly silicified rock containing traces of chalcopyrite and molybdenite near fractures.
76–83	Unaltered hornblende-quartz diorite.

Drill hole 9

[130 level, west drift, 145 ft south of main crosscut; elevation at collar, 5,211 ft; drilling date, August 9–16, 1943; inclination, +10°; bearing, S. 40° W.; length, 146.5 ft]

Interval (feet)	
0–42	Breccia with abundant quartz; moderate amounts of molybdenite and chalcopyrite.
23–26	Aplite.
26–30	Quartz vein; barren core and mineralized (feldspar, chalcopyrite, molybdenite) borders.
42–58	Altered quartz diorite cut by numerous quartz veins and veinlets; some molybdenite and chalcopyrite.
58–146. 5	Unaltered hornblende-quartz diorite country rock occasionally cut by a thin seam of quartz.
96–99	No core recovered; possible fault zone.
116	Do.

TABLE 2.—*Condensed logs of diamond-drill holes, Copper Hill mine*—Continued

Drill hole 10

[130 level, west drift, 144 ft south of main crosscut; elevation at collar, 5,210 ft; drilling date, August 18 to September 1, 1943; inclination, +10°; bearing S, 65° E.; length, 163 ft]

Interval (feet)	
0–38	Silicified breccia containing more than average amount of molybdenite and some chalcopyrite.
38–55	Breccia containing moderate amounts of chalcopyrite but little molybdenite.
55–105	Zone of very poor core recovery, probably in or near a fault zone; rock is probably breccia.
105–113	Pyrite-rich quartz vein; some chalcopyrite and traces of molybdenite.
113–118	White fine-grained kaolinized (probably hydrothermally altered) rock that was originally fine-grained diorite.
118–121	Massive white quartz vein.
121–155	Zone of very poor recovery; possibly drill hole parallels a fault zone; apparently rock is hydrothermally altered coarse-grained diorite, rich in epidote, kaolin, and chlorite.
155–156	Vein rich in chalcopyrite.
156–163	Fine- to medium-grained granitic rock, rich in biotite and epidote. Green color on wet surfaces.

Drill hole 11

[300 level, 140 ft east of main shaft; elevation at collar, 5,010 ft; drilling date, September 7–21, 1943; inclination, +5°; bearing, S. 69° E.; length, 180 ft]

Interval (feet)	
0–38	Hornblende-quartz diorite altered to kaolin and biotite.
2–6	Partially silicified quartz diorite; some chalcopyrite.
6–21	Altered quartz diorite, a few quartz stringers, and some silicified rock; sparse chalcopyrite; no molybdenite; alternating coarse- and fine-grained rock.
21–58	Fresh coarse-grained hornblende-quartz diorite; hornblende occasionally altered to biotite.
58–60	Unaltered fine-grained diorite.
60–68	Unaltered coarse-grained diorite.
68–71	Crushed zone; core recovery poor. Probably a fault zone.
71–103	Unaltered fine-grained diorite; a few thin mineralized fractures cut this zone.
103–122	Alternate zones of fine- and coarse-grained diorite and breccia, some silicified rock and traces of chalcopyrite and molybdenite.
122–128	Mud and crushed rock; fault zone.
128–152	Silicified breccia; scattered chalcopyrite and molybdenite; low grade.
152–180	Silicified breccia; very poor in chalcopyrite and molybdenite.
170–175	Fault zone, no core recovery; 30–60 gallon per minute flow of water out of drill hole.

LOMA PRIETA MINE

In 1943, Mrs. Sophia Smoot, Prescott, Ariz., owned the Loma Prieta mine, which was under lease and option to the Copper Basin Molybdenum Co., a partnership of Vic Hale, Nick Duyn, and Fred Gibbs. The Copper Basin Molybdenum Co. was granted a loan by the RFC to unwater and sample the mine. During part of June and July, 1943, Anderson and Creasey studied the geology and aided W. B. Maitland, supervising engineer, RFC, in the sampling. Altogether, 1,170 feet of drifts on four levels was examined and sampled. After the sampling was finished on July 15, 1943, the pumps were removed and the mine workings again filled with water.

The Loma Prieta mine was developed between 1916 and 1918 by the Loma Prieta Mines Co. The development work yielded two to three cars of sorted copper sulfide shipping ore.

Because of a blanket of terrace gravels as much as 25 feet thick, outcrops of underlying rocks occur only in the gulches, banks of the washes, and roadcuts, except for a few scattered outcrops that project through the terrace gravels. Contacts between the rock units can only be inferred. Figure 7 is essentially an outcrop map.

The prevailing rock is fine- to medium-grained quartz diorite, deeply weathered in part and locally mineralized along joints with pyrite. Dikes of rhyolite and quartz diorite porphyry intrude the quartz diorite.

In the vicinity of the Loma Prieta mine, the quartz diorite has been brecciated, altered by hydrothermal activity, and cemented by quartz containing sulfide minerals, which are oxidized at the surface to limonite. The texture of the quartz diorite varies, and in the breccia, fragments of the textural variants and quartz diorite porphyry are mixed. The general elliptical horizontal outline of the breccia and the heterogeneity indicate that the mineralized breccia is part of a breccia pipe. Because some of the centers of the larger fragments, which are 10 feet or more in maximum dimension, are not appreciably altered, it is difficult in small surface exposures to distinguish massive quartz diorite from brecciated core of the pipe. Some exposures of the quartz diorite are cut by narrow intersecting quartz veins containing pyrite and a little chalcopyrite. Whether these latter exposures of quartz diorite represent less mineralized parts of the breccia pipe or fractured and mineralized rock adjacent to the pipe was not determined. In weakly altered areas, small exposures of silicified breccia capped by limonite-rich gossans suggest perhaps a very large pipe that contains local masses of strongly brecciated and mineralized quartz diorite.

Mineralized breccia is best exposed in the Loma Prieta mine because the surrounding shallow shafts and short prospect adits rarely

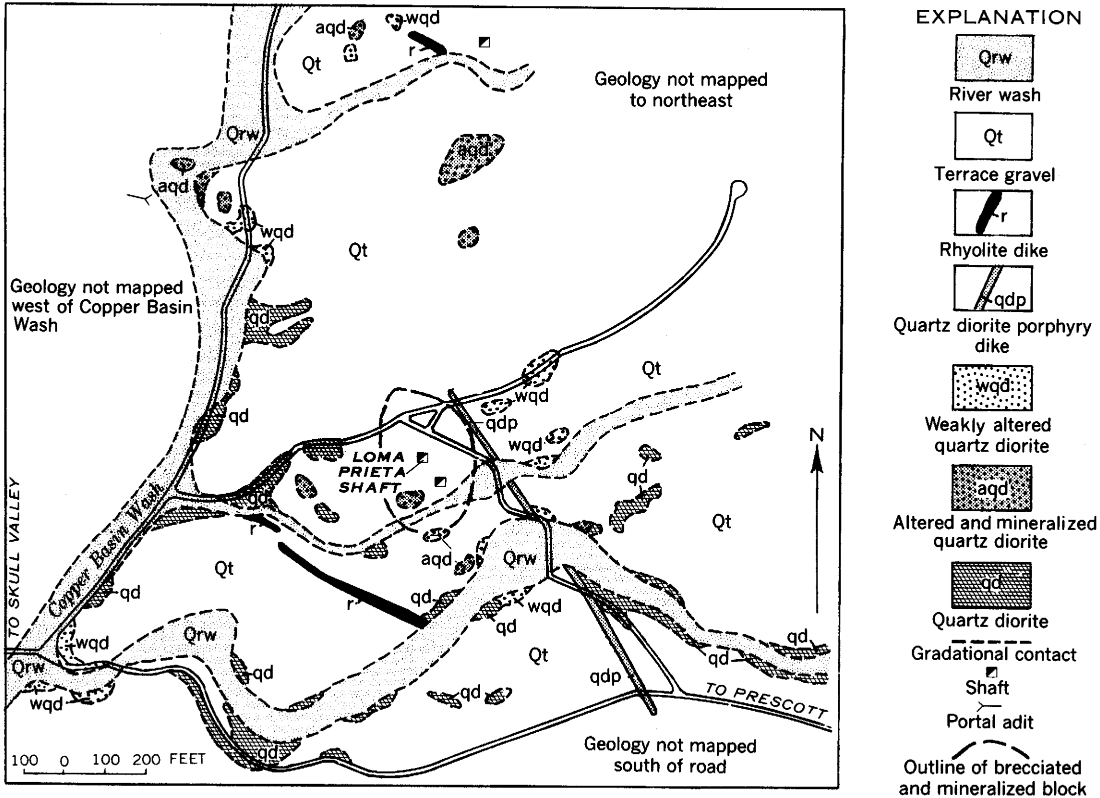

FIGURE 7.—Geologic map of the area around the Loma Prieta mine, Yavapai County, Ariz.

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penetrate below the zone of oxidation. No molybdenite or ferrimolybdite was observed at the surface.

The quartz cementing the breccia fragments is of two types. The more common type is white, contains coarse feldspar crystals, and has vugs lined with dolomite. The less common type of cementing quartz is dense and flinty, and its fuzzy margins against the quartz diorite suggest some replacement of the fragments. In both types of quartz, sulfide minerals—pyrite and chalcopyrite—form coarse blobs and bunches that are generally confined to the center of the cementing veins. The molybdenite is finely divided and forms narrow veinlets either at the margin of the veins or crosscutting the quartz. In a few places, the quartz veins are brecciated and cemented by younger finely divided molybdenite.

The proportions of molybdenite and chalcopyrite vary from place to place; some of the richer chalcopyrite-bearing veins have only a trace of molybdenite, and the richer molybdenite-bearing rock may have a low content of copper (table 3). On the 150 level, the ore northeast and northwest of the shaft contains more molybdenite than the average, whereas on the 400 level, the higher grade areas are northeast and southeast of the shaft (fig. 8).

The faults in the mineralized breccia are short and discontinuous, and they commonly grade along the strike into joints. The gouge along the faults is thin, and smears of molybdenite along the gouge indicate that some movement took place after the molybdenite mineralization.

The underground workings comprise the 46, 75, 150, and 400 levels and a vertical shaft 414 feet deep (fig. 8). The shaft consists of a compartment and a half from the collar to 141 feet (150 level) and a

TABLE 3.—*Sample and assay data for the Loma Prieta Mine*

Sample (fig. 8)	Samples assayed	MoS_2 (percent)	Copper (percent)
1	4	0.13	1.21
2	1	.08	.93
3	4	.29	.86
4	6	.22	.80
5	7	.12	1.30
6	3	.09	.67
7	4	.04	.56
8	17	.07	.68
9	13	.22	.79
10	4	.09	.33
11	5	.08	1.27
12	5	.15	1.46
13	4	.09	.41
14	15	.09	1.00
15	10	.06	.19
16	1	.11	.46
17	1	.21	.84
18	1	.11	.82
19	1	.13	.64

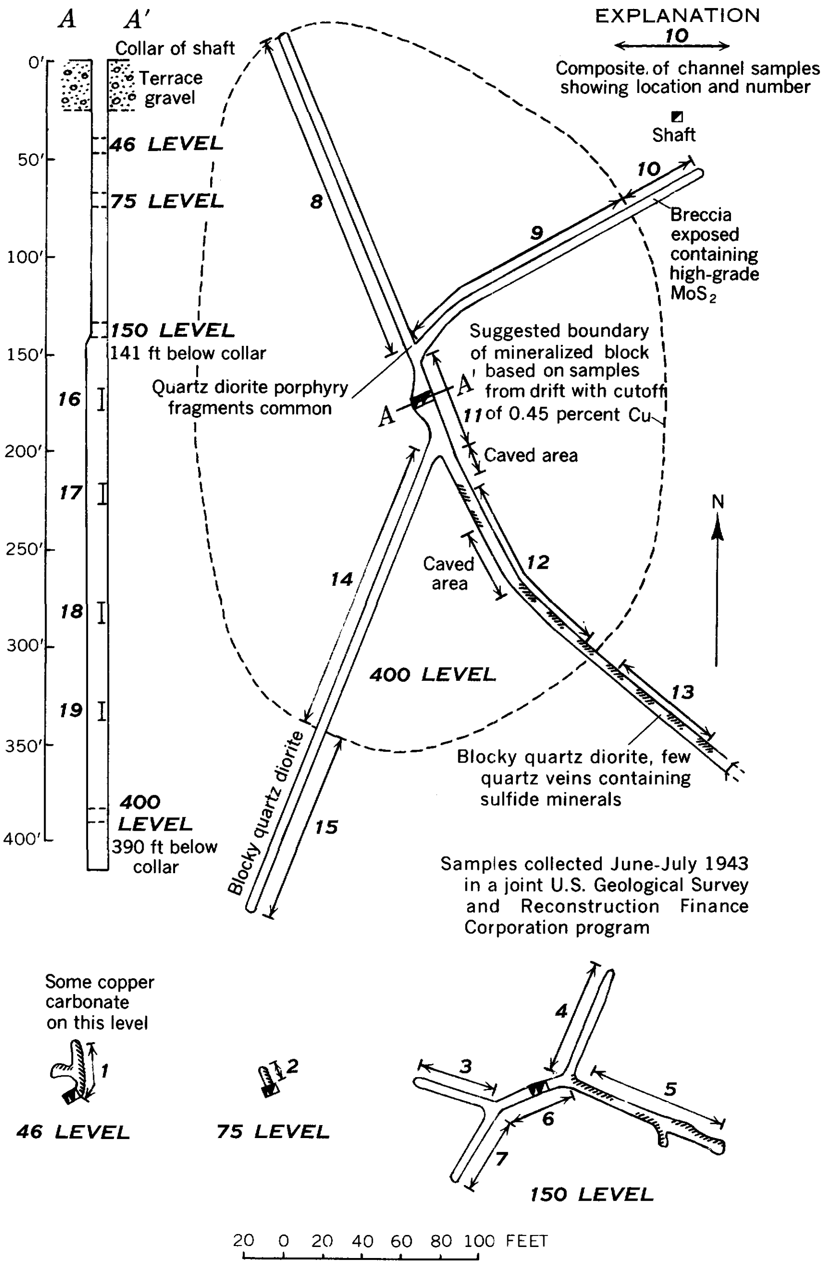


FIGURE 8.—Geologic maps of levels of the Loma Prieta mine, Yavapai County, Ariz., showing location of assay samples for copper and molybdenite.

double compartment below that. The 46 level contains 40 feet of workings; the 75 level, 10 feet (stub drift); the 150 level, 270 feet; and the 400 level, more than 850 feet.

The underground workings of the Loma Prieta mine were sampled by horizontal channels cut largely with pneumatic chippers. The channels were cut deep enough to yield 80 to 100 pounds per 10 feet of sample length. The samples, broken into small fragments and halved (40 to 50 lbs), were assayed for Cu and MoS_2 by the Union Assay Office, Salt Lake City, Utah. A total of 104 samples was collected while the mine was unwatered.

The channel samples (table 3) indicate that the average grade for the 150 level is 0.9 percent Cu and 0.15 percent MoS_2. On the 400 level, a cutoff of 0.45 percent Cu was used to determine the margin of the mineralized block; the average grade is 0.89 percent Cu, and 0.125 percent MoS_2. Considering the somewhat erratic distribution of the sulfide minerals, the grade of the sampled block is probably within the following limits: 0.85 to 0.90 percent Cu and 0.10 to 0.15 percent MoS_2.

The outline of the mineralized breccia (figs. 7 and 8) was determined by using a cutoff of 0.45 percent Cu. All the workings on the 150 level are in this block; on the 400 level, however, the area within the cutoff limits is approximately 60,000 square feet. No evidence on the surface contradicts the assumption that this horizontal area of mineralized rock persists to the surface beneath the terrace gravels. Mineralized rock containing unaltered sulfide minerals is exposed on the 46 level, and, according to A. B. Peach (written commun., 1917) who was in charge of the mine development, ore found in the shaft at 60 feet extends to the bottom at 414 feet. A vertical range of 350 feet therefore seems permissible in calculating reserves.

SQUAW PEAK MINE

The Squaw Peak mine in secs. 30 and 31, T. 13 N., R. 6 E., 6 miles south of Camp Verde, is reached by a graded road from Camp Verde. The mine is owned by the Squaw Peak Copper Mining Co., and in 1943, Edison Thacker was president and manager. In 1942, the RFC granted the company a $20,000 loan for development. The money was spent in exploring and developing molybdenite-copper ore on the main level of the mine. Anderson and Kupfer examined the mine in February 1943.

W. B. Gohring of the RFC supplied assay reports and maps prepared by D. F. Campbell, supervising engineer, RFC, and W. B. Maitland, also of the RFC supplied additional information based on his work as Supervising Engineer of the project.

In 1943, there was more than 4,000 feet of underground workings on three levels. The lower haulage adit was 1,935 feet long. About 305 feet above it was the main level adit, which had more than 2,000 feet of crosscuts and drifts. The upper adit, about 105 feet above the main level adit, was 280 feet long. An inclined shaft, 76 feet deep, connected to the upper adit from the surface. Only the upper adit and southern workings of the main level adit (fig. 9) were mapped. By 1943 there had been no production, but in April 1944 a pilot flotation plant with a capacity of 1 ton per hour produced a commercial grade of molybdenite concentrate. Continued operations in 1944 resulted in shipments of molybdenite concentrate to the Metals Reserve Co., the only purchases of domestic molybdenum under the small-lot purchasing program announced on July 8, 1943 (Jenckes and van Siclen, 1946, p. 634). Molybdenite concentrates were produced sporadically during the first 4 months of 1945 and a small output was made in 1946 (Jenckes, 1947, p. 640, and Jenckes, 1948, p. 798).

The country rock, which is quartz diorite of Precambrian age, is cut by small quartz veins ranging from narrow stringers to veins several inches wide. Many of the veins are discontinuous and are barren of sulfides. Some of the veins trend northwest and dip steeply southwest; others trend northeast and dip steeply northwest or are vertical. Only in the area of stockwork (fig. 9) on the main level adit where the quartz veins separate blocks of quartz diorite are they irregular and thicker. In the stockwork, molybdenite, chalcopyrite, and pyrite occur in the quartz and quartz diorite. The molybdenite, in small to large crystals, is erratically distributed; the chalcopyrite is more evenly distributed. D. F. Campbell, who systematically sampled the stockwork on the main level, determined an average grade of 0.18 percent MoS_2 and 1.28 percent Cu (W. B. Gohring, written commun. 1943). According to the Mining World (1944), a raise in the stockwork 43 feet above the main level exposed ore, and the mill heads for the first operations of the pilot plant were estimated to average about 1.4 percent Cu and about 1 percent molybdenite.

Disseminated molybdenite is exposed at the face of the haulage adit, mainly under the stockwork exposed on the main level (fig. 9), but the intersecting quartz veins are missing. Molybdenite is found on the dump of the shaft connecting to the upper adit. According to Edison Thacker (oral commun.), this ore came from about 60 feet below the collar of the shaft.

Other mineralized stockworks may be present in the area, but the exploration up to 1943 failed to reveal geologic guides to their possible locations.

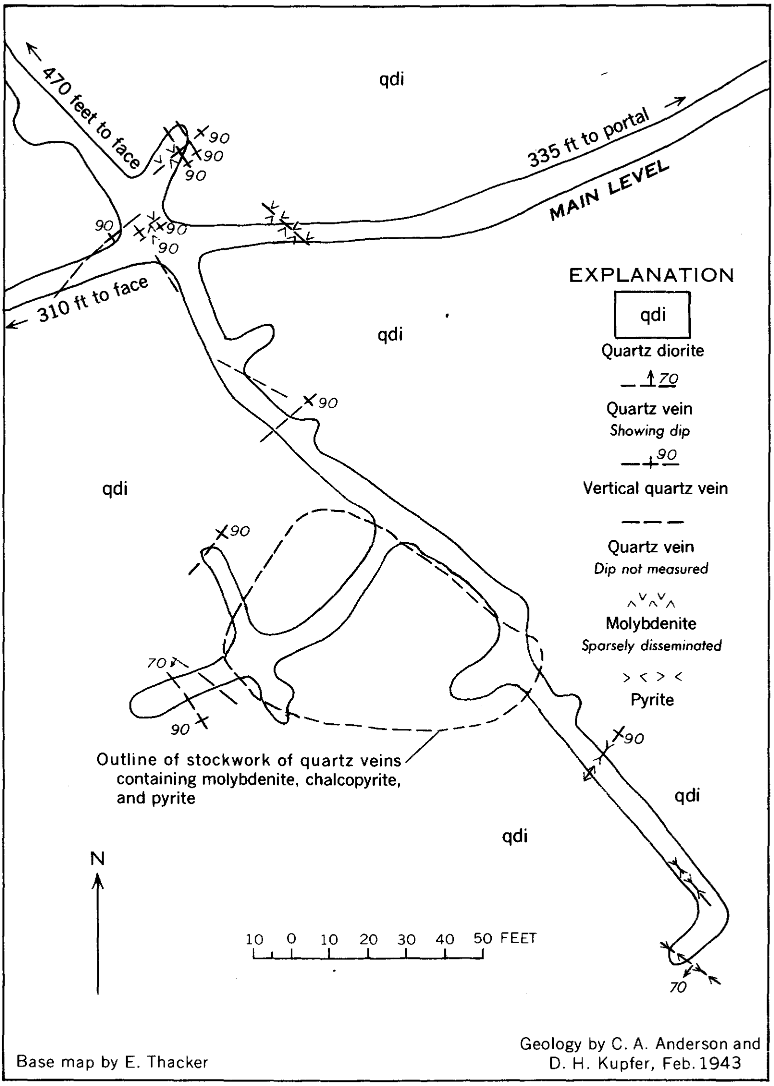


FIGURE 9.—Geologic map of part of the main level of the Squaw Peak mine, Yavapai County, Ariz.

TWIN LEDGE PROSPECT, by D. H. Kupfer

Three Twin Ledge claims, held by location in 1943 by Marguerite Williams, Groom Creek, Ariz., were examined by Kupfer in August 1943. The claims are in the NW¼ sec. 33, T. 12 N., R. 2 W., in the Mount Union quadrangle and may be reached by gravel road from Groom Creek.

A quartz vein trending north-northwest crops out for about 1,000 feet. The main development is an adit 100 feet long, and the face is about 30 feet vertically below the surface. In the outcrop, the vein averages about 24 inches wide, but in the adit it is only 8 inches wide. The vein is oxidized near the surface, and the quartz is stained with limonite and malachite. Molybdenite, chalcopyrite, and pyrite are scattered through the quartz vein, and molybdenite seams coat several of the faults near the vein. Chalcopyrite is disseminated in the granitic country rock contiguous to the vein.

The quartz vein and adjacent mineralized rock were sampled by four cuts: Sample TL 1 was cut across the face of the adit, and sample TL 2 (composited from three channels spaced 20 feet apart) was cut across the back of the adit. The assays for MoS_2, copper, silver, and gold were:

TABLE 4.—*Sample and assay data for the Twin Ledge prospect*

[Assays by Union Assay Office, Salt Lake City, Utah]

Sample	Percent		Ounces per ton	
	MoS_2	Copper	Silver	Gold
TL 1	0.28	0.25	0.9	0.020
TL 2	.18	.20	.9	.20

CALIFORNIA

CALAVERAS COUNTY

WHITE HORSE AND BAY HORSE CLAIMS, by H. K. Stager

The White Horse and Bay Horse claims are on the south side of Moore Creek in the S½ sec. 7, T. 7 N., R. 16 E., on the west slope of the Sierra Nevada at altitudes between 3,000 and 4,200 feet. The claims are accessible by dirt road that leads 10½ miles south from California Highway 88 at Lumberyard Ranger Station, 31 miles east of Jackson, Calif. The claims were located in 1941 and were leased in 1954 to the Moore Creek Mining Co. by the owners, Grover C. Bruce and Evelyn Bruce. H. K. Stager, U.S. Geological Survey, and B. H. Sheahan, U.S. Bureau of Mines, visited the property in 1957 on behalf of the DMEA.

About 320 feet of underground workings in two adits on the White Horse claim (fig. 10) and shallow opencuts on the Bay Horse claim had been completed. The lessees built and operated a 50-ton per day gravity concentrator on the property. Production to July 1957 totaled a few hundred pounds of molybdenite concentrate and 4,850 pounds of scheelite concentrate that averaged about 50 percent WO_3; the production was from about 1,000 tons of low-grade ore.

The mine area is in metamorphic rocks at the north end of a roof pendant approximately a mile long and 1,000 feet wide. The roof

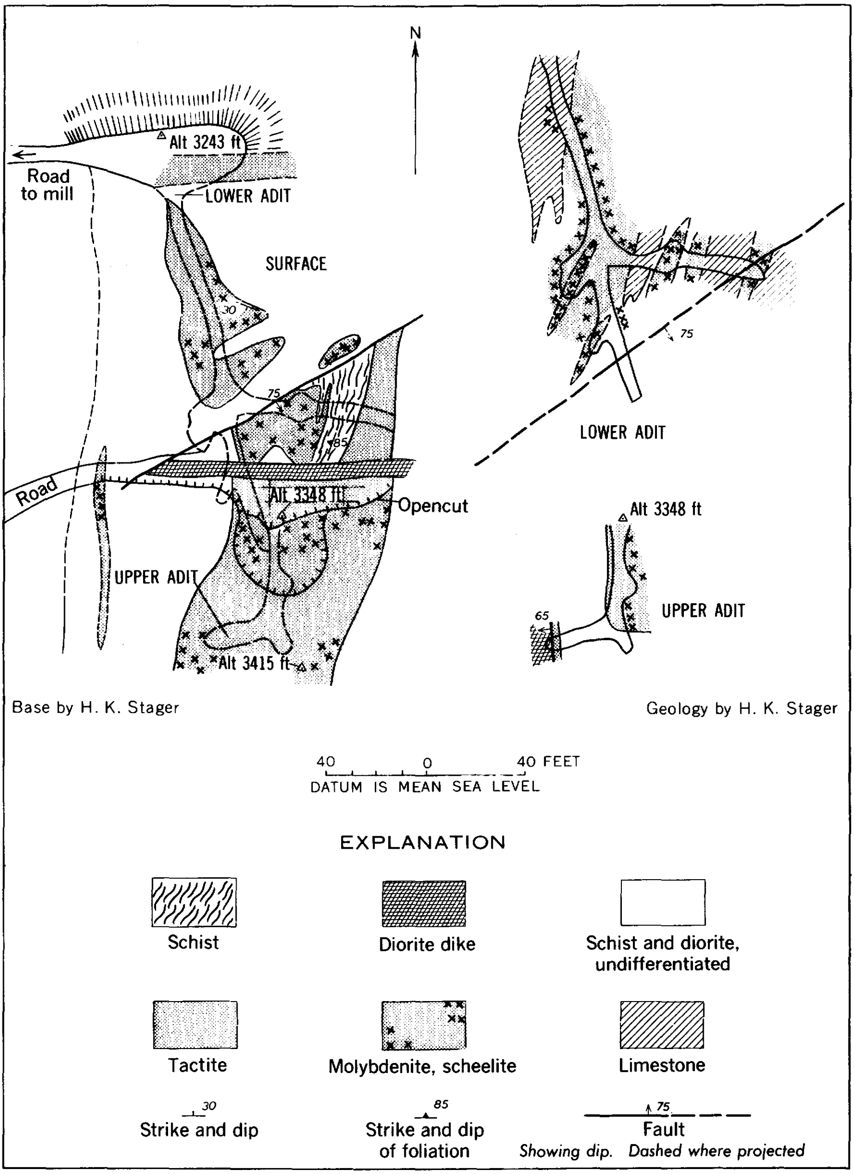


FIGURE 10.—Geologic sketch maps of the surface and the upper and lower adits, White Horse claim, Calaveras County, Calif.

pendant is bounded on all sides by granitic rocks of the Sierra Nevada batholith. Schist and garnet-epidote tactite are the main metamorphic rocks. The schist is intimately mixed with dioritic material that has been injected lit-par-lit and as dikes. The tactite occurs as lenses and as thin beds near and along the west edge of the pendant. Some fine-grained limestone is exposed in the underground workings, but it does not crop out at the surface. Foliation and bedding planes in the metamorphic rocks strike north and are vertical or dip steeply west. Numerous minor faults are present, and one prominent fault is exposed in the center of the mine area. The faults, however, evidently did not control the mineralization.

The deposit consists of small lenses of molybdenum-, tungsten-, and copper-bearing material in garnet-epidote tactite scattered along and near the contact of metamorphic rocks and granodiorite. The ore minerals are molybdenite, scheelite, powellite, and chalcopyrite, and the gangue minerals are calcite, quartz, garnet, epidote, and pyrite. Molybdenite occurs chiefly in flakes disseminated in the tactite and rarely as masses of crystals several inches in diameter. Most of the scheelite crystals disseminated in the tactite are one-eighth to one-quarter inch in diameter, although some crystals are as much as 1 inch across. Disseminated crystals of powellite and zoned crystals of powellite and scheelite occur in and near the concentrations of molybdenite. Chalcopyrite is sparsely disseminated throughout the tactite, but it is most abundant in the scheelite- and molybdenite-rich zones. The ore lenses are 1 to 10 feet wide, 10 to 40 feet long; they have been mined to a depth of 10 to 15 feet. The grade, estimated from samples and mill concentrates, averages about 0.08 percent MoS_2, 0.2 percent WO_3, and 0.2 percent Cu. All the production has been from the three ore lenses exposed in the lower adit and from the open pit at the portal of the upper adit.

EL DORADO COUNTY

CONSUMNES COPPER MINE, by J. F. Robertson and D. B. Tatlock

The Consumnes Copper mine, also called the Cosumnes mine, is 13½ miles southeast of Placerville, Calif., and east of the Mother Lode Belt. It is on the west side of the Middle Fork Cosumnes River (pl. 2) at an altitude of about 2,000 feet in sec. 25, T. 9 N., R. 12 E., in the Placerville quadrangle. The mine is owned by Clifford Smith, Fairplay, Calif. O. C. Brink acquired a lease and option agreement on the property in 1951, and subleased it to a group of individuals who formed the Consumnes Development Co. The property was examined on behalf of DMEA in April and May 1952 by W. P. Irwin, J. F. Robertson, and D. B. Tatlock of the U.S. Geological Survey. The mineworkings consist of five adits, several hundred feet of drifts and crosscuts, a raise, and several winzes. The property was worked before 1910 for gold. Shipments of copper ore also have been reported but records of production are not available. The mine area is underlain by marble, biotite schist, and granodiorite. Metamorphic skarn rock occurs along the contact between the marble and the granodiorite, and it is within this contact zone that several shoots of mineralized rock have been found.

The marble is massive; bedding has been obliterated by recrystallization. The marble underlies the east half of the mine area, and extends to the east bank of the Cosumnes River. Interbedded with it is fine- to medium-grained biotite schist. Foliation in the schist strikes from north to N. 35° E. and dips consistently 75° E. The composition of the schist is uniform except for a narrow zone of migmatite at the contact of the granodiorite with the marble.

The zone of skarn rock strikes northeast in the southwestern part of the mine area and to the north in the north-central part. All observed dips are vertical or nearly so. The skarn rock consists of coarse-grained garnet, epidote, hornblende, calcite, and quartz mixed heterogeneously with clumps of biotite schist, calc-silicate(?) hornfels, white quartz, marble, granodiorite, and biotite feldspar pegmatite.

The ore minerals, found only in the skarn rock, are chalcopyrite, bornite, and molybdenite; they are intimately associated in scattered bunches and blebs of irregular size and shape. Molybdenite also occurs in seams and fractures one-eighth inch wide or less within the skarn rock. Pyrite occurs sparingly in the schist and none was found in the skarn rock. Oxidation of sulfides is slight; malachite, azurite, and limonite being restricted in distribution to a depth of about 150 feet below the surface. Examination of near-surface occurrences of molybdenite with an ultra-violet lamp disclosed a minor amount of powellite. Chalcopyrite and bornite occur within a few feet of the surface.

Two mineralized zones recognized in the mine can be correlated with surface exposures of skarn rock. One exposure in the north-central part of the property is 10 feet wide and 125 feet long; possible occurrences are scattered over another 275 feet to the north. On level No. 3, 150 feet below the surface, the skarn rock occurs as irregular pods associated with marble.

Another exposure of skarn rock in granodiorite occurs in the west-central part of the area. Also exposed here is the top of a pipelike ore shoot which plunges 75° at about N. 60° E.; it is about 30 by 50 feet. This shoot has been cut in two adits and in a winze to a depth of about 225 feet from the outcrop. The shoot is bounded in part or is cut by faults; it appears to steepen and taper to a point at depth.

Six samples of mineralized skarn rock believed to be representative of the deposit were taken from the two adits shown on plate 1. The assay results ranged from 0.08 to 0.83 percent MoS_2, 0.28 to 3.09 percent copper, 0.005 to 0.22 ounce gold, and 0.20 to 2.00 ounces silver per ton.

INYO COUNTY

ATKINS PROSPECT

In August 1943, Anderson made a brief examination of the Atkins molybdenite prospect, which consisted of unpatented claims held by location by D. C. Atkins and R. F. White, Los Angeles, Calif. The deposit, in sec. 24, T. 8 S., R. 30 E., is 1 mile east of Mount Emerson in the Mount Goddard quadrangle, 18 miles southwest of Bishop. It was reached by taking an oiled road from Bishop to Lake Sabrina, then a dirt road from Lake Sabrina to the west end of North Lake, next the Piute trail west for 1 mile, and finally by climbing the talus slopes on the south side of Mount Emerson. The molybdenite deposit has an approximate altitude of 11,000 feet.

Near the deposit, exposures are limited to the base of cliffs projecting above the talus. They show a quartz monzonite containing a small pendant of quartzite and, to the east of the quartzite, a broad north-trending aplite dike.

Along the western margin, the aplite dike is stained yellow from limonite derived by oxidation of pyrite, which occurs in thin seams or in scattered vugs associated with quartz crystals. Molybdenite is present in small crystals in and near the vugs; at two places, molybdenite-crystal aggregates form zones several square feet in area. Locally the molybdenite crystals reach a diameter of 1 inch. The bulk of the pyrite-bearing aplite is barren of any visible molybdenite.

The grade of the deposit is too low to warrant assays for grade determination.

WAR BABY PROSPECT

In May 1943, Anderson made a brief examination of the War Baby molybdenite prospect, which consisted of two claims held by location by L. C. Rowe and O. O. Dorsett of Lancaster, Calif. The deposit, in sec. 13, T. 20 S., R. 36 E., is in the Olancha quadrangle on Hogback Creek on the east-facing slope of the Sierra Nevada at an elevation of about 5,300 feet. The deposit was reached from Highway 6, 5 miles south of Olancha, by turning west on a graveled road to Jordan Hot Springs Pack Station; Monache Pack Station. Three miles from Highway 6, a dirt road to the left was followed for 1.3 miles. A trail one-half mile long on the north side of Hogback Creek leads to the mineralized rocks on the War Baby claims.

In 1943, an open cut and shallow pit had been excavated from the steep slope on the north side of Hogback Creek.

The prevailing rock is quartz monzonite, and, at the mineralized area, a quartzite pendant 30 feet wide trends eastward. The north margin of the quartzite pendant dips steeply north. An aplite dike, 30 to 50 feet wide, is north of the quartzite pendant and parallel to it.

Molybdenite is present in the aplite as radiating crystal aggregates, from ¼ to 1 inch in diameter, forming nests a foot or more in dimension; the molybdenite aggregates are spaced 2 to 3 inches apart. Vugs in the mineralized aplite contain pyrite crystals, and limonite stains are common where molybdenite is present.

The mineralized area, which is 10 feet wide and 40 feet long, contains scattered nests of molybdenite several feet apart. According to O. O. Dorsett (oral commun., 1943), a number of assays of specimens ranged from 0.19 to 1.4 percent MoS_2. Determination of the grade of the deposit would require a large sample of the mineralized rock because of the spotty distribution of the molybdenite.

MONO COUNTY

BLUE SPECK MINE

A brief examination of the Blue Speck molybdenum mine was made by Anderson and M. W. Cox in 1943. The mine, in sec. 19, T. 7 N., R. 25 E., is near the California-Nevada State line in the Sweetwater Mountains along Herrin Creek at an altitude of 7,000 feet. A poor graveled road from Sweetwater, Nev., ended within a quarter of a mile from the mine.

The property consisted of six unpatented claims, held by location by Judge Clark and J. Guild, Carson City, Nev., and J. S. Adams, Yerington, Nev. According to the records of the district engineer, U.S. Bureau of Mines, Reno, Nev., four adits on the property are 80, 150, 250, and 600 feet long. All were caved at their portals and otherwise inaccessible on the date of the examination. Between 1932 and 1935, a small mill was installed to concentrate molybdenite, and reportedly between $8,000 and $10,000 worth of concentrates were sold.

The country rock is deeply weathered granodiorite. Fragments on the dumps of the adits contain molybdenite crystals in quartz veins and disseminated in aplite. The mineralized zone was poorly exposed.

In 1925, E. J. Schrader (written commun., 1943) sampled two adits. Eight channel samples from these adits ranged from 0.2 to 0.90 percent MoS_2 and averaged 0.33 percent MoS_2. Perhaps higher grade pockets were exploited at the time the mill was in operation.

LAUREL CREEK MOLYBDENUM AND TUNGSTEN PROSPECT

The Laurel Creek molybdenum and tungsten prospect is in a cirque wall at an approximate elevation of 11,500 feet on the north slope of Bloody Mountain in the Mount Morrison quadrangle. The property, in sec. 29, T. 4 S., R. 28 E., was reached from the Bishop-Reno highway by a dirt road that leads to the mouth of Laurel Creek. In 1943, the first mile of the road following Laurel Creek to the south was too steep for ordinary cars, and it was necessary to use horses or to hike the 4½ miles from the mouth of Laurel Creek to the prospect.

Anderson made a brief examination in August 1943 to evaluate the molybdenite potentiality, and D. M. Lemmon made a similar examination in September 1943 for tungsten. At the time of the examinations, 11 claims were held by location by the Selbie Estate, Mrs. Jessie Selbie, Lloyd Summers, and Sybil Summers.

Bloody Mountain is composed of metamorphic rocks intruded by granitic rocks. The molybdenum-tungsten prospect is exposed in a cliff face 200 feet high and about 400 feet long at the base, almost surrounded by long slopes of talus. Granitic rock is exposed at the base of the cliff, and black hornfels, marble, and diopside-garnet rock (tactite) are exposed in the cliff face. The bedding of the metamorphic rock is inclined about 45° into the cliff.

Ropes and ladders were suspended from iron stakes driven into the face of the cliff, but because they had been exposed to the weather for several years, the owners of the prospect considered them unsafe. Inspection of the prospect was therefore limited to the base and sides of the cliff and to boulders in the talus.

Molybdenite was observed in two places along the base of the cliff. In one place, seams and nests of disseminated molybdenite occur in an area of marble 10 by 4 feet, and in another place, short molybdenite-bearing seams, one-half inch wide and several inches long, are near two quartz veins. The veins are 1 to 2 inches wide and contain molybdenite veinlets along their margins. A few boulders of tactite containing richer seams of molybdenite were found in the talus, and these presumably came from high on the cliff face. Lloyd Summers (oral commun., 1943) stated that all the high-grade molybdenite-bearing rock from the cliff face was blasted out during a sampling program by an unknown ferroalloy company. This report indicates that the distribution of the molybdenite is spotty, a conclusion supported by observations of the base of the cliff.

Low-grade scheelite is widely disseminated in tactite above the black hornfels, but only a small part of the scheelite fluoresces blue or white, and most of it fluoresces yellow; a high content of molybdenum is thus indicated (Lemmon, written commun., 1943). Lemmon also identified a form of powellite, which is probably barren of tungsten. Lemmon believes that much of the molybdenum is in the form of powellite rather than molybdenite. Samples were reported to have assayed as much as 1.30 percent MoS_2 and 0.7 percent WO_3, a higher grade than Lemmon's and Anderson's visual estimate.

SEPTEMBER GROUP OF CLAIMS, by H. K. Stager

The September group of claims is about 1 mile north of the East Gate checking station of Yosemite National Park and on the west side of the Tioga Pass road (California Highway 120). The claims are in secs. 19 and 25, T. 1 N., R. 25 E., at an altitude of 9,800 feet. Leevining, Calif., 12 miles to the east, is the nearest source of supplies. A field examination was made by H. K. Stager in October 1959 on behalf of the OME.

The claims, September No. 1 through 11, were held by right of location by P. C. Hillen and W. C. Holding, Menlo Park, Calif. An option to purchase the property was held by Mono Lake Mines, a partnership of Robert C. Read and R. S. T. Fraser, Norwalk, Conn.

The property has been developed by a bulldozer trench, 700 feet long, 15 feet wide, and 1 to 5 feet deep, and by several prospect pits a few feet in diameter and 1 to 5 feet deep, all on the September No. 2 claim.

The September claims lie on the east edge of a large roof pendant of Paleozoic metamorphic rocks that are surrounded by Cretaceous granitic rocks of the Sierra Nevada batholith. The metamorphic rocks are predominantly siliceous and calcareous hornfels interbedded with small lenses of tactite; granite crops out in the southeast part of the property. Talus and slope wash covers much of the claim area.

A bed of siliceous white hornfels several hundred feet thick crops out along the west side of the September No. 2 claim; it forms a steep cliff face and is the source of the talus that covers much of the mineralized area. The bed is about 600 feet west of the contact of the granite and metamorphic rocks and forms the west boundary of the principal area of tactite and calcareous hornfels that contains the molybdenum deposit. Foliation in the metamorphic rocks is parallel to the bedding, strikes about N. 30° to 60° E., and is vertical or dips steeply northwest.

The highest grade tactite lenses are localized in the calcareous hornfels about 400 feet west of the contact of the granite and metamorphic rocks on the September No. 2 claim. The tactite lenses are vertical or dip steeply; they range in length from a few feet to a hundred feet and in thickness from a few inches to 50 feet.

The ore minerals are molybdenite, ferrimolybdite, powellite, and scheelite, and the gangue minerals are pyrite, arsenopyrite, quartz, diopside, epidote, garnet, and calcite. Most of the mineralized lenses contain a trace to about 1 percent molybdenum and tungsten, but the metal content probably averages less than 0.1 percent. The highest grade lens exposed on the property is about 70 feet long and 30 feet wide, and is inferred to extend down dip about 50 feet. The estimated average grade of this lens is about 0.6 percent MoS_2 and 0.3 percent WO_3.

SAN DIEGO COUNTY

BOUR MINE

In May 1943, Anderson made a brief examination of the Bour molybdenite mine, which is located 6 miles west of Romona, Calif., at the midpoint of the boundary of secs. 10 and 11, T. 13 S., R. 1 W. The Romona topographic quadrangle map shows an improved road leading to the property, but in 1943 the road was washed out and overgrown by chaparral.

According to records of the California State Bureau of Mines, the owner of the property in 1943 was Mrs. E. M. Bour, San Diego. Available records indicate that in 1917 milling ore taken from an opencut 115 feet long yielded 1 ton of concentrates that averaged 60 percent MoS_2. The mill had been removed by 1943. Northeast of the opencut, an adit had been driven S. 40° W. to intersect the ore zone. No mineralized rock was found on the dump of the adit; the adit was inaccessible in 1943.

The country rock is granodiorite; it is cut by a north-northwest-trending aplite dike, that is about 30 feet wide in the area of the opencut. Most of the exposed dike is barren, but in the opencut the dike contains two mineralized zones that consist of scattered crystals of molybdenite as much as one-quarter of an inch in diameter. A little pyrite is associated with the molybdenite. The more northerly mineralized zone is about 10 feet long; the second zone, which is 15 feet to the south, is about 50 feet long. The molybdenite is so widely scattered in these zones that only a large sample would represent the grade of the deposit. Visual inspection suggested a grade between 0.10 and 0.20 percent MoS_2.

SHASTA COUNTY

BOULDER CREEK MINE

The Boulder Creek molybdenite mine is south of Boulder Creek in the Dunsmuir quadrangle in the center of sec. 33, T. 37 N., R. 5 W. In 1942, the property was accessible over a Forest Service road leading west from U.S. Highway 99, 17 miles south of Dunsmuir, Calif. The Forest Service road was followed for 2.4 miles, at which point a dirt road branches to the left. The dirt road, which is 2 miles long, leads to the property. Kupfer and Anderson made a brief examination of the property in September 1942.

The property was owned by L. H. Brown and M. M. Brown, Dunsmuir. Development work consisted of several trenches and cuts, a main shaft 70 feet deep connecting with a short crosscut at 50 feet, and a shaft 15 feet deep that was partly filled with water. Other workings, which were caved and inaccessible, included an inclined shaft connecting with the main shaft and an adit east-northeast of the main shaft. According to M. H. Brown (written commun., 1942), three carloads of molybdenite ore averaging about 3 percent MoS_2 were shipped in 1917. A flotation mill, built and operated for a short time in 1918, produced a concentrate averaging 90 percent MoS_2.

Despite poor exposures and a thick soil cover, the sparse outcrops indicate that serpentinized periodotite is the prevailing rock. Scattered outcrops of aplite trend northeast, but no exposures reveal a positive intrusive relationship to the serpentinized periodotite. Locally, faults cut the aplite. According to M. H. Brown (oral commun., 1942), the adit was driven entirely through serpentine without intersecting the aplite that is exposed directly over the adit (fig. 11); therefore some of the aplite outcrops may be landslide blocks.

Molybdenite associated with pyrite is locally disseminated through the aplite, forming mineralized areas 2 to 3 feet in diameter. These areas are more numerous around the main shaft, except for one out-

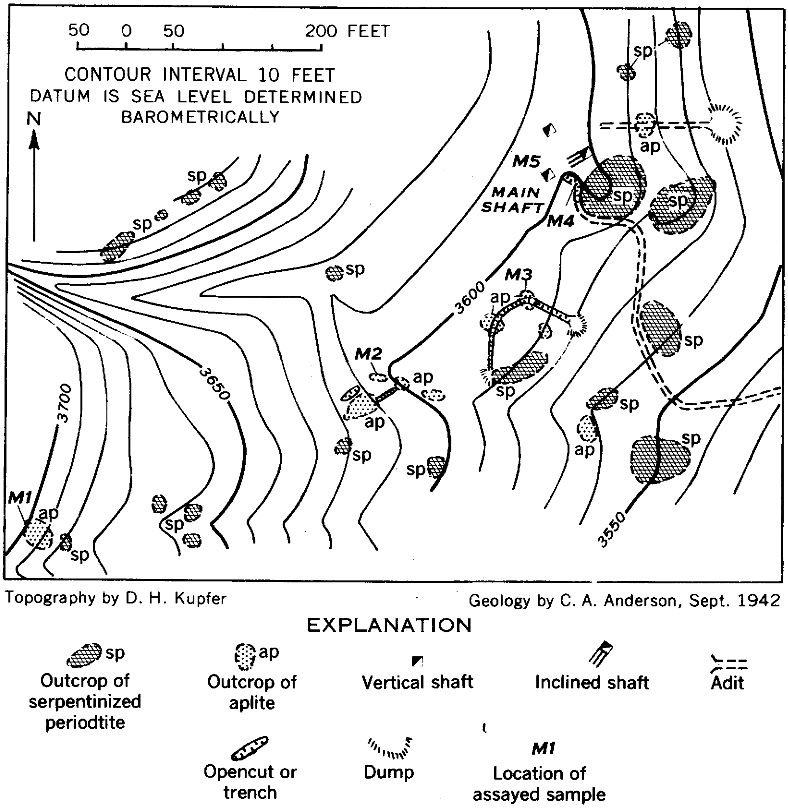


FIGURE 11.—Outcrop map of the area around Boulder Creek mine, Shasta County, Calif., showing location of assayed samples.

crop (M–1) in the southwestern corner of the mapped area (fig. 11). The mineralized rock is very hard except where it has been broken by faults, and sampling the mineralized aplite is difficult. Chip samples were taken for assaying; the results are shown in table 5:

TABLE 5.—*Sample and assay data for Boulder Creek mine*

[Assays by Union Assay Office, Salt Lake City, Utah]

Number (fig. 11)	MoS_2 (percent)	Location, size of sampled area	Remarks
M1	0.55	Southwest prospect cut, 6×8 ft	Molybdenite in scattered bunches.
M2	.13	Stream bank, 3×4 ft.	
M3	1.33	130 ft south of main shaft, 2×4 ft.	
M4	.77	East of main shaft, zone 10 ft long.	
M5	.41	4-ft sample across face of crosscut on 50 level from main shaft.	

COLORADO

CHAFFEE COUNTY

LITTLE GUY MINE, by D. R. MacLaren

The Little Guy mine is in the La Plata mining district in sec. 23, T. 12 S., R. 81 W., at an altitude of 10,000 feet. A group of six claims centers around the junction of Clear Creek and Lake Fork Creek. The claims are readily accessible from Buena Vista on U.S. Highway 24 by driving northwest for 15.7 miles and thence southwest on County Road 170.

The property, formerly known as the Crescent mines, was examined in September 1952 by D. R. MacLaren, U.S. Geological Survey, and C. M. Harrer, U.S. Bureau of Mines, on behalf of the DMEA. At that time the property was owned by the C & B Mining Co., Florence, Colo.

Drifts 175 feet and 100 feet long reportedly have been driven from the bottom of an 80-foot shaft. Water in the shaft to within 10 feet of the surface precluded underground inspection of these workings.

The claims lie, for the most part, in a broad, flat valley. Clear Creek has cut a canyon 10 to 50 feet deep in the valley floor. Rock exposures were examined in the walls of this canyon and in an area east of the shaft. The rocks are Precambrian (?) granite cut by veins of quartz and pegmatite that strike N. 10° to 17° E., and dip from 78° to 80° W. A careful examination of the walls of the canyon failed to reveal any molybdenite-bearing veins although there is some evidence that mineralized faults may exist beneath the streambed.

The only mineralized vein noted is about 300 feet east of the shaft. It is 6 inches wide and consists of quartz containing small scattered flakes of molybdenite, some of which are coated with yellow ferrimolybdite. Sparsely scattered molybdenite and ferrimolybdite with pyrite in a gangue of quartz and feldspar were noted in material on the dumps in the vicinity of the shaft. Indications are that only small lenses of mineralized material were found in the mine.

RED MOUNTAIN DEPOSIT, by A. H. Koschmann

The Red Mountain molybdenite deposit in sec. 11, T. 12 S., R. 82 W. lies at the headwaters of the South Fork of Lake Creek in the Sawatch Range, northern Chaffee County, Colo. The area is extremely rugged and is traversed with difficulty; altitudes range from about 10,500 feet in the creek to 13,000 feet or more on the peaks and crest of ridges. The deposit can be reached by traveling over State Highway 82 to Everett (a small settlement at the junction of the North Fork and South Fork of Lake Creek), thence over a secondary dirt road for about 4 miles to the end of the road, and finally on foot over a steep trail for the last 2½ miles.

A. H. Koschmann and J. C. Haff, U.S. Geological Survey, accompanied by C. H. Stenner, Pete Solo, and Jack Berry, all part owners of a large block of claims in the area, made a brief examination of the deposit in September 1943. A 1,300-foot adit, which explores the deposit, was partly caved at the portal, and 3 feet or more of water in the adit made underground mapping and sampling impossible.

The country rock of the Red Mountain area consists of granite and gneiss of Precambrian age, capped by a rubble of Precambrian rock fragments; the rubble is in turn overlain by rhyolite. Red Mountain derives its name from the iron-stained country rock. Apparently the staining is due to the oxidation of disseminated pyrite. The rock is considerably fractured, and much of the area is covered by talus and debris.

In the Red Mountain deposits, molybdenite is associated with pyrite and small amounts of chalcopyrite and occurs in the rhyolite in fractures and quartz stringers an inch thick or more. Whether or not the mineralization was restricted to the rhyolite has not been determined. According to Howell (1919), the country rock in the tunnel consists "almost wholly" of rhyolite.

Southeast of Red Mountain, in Clear Creek near Winfield, molybdenite occurs in quartz veins in the granitic rocks and lends support to the concept that the granitic rocks in the Red Mountain area may be mineralized. The extent of mineralization could not be determined in the time available.

The molybdenite-bearing rock fragments on the dump were visually estimated to contain about 0.5 percent MoS_2; because these fragments are scarce, the grade of the deposit may be lower.

WAGNER CLAIMS, by A. H. Koschmann

The Wagner claims in sec. 20, T. 12 S., R. 81 W., lie on the north side of the North Fork of Clear Creek in the Sawatch Range, about a mile west of Winfield, Chaffee County, Colo. Winfield is reached over a dirt road that leaves U.S. Highway 40S about 2 miles south of Granite and follows the valley of Clear Creek. From Winfield the property is reached by trail.

A. H. Koschmann and J. C. Haff, accompanied by Orin Wagner of Canon City, Colo., made a brief examination of the property in September 1943 to determine the mode of occurrence, distribution, and grade of the molybdenite deposit. The owners at that time were W. C. Wagner, of Salt Lake City, Utah, and Orin Wagner, of Canon City, Colo. The examination was made on behalf of the Metals Reserve Corp.

The country rock in the vicinity of the molybdenum deposits is Precambrian granite and gneiss. Rhyolite may cap the ridges, but none was found in place on the slopes. Molybdenite associated with pyrite occurs in quartz veins that probably follow shear zones and faults, as suggested by gougelike material found along the veins. The number and extent of the veins were not determined. No disseminated molybdenite was seen in the country rock. One vein occurs near the bottom and another near the middle of the slope on claim No. 5. Apparently they are the most promising, if not the only veins, on the lower slope; they have been prospected by short adits.

Two adits were examined; one is about 400 feet below the other. In the lower adit, sparsely disseminated molybdenite associated with abundant pyrite occurs in ramifying quartz veinlets as much as 6 inches thick in a shear zone about 2 feet wide in altered granite. Two samples across widths of 2 feet and 1 foot assayed 0.01 and 0.20 percent MoS_2, respectively.

In the upper adit, molybdenite and pyrite occur in a quartz vein 3 to 3½ feet thick that cuts altered granite. Two samples representing this vein were collected, a 4-foot channel sample and a grab sample of selected material from the dump. Analyses showed that the channel sample contained 0.41 percent MoS_2, and the grab sample 0.91 percent MoS_2.

CLEAR CREEK COUNTY

URAD MINE, by D. R. MacLaren and R. U. King

The Urad mine is located on the southeast side of Red Mountain about 10 miles northwest of Empire, Colo. The lower adit portal and the mill are located on Woods Creek, a tributary of Clear Creek. The mine is 2 miles by road from U.S. Highway 40. Altitude in the vicinity ranges from 10,000 feet in the Woods Creek valley near the mine to the 12,309-foot summit of Red Mountain.

The Primos Chemical Co. began developing the Urad mine in 1914 and continued operations until 1919. Production in this period was probably several hundred thousand pounds of molybdenum. Subsequently, all equipment was removed and the buildings were dismantled.

In 1940, the Molybdenum Corp. of America leased the mine from the Vanadium Corp. of America, and, under a contract with the Defense Plant Corp., in 1942 began mine operations, built a 200-ton-per-day mill, and developed a successful method for treating the ore. Mining and milling continued from June 1944 until July 1946, but no data are available on the production. After mining was discontinued, development work and drilling to determine the limits and average grade of the deposit continued for some time.

D. R. MacLaren, R. U. King, U.S. Geological Survey, and Scott W. Hazen, Jr., U.S. Bureau of Mines, examined the property in March 1952 on behalf of the DMPA.

Mine workings at the time of the examination included about 20,000 feet of drifts, crosscuts, and raises, and about 85 diamond-drill holes totaling approximately 17,000 feet. These workings extended over a vertical range of 1,400 feet, a length of 1,300 feet, and a width of 800 feet.

In the vicinity of the Urad mine, Precambrian granite and schist have been intruded by a stock of porphyritic quartz monzonite. The contact between the quartz monzonite and the older rocks is nearly vertical. Molybdenite occurs in an east-trending vein system that dips 45° to 50° N. in the granite and schist. Possibly the zone of intersection of the vein system with the quartz monzonite contact controlled the localization of the molybdenite. The ore body consists of some replaced wall rock and of many small branching and intersecting veins containing molybdenite. Pyrite is common throughout the deposits, but quartz seems to occur only in the larger veins. Galena, sphalerite, fluorite, and some rhodochrosite are associated with the molybdenite. Spectrographic analysis shows small amounts of titanium, tin, tungsten, vanadium, and uranium in the ore.

Detailed studies of the geology of the Urad mine have been published by Vanderwilt (1947) and Carpenter (1960b).

The Mining World (1961) has reported renewed interest in the Urad deposit in that the Climax Molybdenum Co. has secured a lease and option and recent exploration has proved low-grade ore on each side of the vein.

GILPIN COUNTY

WILMA CLAIM AND OTHERS, by E. N. Harshman

The Wilma and 21 associated claims are on Dakota Hill in the Apex mining district about three quarters of a mile east of the town of Apex, Colo. The property is in secs. 15, 16, 21 and 22, T. 2 S., R. 73 W., at altitudes ranging from 9,800 to nearly 11,000 feet. From Black Hawk, the claims can be reached by driving 2 miles northwest on paved Colorado Highway 119 to a junction with the Apex road, then 5½ miles northwest on a dirt road to Apex, and finally about 1¾ miles north and east from Apex. Nye-Mathews Mining, Inc., Indianapolis, Ind., owned the claims in July 1957 when E. N. Harshman, U.S. Geological Survey, and C. M. Harrer, U.S. Bureau of Mines, examined the property on behalf of the DMEA.

The claims have been explored by several shallow pits and trenches, a 130-foot adit, and a shallow shaft. The adit on the Wilma No. 3 and the shaft on Wilma No. 1 claims were not accessible, but Harshman and Harrer were able to examine the dumps and small exposures of vein in bulldozer trenches. In addition, the property was prospected by a geochemical (soil sample) traverse.

The country rocks are the Idaho Springs Formation and quartz biotite gneiss, both of Precambrian age, and quartz monzonite porphyry, Eocene(?) in age and intrusive into the older rocks.

The Idaho Springs Formation crops out on the western part of the claim group; it consists of metamorphosed sedimentary rocks. Pegmatitic bodies, generally small, occur throughout the Idaho Springs Formation; they appear to be related to igneous activity associated with the emplacement of the larger Precambrian granitic intrusives.

The eastern part of the claim group is underlain by Precambrian quartz monzonite gneiss and by Tertiary (Eocene?) intrusive quartz monzonite porphyry. The quartz monzonite gneiss is a gray medium-grained rock composed of quartz, feldspar, biotite, and various accessory minerals. On weathered surfaces the rock is somewhat yellowish, owing to oxidation of the iron-bearing minerals.

The quartz monzonite porphyry crops out in the extreme eastern part of the claim group; it is obviously intrusive into the earlier rocks. It is a gray porphyritic rock with a fine-grained groundmass and phenocrysts of feldspar and quartz.

The principal structures in the area are a series of northeastward-trending shear zones ranging in width from a few inches to as much as 5 feet, and a less pronounced series of northwest-trending shears. Jointing, on a small scale, has broken all rocks in the area.

The ore deposits observed on the group of claims are related to the northeast-trending silicified shear zones containing molybdenite, pyrite, and biotite. Although the shear zones are as much as 5 feet wide, the observed maximum width of the silicified molybdenite-bearing zones was about 8 inches.

The shear zones and included molybdenite-bearing veins strike approximately N. 50° E. and dip steeply both to the northwest and southeast. Alteration in the shear zones is intense, but the wall rock adjacent to them is fresh and unaltered.

Molybdenite occurs as thin flakes dispersed through the quartz veinlets, as small aggregates of flakes filling open spaces in the quartz, and as thin coatings on fractures. Minor amounts of molybdenite were noted in sheared country rock, but most of the molybdenite is associated with quartz in the silicified parts of the shear zones. The yellow oxide ferrimolybdite was noted in near-surface exposures; apparently it was formed by oxidation in place of the molybdenite. Pyrite occurs in all the molybdenum-bearing veins and is unoxidized at a depth of 10 to 20 feet below the surface.

Samples of the silicified molybdenum-bearing part of the shear zones contain as much as 6 percent MoS_2 and minor amounts of ferrimolybdite. A sample taken from the dump of a small shaft on the Wilma No. 1 claim contained 3.97 percent MoS_2. The area of best ore potential appears to be on the Wilma No. 500 claim where at least three molybdenite-bearing silicified shear zones about 20 feet apart are exposed in two parallel trenches.

GUNNISON COUNTY

GOLD HILL, QUARTZ CREEK, AND TINCUP MINING DISTRICTS, by Ogden Tweto

An open-file report on the geology of the molybdenum and tungsten deposits on Gold Hill ridge (Tweto, 1943), prepared in cooperation with the State of Colorado and the Colorado Metal Mining Fund, has the following abstract:

The Gold Hill molybdenum-tungsten deposits are at elevations of 11,200 to 12,200 feet, on the western flank of the Sawatch Range, 10 miles north of Pitkin and 5 miles south of Tincup, Gunnison County, Colo. Most of the development work on the veins was done for gold and silver before 1900, but a few hundred tons of sorted molybdenum ore containing 4½ percent MoS_2, and less than 100 tons of tungsten ore containing 11 percent WO_3, were produced in 1917–18.

Gold Hill consists of Precambrian gneissic quartz monzonite, flanked on the northeast and southwest by lower Paleozoic sedimentary rocks that are cut by porphyries of Laramide age. Nearly all of the veins are in the Precambrian quartz monzonite, but a few extend into the Cambrian quartzites. The veins are relatively short fissures filled by quartz that contains some pyrite and small amounts of hubnerite, molybdenite, and chalcopyrite. The strongest molybdenum veins strike nearly east-west, and the tungsten veins all strike northeast. Molybdenite is also present in a group of north-northwest veins that appear to be related to two strong faults of the same direction.

Molybdenum and tungsten occur together on many veins, but each is limited to clearly defined bands or streaks of different varieties of quartz. Molybdenite occurs in sugary quartz or milky vitreous quartz, and hübnerite occurs in a younger, coarsely crystalline, colorless quartz in which the crystal outlines can usually be seen.

Origin of the veins at relatively high temperatures is indicated by the assemblage of hübnerite, molybdenite, quartz, pyrite, and chalcopyrite. Veins of this type are largely confined to Gold Hill. Profitable deposits of silver and gold ore were mined in the area surrounding Gold Hill, and the change in the ores from molybdenum-tungsten-copper to silver-copper-lead to silver-lead-gold to silver-lead-zinc outward from Gold Hill indicates a fairly well defined zonal arrangement, and that most of the molybdenum-tungsten veins are restricted to the vicinity of Gold Hill. There is no reason to expect any immediate change with depth in the mineralogic character of the veins.

The molybdenum veins range from a few inches to 5 feet in width, and the average is 1½ to 2 feet. The greatest proved length of any of the veins is 900 feet. The average tenor of the veins is not precisely known but probably does not exceed 0.5 percent MoS_2. The aggregate length of 6,500 feet of exposed veins and 20,000 feet mapped by float is distributed among several dozen veins that would have to be mined individually or in small groups. Costs of development for large operations would, therefore, be relatively high. Some of the larger veins contain streaks of higher grade ore, and small scale high-grade operations might produce a small tonnage of sorted ore with an MoS_2 content of about 3 to 4 percent.

The average tenor of the tungsten veins in veins or streaks averaging 5 inches in width is probably 2½ percent WO_3.

ROUTT COUNTY

FOCH, COPPER MASK NO. 1, AND OTHER CLAIMS, by E. N. Harshman

The property consists of 34 patented mining claims in the Hahns Peak mining district, T. 9 and 10 N., R. 85 W. About 5½ miles of fair dirt road connects the property with the village of Hahns Peak on State Highway 129 in northern Routt County.

An examination of the surface and underground workings was made in August 1954 by E. N. Harshman, U.S. Geological Survey, and Glenn Walker, U.S. Bureau of Mines, on behalf of the DMEA. The claims were owned by the Colorado Mining Corp. at the time of the examination.

The Hahns Peak mining district is in a belt of disturbed rocks between a Precambrian metamorphic complex that forms the core of the Park Range to the east and a sedimentary province that extends some distance to the west. The deposits examined are in Precambrian metamorphic rocks and associated intrusives similar to the Idaho Springs Formation of the Front Range mineral belt. The fact that the deposits are similar to others regarded as Precambrian in age suggests that these deposits in Routt County are also of Precambrian age. The deposits are not well exposed on the surface because of a thick overburden, and most of the old adits, pits, and shafts are caved. A 797-foot long crosscut bearing N. 15° E. about 400 feet below the highest surface workings was accessible for this examination, however.

The host rocks for the copper-molybdenum deposits exposed in the crosscut are gneissic granite, schist, and probably felsitic porphyry. The rocks have a distinct linear structure that plunges from vertical to steeply north. Chalcopyrite, molybdenite, and secondary copper sulfides and oxides are associated with the metamorphic rocks. Chalcopyrite, secondary copper minerals, and, to a lesser extent, molybdenite are disseminated throughout small lenticular lenses or veins of pegmatitic quartz and feldspar. Molybdenite is concentrated somewhat in the selvages of the pegmatitic veins, particularly where the selvages are composed of biotite or other iron-rich minerals.

The maximum dimensions of the lenticular pegmatitic veins are not exposed either on the surface or in the crosscut. Several of the 20 or more veins exposed in the adit do not extend from one wall to the other, and their lateral extent probably is not more than a few tens of feet. A 40-foot drift on one of the widest veins exposed in the 797-foot crosscut proved this vein to have a strike length of 13 feet and a maximum thickness of 3 feet; its vertical extent is not known, but appears to be less than 15 feet.

Samples of ore collected near some of the caved surface workings, and assumed to have come from them, contain primary copper sulfides, copper oxides, and sparse secondary copper minerals. Ore in the crosscut is composed principally of primary copper sulfides. The occurrence of primary sulfide minerals in shallow surface workings indicates that erosion has kept pace with the oxidation of the deposits and that no extensive zone of supergene enrichment will be found below the present outcrops.

The analyses of 12 samples taken by the examiners had the following ranges:

Copper	percent	0.05 –1.47
MoS_2	do	.01 – .50
Gold	oz. per ton	.005– .03
Silver	do	.1 – .2

SAN MIGUEL COUNTY

MOLYBDENUM PROSPECTS IN OPHIR VALLEY, by J. S. Vhay and D. J. Varnes

Several molybdenite deposits in Ophir Valley were examined by J. S. Vhay and D. J. Varnes in 1942–43. The deposits are in secs. 35 and 36, T. 42 N., R. 9 W.

The molybdenite deposits occur in Tertiary volcanic flows, tuffs, and breccias and in older sedimentary rocks of Triassic and Carboniferous age. Tertiary intrusive masses of quartz monzonite, quartz diorite, and granite porphyry cut the complete section of rocks. The molybdenite deposits occur within the intrusive bodies or in metamorphosed rocks near them.

NEVADA GULCH

The Nevada Gulch molybdenum prospect reportedly was owned by Otto Beselack, Matterhorn, Colo. The deposit was unsuccessfully worked for molybdenite many years ago. It lies at an altitude of about 10,450 feet on the slope south of Ophir Valley in the edge of a large intrusive mass of Tertiary porphyritic quartz monzonite. The intrusive mass invaded the sandstone, shale, and conglomerate of the Cutler and Dolores Formations.

The molybdenite occurs in a roughly elliptical chimney of brecciated quartz monzonite that is cemented and veined by coarsely crystalline glassy quartz. Coarse pyrite, massive sericite (or a hydrothermal clay mineral) closely associated with the molybdenite, and considerable yellow powdery ferrimolybdite are also present. The dimensions of the chimney at the surface are roughly 75 feet north-south by 55 feet east-west. The east edge is covered by talus and the chimney may extend about 20 feet farther; the west edge is partly covered by moraine, and the apparent elliptical shape indicates that the chimney may extend 50 to 75 feet farther westward.

Molybdenite occurs as scattered small pods, irregular veinlets, and isolated crystals. Some of the crystals and pods are one-half inch or more in size, but at the surface the molybdenite has been oxidized to powdery ferrimolybdite and partly washed away. The coarse molybdenite remaining is sparsely and erratically distributed, and consequently the deposit as a whole apparently has a low grade. Owing to the erratic distribution of the molybdenite, a representative sample of the outcrop probably could be obtained only by breaking 50 to 100 tons of rock for a mill test.

The portal of the Deadwood tunnel is about 2,000 feet northwest of the chimney and 550 feet below the outcrop. The tunnel is inaccessible. Reportedly molybdenite was found in the Nevada drift off this tunnel but probably too far west of the outcrop to represent a downward continuation of the chimney. Scattered molybdenite was noted in rock examined on the tunnel dump. In addition to molybdenite, the tunnel workings are reported to have cut several zinc-lead veins of some promise.

DEPOSIT NEAR CHAPMAN GULCH

A deposit similar to the chimney in Nevada Gulch occurs in a gulch just west of Chapman Gulch at the northeast end of Ophir Valley. This deposit is also associated with a porphyritic quartz monzonite plug.

The chimney appears to be about 25 feet in diameter; it is composed of coarsely crystalline quartz, which is more abundant here than in the Nevada Gulch pipe. Within this quartz, a vug heavily mineralized with molybdenite was exposed by picking. This type of intrusive rock underlies much of the valley, and, although the rock is poorly exposed, other chimneys of this kind may exist in the area.

YELLOW JACKET TUNNELS (SILVER TIP)

The Yellow Jacket tunnels are on the north side of the Ophir Valley, about 1¼ miles east of Ophir. The workings are in metamorphosed sedimentary rocks cut by granitic porphyry. Molybdenite coats joint faces for about 400 feet along the lower tunnel. Inasmuch as analysis of a sample of about 50 pounds of quartzite taken adjacent to a porphyry dike showed 0.106 percent copper and no or an exceedingly small quantity of molybdenum, it is concluded that the molybdenite is not disseminated in the quartzite but is present only as a smear on joint faces. The dike material appears to contain no more molybdenite than the quartzite.

NEW DOMINION PROPERTY

The New Dominion property lies on the north side of Ophir Valley across from the Deadwood tunnel. Molybdenite was seen in small quantities on the dumps of both levels of the mine. A few small veinlets were also seen on the lower level in the mine.

SUMMIT COUNTY

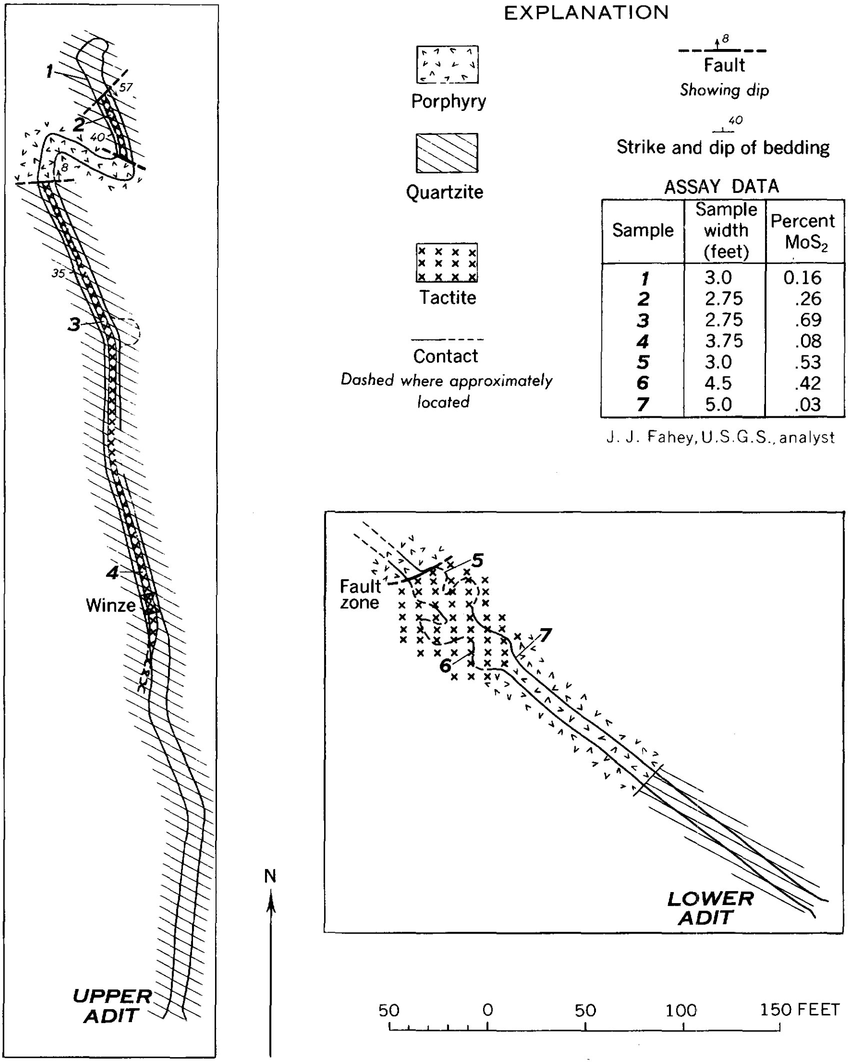
D AND G PROPERTY, by A. H. Koschmann

The D and G property is about 1½ miles northeast of Kokomo, Colo., near U.S. Highway 91 and about 5 miles north of the Climax molybdenum deposit. It is in sec. 13, T. 7 S., R. 79 W., on the southeast slope of Jacque Mountain in the Park Range, Kokomo mining district.

A. H. Koschmann, U.S. Geological Survey, assisted by James Odell, made a preliminary examination of the D and G property on November 28–29, 1942. A geologic map was made of two adits on the property, and seven samples of ore were collected (fig. 12). Snow from 1 to 3 feet deep precluded any examination of the surface geology. Owners of the property at the time of the examination were H. H. Gilman, Kokomo, and John Devine.

The geology of the Kokomo district has been described by Emmons (1898), Koschmann (1947), and Koschmann and Wells (1946). The following summary of the general geology is based on their reports:

The area comprises a thick succession of sedimentary strata of Carboniferous age that have been intruded by numerous sills and a few porphyry dikes of Laramide age. The sedimentary rocks are predominantly buff and maroon and are chiefly conglomerate, grit,



ASSAY DATA

Sample	Sample width (feet)	Percent MoS_2
1	3.0	0.16
2	2.75	.26
3	2.75	.69
4	3.75	.08
5	3.0	.53
6	4.5	.42
7	5.0	.03

J. J. Fahey, U.S.G.S., analyst

Figure 12.—Geologic maps of adits on the D and G property, Summit County, Colo., showing samples and assays.

sandstone, and shale and a few widely distributed beds of limestone. On Jacque Mountain, igneous activity has metamorphosed some of the sedimentary rocks and converted some of the sandstone to quartzite and some of the limestone to tactite (now chiefly garnet and some epidote) that locally carries molybdenite.

The major structural feature of the region is a northward-plunging syncline, and the D and G property is near the axis. The rocks have been faulted and fissured, but displacement along the faults is small.

When visited in 1942, the D and G property had been explored by two adits at altitudes of approximately 10,600 and 11,400 feet. The upper adit is about 1,400 feet northwest of the portal of the lower adit. The lower adit reportedly was about 400 feet long, but only the first 300 feet was accessible. The first 200 feet of the adit cut shattered metamorphosed rocks and decomposed porphyry. Molybdenite-bearing tactite is cut about 200 feet from the portal and extends for 65 feet. At a point 300 feet from the portal, much shattered and decomposed porphyry is faulted against the molybdenite-bearing tactite, and the adit was inaccessible beyond the fault.

Three samples (see fig. 12 for location, width, and MoS_2 content) were collected from the lower adit. Two of these represent the molybdenite-bearing tactite, and the third the porphyry. The tactite samples contain 0.53 and 0.42 percent MoS_2, and the porphyry is barren of molybdenite. The area from the fault to the face reportedly contains no molybdenite-bearing rocks.

The upper adit, driven approximately along the bedding, is 575 feet long. The country rock here consists chiefly of tactite and quartzite and, in the short crosscut near the face, a small faulted block of porphyry. The bedding strikes almost north to north-northwest and dips 35° to 40° W. The tactite, which ranges in thickness from 2½ to 5 feet, is the chief molybdenite-bearing rock, although the quartzite locally carries some of the mineral. No molybdenite, however, was seen in the porphyry. Four samples (fig. 12) were collected from the upper adit, three representing the tactite and one the molybdenite-bearing quartzite near the face. Only one sample (No. 3) contains more than 0.5 percent MoS_2, and the average content of the four samples is 0.30 percent MoS_2.

IDAHO

CUSTER COUNTY

BOULDER CREEK DEPOSIT

The Boulder Creek molybdenite deposit is about 16 miles airline S. 28° W. of Clayton, Idaho, and 5 miles east of Blackman Peak in the central part of Idaho. The property in sec. 3, T. 8 N., R. 16 E., is accessible by graded road along the East Fork of the Salmon River and by trail along Little Boulder Creek. The deposit was mapped by S. C. Creasey and E. A. Scholz in September 1943.

Ten unpatented claims were held by location in 1943 by Lester Fuller, Jess L. Baker, and Mrs. William Baker, Clayton. Two additional claims were held by location by the same group and Mrs. A. Wilson Walker. Jess L. Baker held an additional claim at the northern end of the mineralized area. Exploratory workings consisted of 24 trenches and pits and three short adits.

The geology of the region has been described by Ross (1937). In the vicinity of the Boulder Creek molybdenite prospect, the oldest rocks are the Wood River Formation of Pennsylvanian age; according to Ross (1937, p. 36), this formation is a light-gray to black quartzite which contains minor interbeds of limestone. At the Boulder Creek deposit, the Wood River Formation is light-green massive quartzite; the beds strike about N. 20° E. and dip steeply west (pl. 3).

Porphyritic biotite granite intrudes the Wood River Formation. The granite contains large orthoclase phenocrysts in a granular groundmass of quartz, feldspar, and biotite. Locally it is sheared and contains a few aplite dikes and quartz veins. Ross (1937, pl. 1) indicated the age of the granitic rocks in this general region as Late Jurassic or Cretaceous.

Molybdenite is the dominant ore mineral in the deposit. It occurs disseminated in the quartzite; in a stockwork consisting of small, irregular, randomly oriented, discontinuous quartz veinlets; and in quartz veinlets that strike from N. 10° E. to N. 40° E. and dip southeast and northwest. In general, the molybdenite content is higher in areas of abundant quartz veinlets, which are in a zone 300 to 500 feet wide east of the granite contact. The number of quartz veinlets and the molybdenite content gradually diminish eastward to an indefinite boundary where they are not visible even with a hand lens; this boundary is shown on plate 3. A trace of scheelite was recognized with much of the molybdenite.

A few short irregular veins as wide as 2 feet occupy fracture zones striking N. 40° W. to N. 70° W. (pl. 3). White quartz and gray to black chalcedony form the gangue, and galena, sphalerite, chalcopyrite, arsenopyrite, pyrite, and a trace of molybdenite are the ore minerals present. These northwest-trending fracture zones, which displace aplite dikes and quartz veinlets of the stockwork, prove that these small and probably uneconomic sulfide-bearing veins are younger.

The U.S. Bureau of Mines has furnished the results of their sampling and assaying program made before the studies of the U.S. Geological Survey. Twenty-eight samples—plus four Geological Survey samples—were collected from the surface, and 12 samples were obtained from two underground workings (pl. 3). These samples indicate that the deposit contains an appreciable reserve averaging about 0.15 percent MoS_2.

WALTON PROSPECT

The Walton molybdenite prospect is on Little Falls Creek in the Hailey quadrangle. The property in sec. 7, T. 6 N., R. 19 E., is accessible from Ketchum, Idaho, by graded road along Trail Creek and

Summit Creek. The Walton prospect is 1.7 miles northwest of the mouth of Little Falls Creek at an altitude of about 8,400 feet, and in 1942 it was accessible by a narrow but passable road. The prospect is 16 miles from Ketchum. In 1942, the claims containing the prospect were held by location by Lee Walton, Idaho Falls. Earlier claim holders had made three prospect cuts in two mineralized areas. Anderson and Kupfer spent 2 weeks in October 1942 preparing a topographic and geologic map and collecting samples for assaying.

The regional geology has been described by Umpleby, Westgate, and Ross (1930). In the Little Falls Creek area, the Phi Kappa Formation, consisting of argillaceous and quartzite beds of Ordovician age, is intruded by a small stock of quartz monzonite. The eastern intrusive contact closely follows Little Falls Creek (pl. 4), and the western contact is 1,000 feet higher and about a quarter of a mile from the Walton prospect.

Narrow aplite dikes are common in the eastern exposure of quartz monzonite (pl. 4). In the southern exposures, the quartz monzonite grades into aplite containing lenses of pegmatite as much as a foot in dimension.

Two sets of quartz veins cut the quartz monzonite. The older set strikes N. 20°–30° W. and contains scattered molybdenite crystals. The younger set, indicated by displaced molybdenite-bearing veins, strikes N. 10° W. to N. 10° E. and is barren. Both sets of veins are vertical or dip steeply to the east and west.

Steep exposures of glacially polished quartz monzonite project through widespread talus slopes in the valley of Little Falls Creek; the outlines of these outcrops west of the creek are shown on plate 4.

LOWER PROSPECT

The two areas showing the best concentration of molybdenite are the lower and upper prospects (pl. 4). The lower prospect is a 300-foot zone of quartz veins ranging from a fraction of an inch to more than 2 feet in width; the veins are separated by quartz monzonite or aplite. Individual veins are discontinuous, and the mineralized zone ranges from 7 to 12 feet in width. The strikes of the individual veins are also variable; many are parallel to the mineralized zone, but in others the strike ranges from N. 5° W. to N. 30° W. The veins are mainly vertical.

The molybdenite occurs in bunches or scattered crystals in practically all the quartz veins and locally in the adjacent quartz monzonite. Some of the crystals are as much as three-quarters of an inch in diameter. A trace of pyrite was noted. The distribution of the molybdenite is spotty as revealed by the prospect cut; the south wall is mineralized and the north wall is barren. Seven channel samples were collected for assay (pl. 4; table 6):

TABLE 6.—*Sample and assay data for Walton prospect*

Number (pl. 4)	Length (feet)	MoS_2 (percent)	Remarks
Lower prospect			
W 1	3.0	0.44	Sample of quartz vein 2 inches wide. Strike N. 23° W., dip 85° E.
W 2	4.3	.10	Western half of zone of alternating quartz veins, quartz monzonite, and aplite.
W 5	7.8	.25	Full width of zone of alternating quartz veins and quartz monzonite.
W 6	7.0	.20	Alternating quartz veins and quartz monzonite.
W 7	3.5	.34	West margin of quartz zone.
W 8	5.0	.24	Offset 2½ feet from southeastern end of sample W 7. Alternating quartz veins and quartz monzonite.
W 9	8.0	.11	
Upper prospect			
W 4	2.5	1.91	Cut from eastern part of mineralized zone. Quartz monzonite containing numerous small quartz veins. One mass of molybdenite 3 inches in diameter included in sample.
W 10	8.5	.60	Sample of zone 7.5 feet wide. Representative of rock containing the most molybdenite in the upper prospect. Alternating quartz veins and quartz monzonite.

UPPER PROSPECT

The upper prospect has an elevation of 8,600 feet and is 600 feet west of the north end of the lower prospect. Molybdenite occurs in a zone 40 feet long that trends N. 45° W. The zone consists of quartz veins in quartz monzonite. One vein is 3 feet wide, several more are 1 foot wide, but most are an inch wide or less. Some quartz veinlets are so closely spaced that the molybdenite appears to be disseminated in quartz monzonite. Individual veins strike N. 10°–20° W., discordant to the trend of the zone. Dips are mainly vertical. The veins that strike more northward are shorter than those that strike more westward. The mode of occurrence of the molybdenite is similar to that in the lower prospect.

Two channel samples were collected from where the molybdenite appeared to be most abundant; the locations are shown on plate 4, and the assays are given in table 6.

Molybdenite occurs elsewhere in the mapped area in quartz veins 1 to 2 inches wide that strike N. 20°–30° W. These veins are from 10 to 30 feet long, and the molybdenite is in small and widely scattered crystals. These isolated mineralized veins are found south of the lower prospect and southeast of the upper prospect (pl. 4), but they are rarely closer together than 50 feet and may be as much as 300 feet apart. No samples were collected because of the scattered distribution and obvious low grade.

In summary, the lower prospect contains a mineralized zone about 300 feet long that ranges from 7 to 12 feet in width. The available assays indicate a grade of about 0.20 percent MoS_2. The upper prospect, ranging in width from 2 to 10 feet, is more irregular in outline; it contains a small tonnage of mineralized rock averaging about 0.60 percent MoS_2.

WHITE MOUNTAIN PROSPECT

Anderson and Kupfer made a brief examination of the White Mountain prospect in October 1942 during the period that work was being done on the Walton prospect to the northwest. The White Mountain claims, in sec. 20, T. 6 N., R. 19 E. (unsurveyed), are at an elevation of 9,000 feet on the south side of Summit Creek and may be reached from the junction of Little Falls and Summit Creeks by hiking about a mile south to the outer end of a north-facing glacial cirque.

Nine unpatented claims were held by location by E. H. Dewey, W. C. Dewey, R. L. McConnell, O. G. McConnell, and W. G. Scales, Nampa, Idaho. Only the necessary location work had been done in 1942.

At the White Mountain claims, the Phi Kappa Formation of Ordovician age is intruded by the same stock of quartz monzonite that crops out at the Walton prospect (Umpleby, Westgate, and Ross, 1930, pl. 1). Near the contact, the quartz monzonite is cut by numerous quartz veins that strike north to N. 30° W. and are vertical or dip steeply east or west. The veins range from narrow stringers to a foot in width, but the average is about 2 inches. They are 5 to 10 feet apart and are short, ending abruptly southward near the contact with the Phi Kappa Formation and gradually fading northward into the quartz monzonite. The average length is about 50 feet where they can be observed; to the north some of the veins are covered by talus. Unmineralized quartz monzonite crops out 150 feet to the northwest.

Molybdenite occurs as scattered crystals and as bunches in the quartz veins; a few crystals are three-quarters of an inch in diameter. By visual inspection, individual veins were estimated to contain 1 to 2 percent of MoS_2, but the small average width of the veins and the wide spacing indicate that the average grade of the mineralized area is very low and no samples were collected for grade determination.

VALLEY COUNTY

VIRGINIA-BETH PROSPECT, by C. P. Ross

The Virginia-Beth molybdenite prospect is on the ridge on the west side of Colt Creek, a small tributary of Little Pistol Creek in sec. 4 of unsurveyed T. 16 N., R. 10 E., in the Payette National Forest. It was accessible only by trail in July 1943 when C. P. Ross with Cyrus L. Johnson, one of the owners, made a brief examination of the deposit. The trail followed Pistol Creek for slightly more than 14 miles downstream to the mouth of Little Pistol Creek, and then followed Little Pistol Creek to the mouth of Colt Creek, between 3 and 4 miles. Next, a poor, steep trail up Colt Creek was followed for about a mile to the property. Eleven claims were held by location by Agnes L. Johnson, Cyrus L. Johnson, Carson Hurd, and N. G. Brewster. Development in 1943 consisted of several small pits on the hillside 100 to 150 feet above Colt Creek.

The prospect is in granitic rock of the Idaho batholith, which is here impregnated with aplitic material and crisscrossed by aplitic dikelets. Many irregular inclusions of sedimentary rock were thoroughly soaked with igneous material that obscured their original character.

Several discontinuous fracture zones form a complementary system. The larger zones in general trend about N. 60° E. and dip southeast or northwest. The second set of fractures trends N. 10° E. to N. 25° W. and are nearly vertical. The fractures range in width from a few inches to a foot.

Both sets of fractures have been mineralized, and the sheared rock is impregnated with glassy quartz, amphibole, and, locally, calcite. Molybdenite, some in conspicuous rosettes, is irregularly distributed. Pyrite, pyrrhotite, chalcopyrite, and probably bornite occur in bands parallel to the fractures.

Four samples were taken from the principal pit. Sample 1 was collected for a length of 1 foot across a rusty fracture striking N. 10° W. which is the most highly mineralized of the observed northward-trending fractures. Sample 1 assayed 0.06 percent MoS_2. Sample 3 was taken from a freshly blasted spot north of the fracture represented by sample 1 and assayed 0.98 percent MoS_2. Sample 4 was collected from slabs blasted from northeast-trending mineralized rock and assayed 1.00 percent MoS_2. Sample 5, taken from a picked ore pile, reportedly represents high-grade ore from a pocket in the southwestern part of the pit; it assayed 6.46 percent MoS_2.

MAINE

AROOSTOOK COUNTY

HENDERSON FARM PROSPECT, by W. S. Burbank and R. L. Miller

Molybdenite was discovered on the A. C. Henderson farm before World War II, and in October 1942 W. S. Burbank made a brief examination of the deposit. R. L. Miller made a second study in July 1943.

The Henderson farm is 6 miles north-northeast of Houlton, Maine, and about half a mile west of the international border. The property is reached by traveling east from Houlton on U.S. Highway 2 for 1.5 miles and then north on Foxcroft Road for 5.3 miles. The prospect is about 650 feet east of Foxcroft Road.

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The bedrock in the vicinity of the prospect is steeply dipping limestone of the Aroostook Limestone of Silurian age, locally intruded and metamorphosed by granitic bodies. The limestone is fine grained, even bedded, and black. It strikes, in general, northeast and is vertical or dips steeply. Locally the beds are fractured and silicified or bleached light gray. The granite is medium to coarse grained, and is composed mostly of quartz and orthoclase; mica and hornblende are accessory minerals.

Molybdenite has been reported in minor quantities in the limestone near the contact with granite and in the granite itself. Burbank, however, found an appreciable concentration of molybdenite only in the partly metamorphosed limestone on the Henderson farm. A trench 35 feet long, 5 feet wide, and 5 feet deep at its deepest point exposes the bedrock beneath a 1-foot mantle of surficial material. The limestone in the trench is white, finely crystalline marble that is strongly and evenly laminated on weathered surfaces. Near the south end of the trench, a lens of green calcium-silicate rock and quartz about a foot wide is nearly parallel to the bedding. This lens contained considerable molybdenite part of which is irregularly distributed, but other masses of calcium-silicate rock were uniformly impregnated with molybdenite, pyrite, and minor amounts of chalcopyrite and arsenopyrite. A sample of this mineralized rock assayed by the Swastika Laboratories, Ltd., Swastika, Ontario, contained 2.68 percent MoS_2, and 0.07 percent Cu (H. M. Briggs, oral commun., 1942).

A second mineralized zone in the trench consisted of a calcite-quartz vein containing clusters of molybdenite and scattered pyrite crystals. The vein averages about 6 inches in width. The area surrounding the trench was not cleaned sufficiently to justify an assumption that the zone of mineralized rock is continuous for more than 15 to 20 feet. An outcrop of barren quartz veins and silicified limestone about 40 feet west of the trench may represent an extension or branch of the mineralized zone exposed in the trench. To the northeast of the trench, the bedrock is concealed beneath brush and timber-covered swampy ground.

Burbank collected two samples for analysis; one from the full length of the trench, 30 feet, contained 0.03 percent MoS_2, and the other from a 2-foot-wide zone of molybdenite-bearing rock and quartz and calcium-silicate rock contained 0.12 percent MoS_2. Both samples were analyzed for tungsten with negative results. W. G. Schlecht, U.S. Geological Survey, analyzed the samples.

WASHINGTON COUNTY

COOPER MINE, by W. S. Burbank

The Cooper molybdenite mine is in the town of Cooper, Maine, about 19½ miles north of East Machias and 130 to 250 feet east of Maine Highway 191. This deposit is one of the oldest molybdenite mines in the country, the first recorded activity being in 1902 (Pratt, 1904). At that time, considerable development work was done, and a mill was scheduled to start production in 1903. Apparently, however, activities stopped in 1904. Smith (1905) gave a brief preliminary description of the deposit and later Hess (1908) gave a more complete description. Hess reported that "the mill ran only six weeks, and is said to have made about a ton of concentrates" (Hess, 1908, p. 233).

Inasmuch as several pockets of nearly pure molybdenite were found near the pegmatite dikes during mining, the total production probably exceeded the product of milling operations. The operators were reluctant to divulge information in 1904 and denied Smith access to the property; information on production is considered unreliable. Presumably the grade and quantity of ore now exposed would confirm a small production not exceeding 1 to 2 tons (Horton, 1916, p. 32).

In 1918–19, the Maine Metals Co. rehabilitated the mine and mined and concentrated a small quantity of ore. No subsequent mining has been recorded. In October 1942, W. S. Burbank examined the property briefly.

The country rock is a gray to pink granite cut by joints striking north, east, and northeast. The molybdenite occurs in three ways: (1) As crustifications or intergrowths in narrow pegmatite dikes and associated quartz veinlets, (2) as nests or pockets, and (3) disseminated in the surrounding granite. Other minerals, in minor quantities associated with the molybdenite, include purple fluorite, pyrite, chalcopyrite, and a single specimen of bismuth. The pockety masses of molybdenite were not seen by Burbank, but, according to Hess (1908), some were found that weighed as much as 12 pounds. Apparently the pockets were localized beyond the ends of discontinuous pegmatite dikes. Intergrowths of molybdenite with the pegmatite minerals and quartz were not well exposed in the quarry in 1942, but Burbank observed similar material elsewhere in the vicinity and in some specimens of ore reportedly from the quarry. The principal ore bodies of this type were evidently found along a trench in the quarry floor. In 1942 this trench was filled with water to the level of the quarry floor, which is 8 to 10 feet below ground level.

The north and south walls of the quarry do not contain any conspicuous extensions of the dikelets of pegmatite, which, therefore, must have a length of less than 80 feet. These dikelets range from

1 to 3 inches in width (Hess, 1908). A few small seams of pegmatitic quartz are exposed in outcrops north of the quarry, but the amount of molybdenite in them is insignificant. The exposures are sufficiently abundant to indicate that the molybdenite-bearing dikes as well as associated pockets of molybdenite are too far apart and too small to be of economic importance. A larger and more conspicuous quartz vein 800 to 1,000 feet northeast of the quarry is barren of molybdenite.

The most prominent disseminated-molybdenite-bearing rock is on the north quarry wall and southwest and northeast corners of the quarry. A sample collected across 30 feet of mineralized granite assayed 0.12 percent MoS_2. A sample from an ore pile at the west end of the mill that contained 0.12 percent MoS_2 indicates that the ore actually mined was about this grade. A sample of crushed rock found in the mill bin assayed only 0.03 percent MoS_2. W. G. Schlecht, U.S. Geological Survey, analyzed the samples.

MONTANA

BEAVERHEAD COUNTY

MONAGHAN PROSPECT

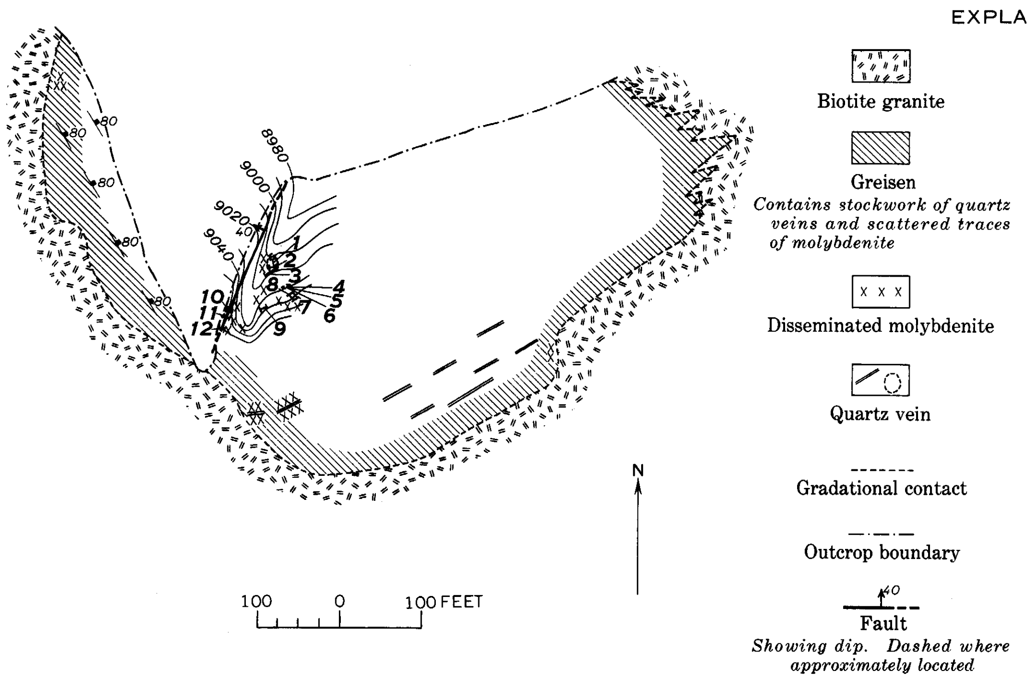
The Monaghan molybdenite prospect is in the Beaverhead National Forest in sec. 5, T. 5 S., R. 11 W. (unsurveyed), about 45 miles airline southwest of Butte, Mont. The property was reached from U.S. Highway 91, 16 miles north of Dillon, by going west on a graded dirt road that passes through Apex and ends at Pear Lake, about 1 mile south of the prospect. Claims were held by location by Dewey Long and F. X. Monaghan, Butte.

Creasey and E. A. Scholz made a brief examination in August 1943; they collected samples of mineralized rock, and prepared a geologic map to show the generalized outline of the altered country rock (fig. 13).

The prevailing country rock is biotite granite composed of orthoclase, small amounts of plagioclase, quartz, and biotite. According to Winchell (1914, p. 31), the granite mass may be a silicic facies of the Boulder batholith, which is dominantly quartz monzonite, or it may be a separate intrusive body of granite.

The granite is locally altered to greisen, an aggregate of white mica and quartz. The greisen contains a stockwork, as much as 14 feet wide, of quartz veins and irregular blebs of white quartz. Molybdenite occurs as bunches or rosettes and as disseminated crystals in both the quartz veins and blebs and in the greisen. Pyrite and traces of chalcopyrite are associated with the molybdenite.

The larger and more persistent quartz veins strike northeast. The southeast margin of the greisen is sharp against the granite whereas



ASSAY DATA

Sample	Sample length (feet)	Percent	
		MoS_2	Cu
1	14.5	0.08	0.02
2	6.7		
3	7.0	.55	.02
4	2.4	.07	.02
5	3.5		
6	2.4		
7	5.0	.07	.02
8	4.0		
9	8.4	.08	.02
10	1.9	.19	.02
11	1.2		
12	3.0		

Base map and geology by S. C. Creasey and E. A. Scholz August, 1943

FIGURE 13.—Geologic map of Monaghan prospect, Beaverhead County, Mont., showing location of assayed samples.

the northeastern margin intertongues with it (fig. 13). These features indicate a strong northeast structural control for the greisen and veins.

Twelve channel samples were collected (fig. 13), but, because samples 1–2, 4–6, 7–8, and 10–12 were combined, only six assays were made. Samples 1, 2, 3, 10, 11, and 12 were collected from areas that had the most molybdenite. Samples 4, 5, 6, 7, 8, and 9 were collected from areas that are representative of the bulk of the exposed mineralized rock. The samples indicate that the grade of the deposit is between 0.08 and 0.12 percent MoS_2 and 0.02 percent Cu.

CASCADE COUNTY

BIG BEN DEPOSIT

The Big Ben molybdenite deposit is in the Neihart mining district in sec. 21, T. 14 N., R. 8 E., about 4½ miles northeast of the town of Neihart, Mont., on the north slope of Poverty Ridge between Snow and Carpenter creeks. A graded road about 2½ miles long connects the property to U.S. Highway 89, which passes through Neihart.

The elevation of the deposit is about 6,000 feet, and the relief is moderate. Lodgepole pines cover the area so thickly that in many places it is impossible to walk without cutting a trail. Outcrops are scarce, and all but a few of the exposures around the deposit are in trenches, pits, and adits. The thickness of the overburden ranges from 3 to 7 feet.

During September and October 1943, Creasey and E. A. Scholz mapped the underground workings and trenches and logged the cores from diamond-drill holes made by the U.S. Bureau of Mines. A generalized surface map was compiled on a topographic base prepared jointly by the Geological Survey and Bureau of Mines (pl. 5). Poor exposures prevented the preparation of a detailed geologic map.

The Big Ben molybdenite prospect was owned in 1943 by Frank Mansikka, Neihart. The property consisted of eight unpatented claims. The development work consisted of two adits, 285 and 300 feet long, and about 500 feet of surface trenches. Frank Mansikka drove the adits, and the Federal Mining and Smelting Co. dug the trenches in 1938 when they held an option on the property.

GEOLOGY

Weed's (1899) folio on the Little Belt Mountains contains a brief description and map of the geology around the Neihart area and was followed by a comprehensive report on the geology and mineral resources (Weed, 1900) and petrographic character of the igneous rocks (Pirsson, 1900). Schafer (1935) has more recently described the geology and ore deposits of the Neihart mining district.

The most abundant rocks in the Neihart district are Precambrian red and gray or white feldspathic gneiss, black mica schist, and amphibolite. Around the Big Ben deposit, biotite schist and biotite gneiss predominate. South of the Big Ben deposit, the gneiss and schist are intruded by a large mass of partly gneissoid Pinto Diorite of Weed (1899). This name was given to the rock by Weed (1899, p. 373) because of the spotted appearance produced by large ovoid and closely spaced feldspar aggregates as large as 1 inch in diameter; green amphibole fills the interspaces. Pirsson (1900, p. 489) reports that the bulk of the feldspar is andesine and the amphibole is common hornblende. At the Big Ben deposit (pl. 5), small dikes and irregular masses of Pinto Diorite intrude the gneiss and schist. Schafer (1935, p. 9) states that the Pinto Diorite is older than the Belt Series of Precambrian age.

Dikes of light to yellow-brown porphyritic rock intrude the Precambrian gneiss and schist as well as the Pinto Diorite. Weed (1899) named this rock the Neihart Porphyry, but Schafer (1935, p. 11) renamed it the Snow Creek Porphyry, a more acceptable term because the Neihart Quartzite is a recognized formation of the Belt Series in this region (Wilmarth, 1938, p. 1473). The Snow Creek Porphyry contains scattered irregular-shaped quartz phenocrysts as large as 3 mm in diameter and a few small orthoclase phenocrysts embedded in a white or light-gray felsitic groundmass. Small inclusions of Pinto Diorite, gneiss, and schist are common. The Snow Creek Porphyry is the prevailing rock in the lower adit and in the cores of all the drill holes except for hole 4, where it constitutes only about a quarter of the rock. Schafer (1935, pl. 2) suggested that the Snow Creek Porphyry is probably early Tertiary in age.

Two well-defined granite porphyry dikes intrude all the other rocks at the Big Ben deposit, and Schafer (1935, p. 11) called this rock the Carpenter Creek Porphyry, as had Weed (1900, p. 376); Pirsson (1900, p. 501), however, referred to the rocks as the Carpenter Creek type of granite porphyry. The Carpenter Creek Porphyry is composed of closely spaced orthoclase phenocrysts surrounded by smaller crystals of white or light-green plagioclase, quartz, and small amounts of biotite and hornblende. The orthoclase commonly occurs as Carlsbad twins. Locally, the porphyry has a fine-grained black border phase.

ORE DEPOSIT

Molybdenite and pyrite occur in quartz veins that have filled numerous fractures. To a minor extent, these sulfide minerals are disseminated in the rocks between quartz veins. The ore deposit has the appearance of a stockwork because the mineralized zone is elliptical in plan and the walls are steep or vertical. The attitudes of the quartz veinlets are extremely variable; some veinlets are slightly offset by others. The most strongly mineralized fractures trend N. 20° E. to N. 85° E., and dip steeply north and south. This northeasterly trend is roughly parallel to the long dimension of the mineralized zone.

Locally the country rock is intensely altered. The Snow Creek Porphyry and, to a lesser extent, the Pinto Diorite are silicified, the silicification in places obliterating the original textures of the Snow Creek Porphyry. Locally, silicified porphyry grades into quartz veins. In general, the higher grade molybdenite ore is associated with quartz veins and with silicified zones in the country rock.

The Pinto Diorite, the gneiss, and, locally, the Snow Creek Porphyry are altered to clay in zones that contain less molybdenite than the silicified zones. Most of the molybdenite in the clay zones is in quartz veinlets, and only a minor amount is disseminated in the rock.

The Snow Creek Porphyry and Pinto Diorite contain the highest grade molybdenite, whereas the Carpenter Creek Porphyry is only slightly altered and mineralized. Perhaps the brittle character of the porphyry and silicified Pinto Diorite caused favorable fractured host rocks for mineralizing solutions.

Minor amounts of galena, sphalerite, chalcopyrite, fluorite, and oxidized copper minerals were observed in the adits and cores. The galena and sphalerite commonly occur in open cavities lined with minute quartz crystals.

The Bureau of Mines investigated the Big Ben deposit from August 11, 1943, to October 25, 1943; the work included diamond core drilling, channel sampling of underground exposures, metallurgical testing, and surveying (Herdlick, 1949). Four drill holes totalling 1,385 feet penetrated a prism 520 feet long, 270 feet wide, and 365 feet deep. Weighted averages of the core samples ranged from 0.19 to 0.26 percent MoS_2. Channel samples over a length of 295 feet in the lower adit ranged from 0.01 to 0.32 percent MoS_2 and averaged 0.21 percent (Herdlick, p. 2).

Locations of the drill holes and sections showing grade of the cores and kind of rock penetrated are shown on plate 5. Detailed logs of the cores prepared by J. J. Collins, Creasey, and E. A. Scholz of the Geological Survey are given in the report by Herdlick (1949, p. 14–18). Details of the geology of the adits and trenches and grade of MoS_2 for the lower adit also are shown on plate 5.

Only a trace of molybdenite was found in the surface trenches, but ferrimolybdite occurs in most of them and from the surface to a vertical depth of 35 feet in hole 4 and to 40 feet in hole 5. Limonite is abundant in the trenches and may mask ferrimolybdite as well as molybdenite. Limonite observed in cores of all holes at comparable depths indicates that oxidation extends to a depth of 35 to 40 feet. Except for hole 5, the MoS_2 content of the first 7 (hole 1) to 30 feet (hole 3) of core is appreciably less than that of the remainder of the core—a fact suggesting that some oxidation of molybdenum took place in the oxidized zone. Trenches containing only a trace of molybdenite above the mineralized rock penetrated by drilling also suggest that oxidation has occurred near the surface.

Determining the size and shape of the mineralized zone is difficult because of the poor surface exposures and the possibility of surface oxidation and leaching of molybdenum. The information available does indicate, however, that the shape of the mineralized zone is elliptical in plan, the long axis trending northeast (pl. 5). The depth is not known, but hole 3, drilled to a vertical depth of 350 feet, bottomed in mineralized rock. The mineralized zone is presumed to have nearly vertical boundaries because most of the larger mineralized fractures dip at high angles.

The limits of the mineralized rock assaying more than 0.25 percent MoS_2 were determined approximately and projected to the surface (pl. 5). A larger area of mineralized rock having a cutoff of 0.15 percent MoS_2, based on drill-hole data, is also shown on plate 5.

The weighted average of 340 feet of core from hole 1 is 0.197 percent MoS_2; 416 feet from hole 3, 0.265 percent MoS_2; and 271 feet from hole 5, 0.188 percent MoS_2 (Herdlick, 1949, p. 8–11). The weighted average of all holes in 0.21 percent MoS_2, the same as the weighted average of the grade of the lower adit. All available information indicates that the grade of the deposit is about 0.20 percent MoS_2.

HEGENER PROSPECT

The Hegener molybdenite prospect is in the Neihart mining district, about 3¼ miles airline northeast of Neihart, Mont., on Hegener Creek, a north tributary to Carpenter Creek. A graded road connects the prospect in sec. 16, T. 14 N., R. 8 E. (unsurveyed), to Montana Highway 6, which passes through Neihart. Creasy, accompanied by John Hegener, owner, made a brief examination of the prospect in October 1943. Numerous shallow trenches and pits, at least nine adits, some crosscuts, and one shaft (reported to be 115 feet deep) have been excavated at various times. In 1943, the shaft and part of the underground workings were inaccessible. In 1927 or 1928, the Silver Dyke Mining Co. held a lease on the property and drilled 23 churn-drill holes. No assays were made for molybdenum, but John Hegener (oral commun., 1943) reported that drill hole 7 (fig. 14) penetrated 40 feet of molybdenite-bearing rock and hole 12 contained the second best grade of molybdenite. Most of the recorded production of $25,000 to $30,000 worth of ore was during the early years of development in the district (Schafer, 1935, p. 53). Silver, gold, zinc, and lead were the chief metals mined.

Outcrops are scarce, and timber is so thick that only a sketch map of the surface was made. Most of the trenches were examined, and two short adits, *A* and *B* (fig. 14), were sampled because they contained the most molybdenite observed.

Precambrian gneiss, Pinto Diorite of Weed (1899), Snow Creek Porphyry, and granite porphyry were observed, but only two mappable units were distinguished on figure 14—predominantly granite porphyry and predominantly gneiss and quartz porphyry. Traces of molybdenite were found in widely separated locations: In adits *A* and *B* (fig. 14) it is in feldspar-quartz gneiss, to the northwest of the area shown in figure 14 it was observed in quartz porphyry, and it also

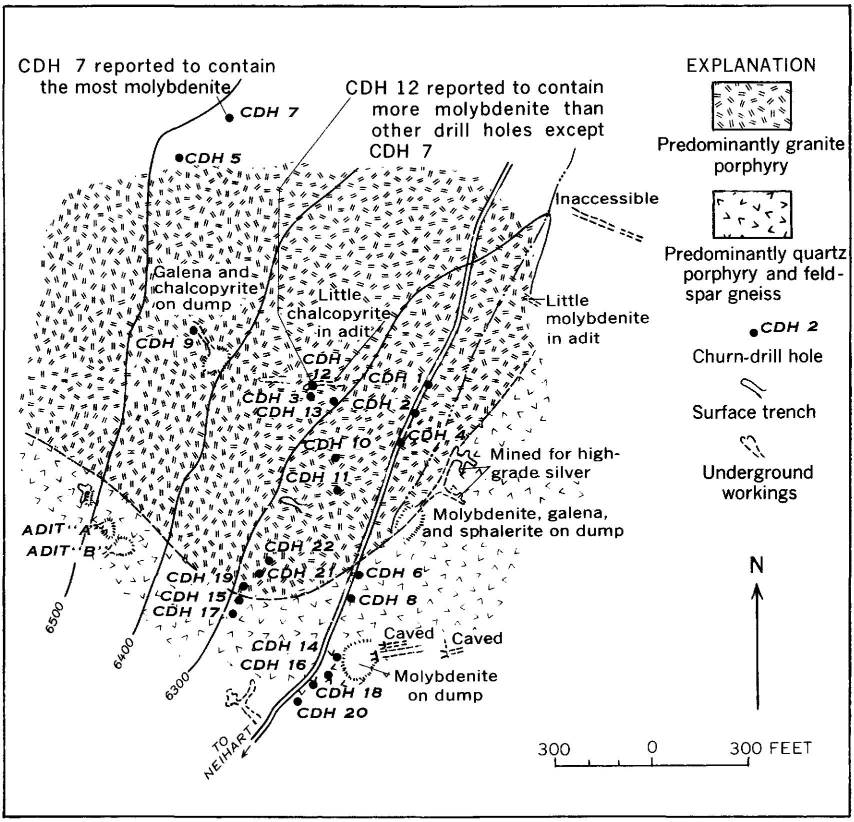


Figure 14.—Sketch map of the Hegener molybdenite prospect, near Neihart, Cascade County, Mont.

occurs in the granite porphyry in the adit in the northeast part of the area shown on the figure 14.

Galena, chalcopyrite, sphalerite, and unidentified silver minerals were observed at various places on the property; some of these localities are shown on figure 14.

A channel sample 11.3 feet long from the face and side of adit *A* contained 0.10 percent MoS_2, and a channel sample 13 feet long from the face and side of adit *B* contained 0.15 percent MoS_2.

PARK COUNTY

EMIGRANT GULCH DEPOSIT

The Emigrant Gulch deposit is on the east side of Emigrant Gulch in sec. 6, T. 7 S., R. 9 E., about 30 miles south of Livingston, Mont. In August 1943 when Anderson and M. W. Cox made a brief examination of the property, a graveled road from Chico led to within 4 miles of the property, and an old wagon road, badly in need of repair, provided a trail to the prospect. The elevation is about 7,500 feet at the portal of the lower adit.

Six unpatented claims were held by location by E. J. Wemlinger and W. L. Kearns, Lynwood, Calif. The most extensive mine working is an adit 700 feet long driven in a northeasterly direction. In this adit 340 feet from the portal, a 50-foot drift follows a southeast-trending zone of molybdenite-bearing rock. In 1943 an upper adit 250 feet vertically above the lower adit was caved at the portal. Two open cuts had been dug on the property, which at one time included a small mill for concentrating molybdenite. The date of operation and information on production are not known, and the mill had been removed by 1943.

W. L. Kearns furnished maps and assay information. Bad air in the lower adit prohibited examination of the ore zone there.

Bedrock exposures are very poor because the slopes of the gulch are steep and covered by talus. The exposed rocks are coarsely porphyritic and dense flow-banded rhyolite, part of the acid porphyrite mapped by Iddings and Weed (1894). The only outcrop of mineralized rock was found at the portal of the upper adit where flow-banded rhyolite, brecciated and sericitized, contains narrow seams of molybdenite. Samples of molybdenite-bearing rock on the dumps of both adits indicate that the rhyolite was brecciated and the molybdenite was introduced along the openings between fragments; however, the surface outcrops are far too few to reveal the areal extent of the breccia zone.

According to W. L. Kearns (written commun., 1943), when the last 30 feet of the eastward extension of the drift was driven, every fifth car of muck was dumped on a turn sheet "quartered down to what a fifty pound flour sack would hold, sometimes a little more. This was crushed through a hand crusher and cut with a Jones splitter to a reasonable sample." Thirteen assay returns ranged from 0.39 to 0.70 percent MoS_2 and averaged 0.50 percent MoS_2. In addition, Kearns cut 10 channel samples in the 85-foot-wide mineralized zone along the drift and crosscut, and these averaged 0.60 percent MoS_2.

The Survey party collected a grab sample of the lower adit, which assayed 0.49 percent MoS_2.

In the lower adit, mineralized rock is exposed for a distance of 50 feet southwest of the drift, and grades into unmineralized rock (Kearns, written commun., 1943). Molybdenite also is present for 33 feet along the adit, but no assay returns are available to indicate the grade. A stub drift to the northwest in the mineralized zone ends in "birds eye porphyry, though containing moly. in the cracks" (Kearns, written commun., 1943).

The information available indicates that 80 to 90 feet of mineralized rock is exposed along the adit and for about 50 feet in the drift. A southeast extension of the mineralized zone seems probable.

NEVADA

ELKO COUNTY

ROBINETTE MOLYBDENUM-TUNGSTEN PROSPECT, by S. W. Hobbs

The Robinette property is in northern Elko County in secs. 9 and 10, T. 46 N., R. 61 E., at the east base of Elk Mountain, 20 miles due west from the town of Contact, Nev. S.W. Hobbs made a brief examination of the deposit in July 1943. He reached the deposit by going west on a road that connected with U.S. Highway 93 approximately 13 miles south of Contact. This road led to O'Neil's Ranch Post Office 31.5 miles from the highway, and a narrow and rough dirt road led northwest for 8.4 miles to the deposit.

The property consisted of 11 unpatented claims held by location by John Robinette, Boise, Idaho. The deposit has been prospected by several open cuts and trenches and by six adits. One adit is 65 feet long, another is 50, and the others are 25 or less. Earlier prospecting for gold is indicated by completely caved adits and a filled shaft at the portal of the 50-foot-long adit.

A series of pure and impure limestone beds has been folded and intruded by granite. Lenses of tactite (garnet rock) occur at the contact between granite in the footwall and limestone in the hanging wall. The largest lens on the June 1 and 3 claims and the Dexter 1 claim is 2,000 feet long and as much as 300 feet wide, and trends N. 30° E.

Small specks of molybdenite occur throughout the tactite, but appreciable amounts were observed only near the 50-foot adit in the east-central part of the largest lens. The molybdenite occurs mainly in narrow veins that trend virtually at right angles to the granite contact. The veins, as much as 2 inches wide, consist of abundant quartz containing some garnet, iron and copper sulfide minerals, and molybdenite. Some of the veins feather out into tactite that contains disseminated molybdenite. In the face of the 50-foot adit, the molybdenite-bearing veins are 1 to 2 feet apart. In surface exposures and in the short adits above the 50-foot adit, molybdenite is less abundant, and none was observed in comparable quantities elsewhere on the property. The average grade for any appreciable volume of molybdenite-bearing tactite here is estimated at 0.1 to 0.2 percent MoS_2.

Small particles of scheelite are sparsely disseminated throughout the tactite. The greatest scheelite concentrations were found near the 50-foot adit and about 1,000 feet to the northeast in the valley of the creek near two cabins. The best scheelite-bearing tactite from the 50-foot adit and the top of the shaft was estimated to contain about 0.25 percent WO_3. Most of the scheelite-bearing tactite, however, contains less WO_3.

ESMERALDA COUNTY

SORENSEN PROSPECT

The Sorensen molybdenite prospect is in sec. 2, T. 7 S., R. 39 E., in Alum Gulch, 5 to 10 miles north of Sand Springs in Death Valley, Calif. M. W. Cox and Anderson made a brief examination of the property in September 1943. A road from Sand Springs through Tule Canyon to the deposit was impassable in 1943, but the property was reached from Lida, Nev., 16 miles to the northeast. At Pigeon Springs, 10 miles west of Lida, a road to O'Connell's Camp was followed southward for 2½ miles to another road that was followed eastward for 3½ miles to the north rim of Alum Gulch.

The topography of Alum Gulch is typically badlands; the walls are steep and rugged. The north rim is gently rolling, and the general rim elevation is about 7,500 feet. Elevations drop about 1,000 feet to the south to Tule Canyon where the Freeport Sulphur Co. had a camp during an earlier exploration program.

The main part of Alum Gulch was covered by 10 unpatented claims held by location by R. B. Sorensen, Tonopah, Nev. To the southeast, two claims were held by location by Mrs. R. B. Sorensen, Arthur Sorensen, a Mrs. O'Connell, and H. P. Berg.

The main part of Alum Gulch contained several short adits and opencuts, but in 1943 all were caved. According to R. B. Sorensen (oral commun., 1943), the Freeport Sulphur Co. drilled two diamond-drill holes north of the gulch and near the northwest corner of the deposit. In the southeastern claims, an adit 750 feet long was caved about 200 feet from the portal in 1943.

Limestone beds were intruded by an alaskite stock, about 2 miles long and ½ to 1 mile wide. The deeper ravines expose stockworks of quartz veins containing fresh pyrite and molybdenite. The associated alaskite is rich in sericite near the top of Alum Gulch; acid derived from oxidation of the sulfide minerals intensely altered the alaskite to clay minerals containing soluble sulfates. Clay coated with efflorescent sulfates appears locally in the lower ravines, undoubtedly washed down from the leached rocks above. Locally, blue ilsemannite ($Mo_3O_8 \cdot nH_2O$?) coats the rocks, and molybdenite may be found nearby.

In July 1944, Creasey collected three chip samples of the molybdenite-bearing alaskite from the bottoms of the ravines where unaltered pyrite and molybdenite are well exposed. These samples contained 0.02 percent MoS_2, 0.05 percent MoS_2, and 0.13 percent MoS_2; a low-grade deposit is thus indicated.

HUMBOLDT COUNTY

DESERT VIEW COPPER AND MOLYBDENUM PROSPECT

The Desert View copper and molybdenum prospect is in the south end of the Pine Forest Mountains, north of the Black Rock Desert in sec. 10, T. 42 N., R. 28 E., about 100 miles northwest of Winnemucca, Nev. In August 1943, M. W. Cox and Anderson briefly examined the prospect, which is accessible from Winnemucca by an oiled and gravel road to Leonard Creek Ranch and then by dirt road north of the ranch. The prospect is 2 miles from the dirt road at an elevation of 6,900 feet, 1,200 feet higher than the road. The topography is rugged, and the canyons deep. The prospect is on the west slope of a northeast-trending ridge.

John Tucker and Frank Roberts, Caldwell, Idaho, in 1943 held two claims, Desert View I and Desert View II, by location and had excavated an opencut and a discovery pit 12 feet deep.

The prevailing country rock is porphyritic granodiorite but dark-gray, finely micaceous schist or phyllite is exposed at the west end of the claims. Quartz veins cut the granodiorite; they strike northeast and dip steeply north. Vein exposures range from 20 to 115 feet in length and from several inches to 10 feet in width. Outcrops of the quartz veins are not continuous; only the wider parts are well exposed, and these appear to pinch and swell along the strike.

Molybdenite, chalcopyrite, and pyrite occur in the wider parts of the quartz veins. Chalcopyrite and pyrite are oxidized and leached at the surface, but molybdenite, associated with some ferrimolybdite, persists locally at the surface. A few molds in the quartz having the shape of molybdenite crystals indicate some leaching of molybdenite. In the opencut and discovery pit, molybdenite, in closely spaced crystals as much as one-fourth inch in diameter, forms nests in the quartz. Irregular bunches of chalcopyrite and pyrite, as much as 1½ inches in diameter, are scattered through the quartz and malachite and azurite are present at and near the surface.

The grade of the prospect was difficult to determine because the sulfide minerals are distributed erratically in the quartz. Two samples were collected for assay, both from the discovery pit. One, a chip sample 4 feet long collected at a depth of 10.6 feet from the surface, assayed 0.40 percent Cu and 0.07 percent MoS_2. The second, a grab sample from the muck at the bottom of the pit, represents the vein material containing nests of sulfide minerals; it assayed 0.43 percent Cu and 0.11 percent MoS_2.

The limitation of sulfide minerals to the wider parts of the quartz veins indicates that the molybdenite-bearing quartz is of local extent and that only small tonnages of fairly low-grade molybdenite ore can be anticipated.

NYE COUNTY

HALL MOLYBDENUM DEPOSIT

The Hall molybdenum deposit is in the San Antonio Mountains in sec. 8, T. 5 N., R. 42 E., about 20 miles north of Tonopah, Nev. Except for 2 miles of paved highway west of Tonopah, the road north to the property in 1943 was a graded gravel road in rather poor condition. Anderson and M. W. Cox prepared a topographic and geologic map (pl. 6) and examined the geologic features of the underground working in September 1943. Creasey visited the property in July 1944 to obtain additional information on the underground workings.

The climate is arid and rock exposures are excellent except in the steep slopes where slide rock locally forms a thick mantle. The collar of shaft 1 is near the west margin of the San Antonio Mountains at an altitude of 5,900 feet, and the highest peak in the adjacent hills has an altitude of 6,524 feet. The drainage is mostly west.

OWNERSHIP AND HISTORY

In 1943 the property was owned by Lee F. Hand, W. C. Rigg, and C. H. Hall, and was divided into two groups of unpatented claims, the Chicago group and the Treasure Hill group. Six claims were included in the Chicago group, which covers the known molybdenite-bearing rocks. The Treasure Hill group included 23 or more claims located north and east of the Chicago group.

In the 1920's, when the property was prospected for silver, shaft 1 was sunk, and the first level (155) was driven. The property was then known as the Liberty mine. (See Ferguson and Muller, 1949, pl. 1.) From 1935 to 1938, the U.S. Vanadium Corp., under the direction of Clarence H. Hall, drove about 3,500 feet of underground workings, all from shaft 1. The work included deepening the shaft to 310 feet and driving a long southeast drift with crosscuts (pl. 6, 280 level). The U.S. Vanadium Corp. relinquished its option, and subsequently the property has been known as the Hall molybdenum property. The Freeport Sulphur Co. studied and sampled the workings in 1940, and the U.S. Bureau of Mines check-sampled them during the summer of 1942 and spring of 1943.

Desert Silver, Inc., as agents for the Metals Reserve Co., explored and sampled the deposit from June to November 1943. Two shafts were sunk, two diamond-drill holes drilled, and one crosscut driven from the main shaft. The purpose of this work was to determine the depth of oxidation and the width of the mineralized zone to the southeast above the lower level. The results of this work have been summarized by Michell (1945).

The underground workings opened between the initial discovery and 1943 are on three claims: Chicago No. 1, Chicago Extension No. 1, and Chicago Extension No. 2. The workings consist of an inclined shaft (65° N.) and two connecting levels. The shaft (shaft 1, pl. 6) is 310 feet deep. The first or 155 level comprises (1) a north-trending 130-foot crosscut in the mineralized zone and (2) a south crosscut 165 feet long and a west drift 85 feet long in barren rock. The second or 280 level consists of a drift 1,250 feet long and six main crosscuts to the north (pl. 6).

Shaft 2 (180 feet deep) has a north and south crosscut 175 feet long at 110 feet below the collar and a north crosscut at the bottom 40 feet long (pl. 6, section *I–I'*). Shaft 3, 150 feet deep, has a north crosscut at the bottom 65 feet long (pl. 6, section *K–K'*). Diamond-drill hole 1 is 302 feet long, and diamond-drill hole 2 is 52 feet long (pl. 6, section *J–J'*).

GEOLOGY

Little is known about the geology of the San Antonio Moutains. Ferguson and Muller (1949, p. 51) state that the northwest end of the range consists largely of interbedded chert, tuffaceous breccia, greenstone, and a little limestone and that these rocks are lithologically similar to the dominantly volcanic upper part of the Permian sequence in the Toyabe Range. Except for limestone, none of these rocks were recognized in the small area shown on plate 6.

The oldest rocks in and near the Hall molybdenum property consist of sericitic quartzite and quartz-mica schist. The quartzite is limited to the northern part of the mapped area, and the mica schist is limited to the southern part (pl. 6). Presumably both rocks belong to the same general sequence because they have somewhat parallel foliation and the same unconformable relationship to younger limestone. The mica schist contains the bulk of the known molybdenite-mineralized rock. The schist is strongly foliated, and contains muscovite as the dominant mica; biotite is accessory. The foliation in general strikes northwest and dips steeply northeast. In the southwest corner of the mapped area, however, the foliation dips southwest.

Dark-gray massive limestone unconformably overlies the schist and quartzite. The limestone is appreciably silicified, and local chert beds are present. Dense gray quartz has replaced much of the limestone, and bedding planes are difficult to recognize; in only a few exposures could their attitude be measured (pl. 6).

The mica schist and limestone are intruded by an alaskite stock that is roughly circular in plan and approximately 2,500 feet in diameter. The westward extent of the alaskite under the alluvium is not known. In the alaskite, which ranges in texture from aplitic to porphyritic, orthoclase phenocrysts are embedded in a medium-grained groundmass of orthoclase, milky plagioclase, quartz, and rare muscovite. Locally, a little biotite is present.

Many narrow quartz veins 1 to 4 inches wide are present in the alaskite, mica schist, and limestone. The alaskite locally contains at least 50 percent by volume of these veins. In some places in the alaskite the veins are oriented completely at random; in other places, the majority of the veins have a persistent strike and dip and the remainder a random orientation. The attitudes of veins with persistent strikes and dips have been plotted on plate 6. The veins with persistent attitude are more common in the eastern part of the area covered by plate 6; some strike into the alaskite contact. The distribution of the quartz vein-alaskite rock indicates that this facies forms a hood over the stock conformable to the contact (pl. 6, sec. *F–F′*). At the southwestern margin of the alaskite stock, only a small amount of quartz vein-alaskite is exposed on the west side of the north-trending fault. This, the upthrown side of the fault, brings originally deeper levels up to higher altitudes, and suggests that the quartz vein-alaskite facies probably has no deep vertical extensions.

The mica schist bordering the alaskite also contains numerous quartz veins, in general parallel to the foliation. Quartz veins in the limestone are more erratically distributed, and much of the limestone even at the contact with alaskite is almost free of veins; however, along

761-341 O-65-6

the eastern margin and in the narrow roof pendant across the northern half of the stock, numerous quartz veins are randomly oriented in the limestone.

The contacts between quartz-veined rocks and non-quartz-bearing rocks are transitional, and scattered quartz veins are found in the areas mapped as quartz free. In general, the rocks mapped as quartz-vein bearing contain 30 percent or more quartz veins.

Plate 6 distinguishes several large masses of pure quartz or quartz containing only traces of alaskite or schist. In the quartz vein-alaskite facies, particularly in the northern part of the stock, many masses of quartz are too small to plot. These masses of quartz apparently are replacements because they grade into the host rocks; they do not extend to the 280 level, which is below their outcrop. Some of the masses of quartz are brecciated and cemented by quartz and, locally, by iron oxides. The origin of all the quartz-breccia masses is not evident, but several clearly are spatially related to faults. If these masses are all fault breccias, many of the faults have displacement too small to be recognized by offset contacts.

A dikelike mass of rhyolite tuff in the south-central part of the map area consists of fragments of quartz, feldspar and volcanic ash; the latter two constituents locally altered to sericite. The western end of this mass dips 15° N. and at a marked angle to the bedding of the limestone. To the east, the strike changes appreciably and the dip is near vertical. Where the dike is widest, quartz veins that parallel its west margin were mineralized with sulfides, now altered to limonite.

Andesite dikes cut the quartz-veined schist. They are poorly exposed at the surface, the widest exposures being about 20 feet, but in the underground workings, dike widths of as much as 50 feet are exposed. The rock is greenish gray, and the texture porphyritic, most of the original phenocrysts being altered to sericite or chlorite. A few plagioclase phenocrysts were recognized. On the 280 level, where the andesite is best exposed, the intrusive contacts with the schist are parallel to the schistosity, with but one exception. Several of the contacts with schist are faults; the small width of the exposure of andesite in the 222 crosscut (pl. 6) is due to a fault that has segmented the dike. Whether one or two dikes are exposed on the 280 level is not certain, because the andesite at the south end of the 210 drift may be the offset part of the dike exposed in the 220 drift. The andesite was cored in two places in the diamond-drill hole (pl. 6, section *J–J′*), and two explanations are possible: (1) there are several dikes, each parallel to the foliation, or (2) there is one dike that has been faulted into segments as illustrated in section *J–J′*. This latter interpretation is favored because of the visible faults on the 280 level. However, projection of the andesite dike near the collar of the diamond drill hole to the 280 level would require a fault-produced horizontal offset in the plane of section *J–J′* of about 200 feet, if only one dike exists. If there are two dikes, as suggested by section *J–J′*, or if a single dike crosscuts the foliation, such a large fault displacement is not necessary to explain the spatial relations of the two exposures of andesite in addition to the two intersections in the diamond-drill hole.

The age of the rhyolite and andesite dikes is unknown. Presumably the dikes are related to the volcanic rocks that make up the major part of the San Antonio Mountains and that are exposed only a short distance to the east of the mapped area (Ferguson and Muller, 1949, p. 7, 49).

STRUCTURE

The distribution of the limestone in relation to the measured attitudes of bedding suggests an anticline that plunges northeast and that may have been caused by the doming action by the stock at the time of intrusion.

Numerous faults of small displacement were observed underground, but only those that displaced contacts could be plotted with assurance on the geologic maps. Two sets of faults occur, one striking northwest, the other northeast. One additional fault strikes north. All faults on which the direction of relative movement was determined were high-angle reverse. Four of these faults are younger than the quartz veining in the alaskite; the one fault that crosses the mineralized zone is younger than the introduction of molybdenite, for the east side of the ore zone is displaced southward (pl. 6). The andesite dikes were injected after the deposition of the molybdenite, and they have been broken by faults.

There is no evidence of more than one period of faulting. The evidence is clear, however, that the faults did not control molybdenite deposition and that in places they displaced the mineralized rocks.

MINERALIZATION

The molybdenite-bearing rocks occur along the southwest contact of the alaskite stock, and they are exposed only in the underground workings. At the surface, the rocks are deeply weathered, and the original sulfide minerals are oxidized. Molybdenite was found in two prospect cuts in the limestone to the east of the alaskite stock but only as small scattered crystals in widely spaced quartz veins; there was no indication that molybdenite is concentrated in possible economic quantities. Instead, low-grade molybdenite is probably widespread in the surrounding rocks, and it may have escaped oxidation in the dense, hard quartz veins.

In the mineralized zone exposed underground (pl. 6), molybdenite, pyrite, and a little chalcopyrite occur in quartz veins and pods that cut both the alaskite and schist. In the schist, the sulfide-bearing veins largely parallel the foliation planes. In the alaskite, the quartz veins that are parallel in strike and dip contain much less MoS_2 than those having a random orientation, as revealed by many assays. The molybdenite occurs largely along the margin of the quartz veins, whereas the pyrite is disseminated throughout the quartz. The mineralized zone has no sharp boundaries, and quartz veins are just as abundant away from the zone but their sulfide content decreases; assay limits will determine the width of minable ore. The outline of the ore body as determined by Michell (1945, p. 100) is shown on plate 6.

Mineralized schist inclusions are present in the andesite dike on the 221 crosscut (pl. 6), but otherwise the andesite is barren of quartz veins and molybdenite.

The ore body as outlined by Michell ranges from 50 to 90 feet in width on the 280 level; the zone progressively narrows upward and is only about 30 feet wide at the surface (Michell, 1945, p. 102).

Michell (1945) has given an excellent description of the oxidation of the mineralized zone, and the following statements are summarized from his report: The oxidized part of the mineralized zone contains abundant yellow-brown limonite and associated ferrimolybdite, and the contact between oxidized and unoxidized mineralized rock is sharp but irregular in detail. The surface at the bottom of the oxidized material rises upward toward the east with a gradient of about 9 percent, which is closely parallel to the gradient of the overlying dry wash. The mineralized zone east of the north-trending fault on the 280 level averages 0.34 percent MoS_2, and the oxidized parts of the same zone that were explored by Desert Silver, Inc., have about the same molybdenum content.

NEW MEXICO

DONA ANA COUNTY

BILLIE H. AND DONA LOGA PROSPECTS, by C. C. Albritton, Jr.

The Billie H. and Dona Loga prospects in sec. 28, T. 21 S., R. 4 E., are in the Organ mining district about 4½ miles east-northeast of Organ, N. Mex. The prospects were examined briefly by Albritton, Jr., and V. E. Nelson in February 1943. They were reached by following U.S. Highway 70 east from Organ for 4.9 miles and then a dirt road northward for 1.2 miles to the Billie H. prospect. The Dona Loga prospect is 0.6 mile west of the Billie H. prospect.

The Billie H. prospect consists of three claims held by location by W. P. Houser, Organ, N. Mex., and W. J. Hammer, Corpus Christi, Tex. The prospect was opened in January 1942, and by February 1943 a trench 24 feet long led to the portal of a west-trending adit 16 feet long. A small trench had been excavated near the northeast corner of the dump.

Quartz veins containing molybdenite and pyrite which have been oxidized to ferrimolybdite and limonite are exposed in the workings. The vein in the adit strikes N. 85° E. and dips 65° S., and is less than a foot wide. Clay gouge is present on the hanging wall and limonitic material on the footwall of this vein. Of two samples collected from the vein in the adit, one assayed 3.3 percent MoS_2 and the other 0.36 percent MoS_2. A sample of the limonitic material assayed 2.5 percent MoS_2. A quartz vein exposed for 10 feet in the trench northeast of the dump is 2 inches wide. The attitude of this vein is similar to that of the vein in the adit. Molybdenite and ferrimolybdite are present in the narrow quartz vein.

The Dona Loga prospect was originally opened up for lead and silver, and in 1943 was held by location by W. P. Houser and W. T. Hammer. An opencut and adit trending N. 65° E. and totaling 80 feet in length expose granite for the first 5 feet and quartz monzonite for the remaining distance to the face. The quartz monzonite in the first 30 feet of the adit is altered, but the rest is fresh except for irregular and discontinuous fractures containing films of molybdenite and pyrite. A fracture zone 3 feet wide, which trends N. 70° W. across the adit at the portal, contains siderite, limonite, and gouge. A sample of quartz monzonite collected near one of the mineralized fractures contains only a trace of MoS_2; practically all the molybdenite is concentrated in the fractures.

TAOS COUNTY

QUESTA (MOLY) MINE

The Questa (Moly) molybdenite mine is on the western slope of the Taos Range of the Sangre de Cristo Mountains in north-central New Mexico. It is in sec. 36, T. 29 N., R. 13 E., about 8 miles east of the town of Questa via New Mexico Highway 38. The mine workings underlie steep slopes north of the highway and the Red River. Altitude in the claim area ranges from about 8,000 to 10,000 feet.

The Molybdenum Corp. of America acquired the property in 1920. Since 1923, the corporation has been actively exploring and mining the deposit. The mine has been developed by more than 35 miles of underground workings in a vertical interval of 1,200 feet. The surface plant includes a mill having a daily capacity of 50 tons of mine ore. Production to January 1, 1956, was 18,095,000 pounds of molybdenite (Schilling, 1956).

At the Questa mine, Precambrian granitic rocks are overlain by Tertiary volcanic rocks. Late Tertiary granite intrudes all the older rocks. Structurally the mine is in a long east-west down-faulted zone that trends across the Taos range.

Molybdenite, the principal ore-bearing mineral in the Questa deposit, occurs mainly in veinlets and as fracture filling in a zone more than 1,000 feet thick along the contact of altered andesite and granite and also as disseminated grains chiefly in the andesite.

Anderson and Kupfer examined several prospects in the vicinity of the Questa mine in December 1942 and January 1943 at the request of the War Production Board. The more promising prospect adits were mapped, but the molybdenite content in these was too low to encourage exploration during World War II. During 1951–55, Schilling (1956) made a detailed study of the Questa mine and examined the same prospects covered by the Geological Survey study. Schilling's report includes a thorough geological study of the area surrounding the Questa mine, and he places the various molybdenite prospects in the proper perspective in relation to the Questa mine.

R. H. Carpenter (1960a) also made detailed geologic studies of the Questa mine, beginning in 1953. He points out that the molybdenite mineralization appears to have begun during a period of intense hydrothermal alteration and to have continued until this alteration had virtually ceased.

During operations under a DMEA contract at the mine in 1956–60, personnel of the U.S. Geological Survey and the U.S. Bureau of Mines made frequent examinations. Among these were D. N. Richter and R. U. King of the Geological Survey and D. E. Redman and T. M. Romslo of the Bureau of Mines.

The Molybdenum Corp. of America started intensive exploration of the deposit in 1954, and during the period 1957–60, the DMEA provided financial assistance. Results of the DMEA project and company plans for the future were reported in the Engineering and Mining Journal (1960):

> Molybdenum Corporation of America has announced discovery of an estimated 260-million ton molybdenum ore body in the Red River district of New Mexico, near Taos. The ore grades about 0.25% MoS_2.
>
> Drilling on the property from mid-1957 to mid-1960 at the Questa site was done with DMEA assistance, and resulted in the ore estimates. The corporation is reported to have discovered higher grades in other drilling, and, in the period from 1923 to 1956, Moly Corp. had mined individual high grade deposits which ranged from 3% to 8%. The property ceased production in 1956 when the high grade became scarce.
>
> A 50-ton mill is on the property, and, according to Marx Hirsch, president of the firm, can be expanded to handle 200 tpd. Hirsch said additional drilling and exploration must be carried on at the site before a decision on mining methods can be made.

NORTH CAROLINA

HALIFAX COUNTY

BOY SCOUT-JONES AND MOSS-RICHARDSON (DRYDEN) PROSPECTS, by G. H. Espenshade

The Boy Scout-Jones and Moss-Richardson (Dryden) molybdenum prospects are in Halifax County, northeastern North Carolina, 3 to 4 miles east of Hollister, and about 15 miles southeast of Littleton, the nearest rail point. The Boy Scout-Jones prospect is about 1¾ miles north of the Moss-Richardson prospect.

The Boy Scout-Jones deposits were discovered in 1936 and were sampled by the American Zinc Co. in 1939. A few years later, some shallow trenches were dug on mineralized outcrops here and at the Moss-Richardson deposits by Charles P. Mitchell. The Jones property was later acquired by Southgate Jones, who dug some trenches and shallow shafts.

The prospects were examined in August 1942 by A. F. Robertson of the Bureau of Mines. A. H. Koschmann and R. J. Wright of the Geological Survey made topographic and geologic maps of both prospects and took eight channel samples in March 1943 (Koschmann, 1943). Deposits at both prospects were explored by the Bureau of Mines by means of 28 diamond-drill holes during the period July 1943–January 1944 and by four deeper drill holes from July to December 1946; in addition, trenches were dug and channel samples taken (Robertson and others, 1947). C. J. Cohen of the Bureau of Mines made a reconnaissance geologic map of an area of about 5 square miles around the deposits in 1943. R. J. Wright and others of the Geological Survey logged the drill core during the 1943–44 exploration program.

GEOLOGY

The molybdenum deposits are molybdenite-bearing quartz veins that occur mainly in granite (pl. 7). Reconnaissance mapping by Cohen (written commun., 1943) has shown that the granite forms an oval-shaped body that extends nearly due north for about 2 miles and is ½ mile wide. The Moss-Richardson deposits are near the south end of the granite mass, and the Boy Scout-Jones deposits are at the north end. Siliceous chlorite schist and gneiss are exposed at the north end of the granite body and at other places in the vicinity. Exposures of granite and schist are scarce and are found mainly in streams and roadcuts. The area is near the eastern edge of the Piedmont province; Coastal Plain sands and gravels of Cretaceous age or younger are exposed in roadcuts about a mile east of the granite area.

The granite is commonly medium to coarse grained, tan to pink or red, and massive. The tan variety generally carries more quartz than the pink or red varieties; both muscovite and fine biotite are present, and pyrite, magnetite, and zircon are accessory minerals. The country rocks at the north end of the granite mass are fine-grained banded dark-green siliceous chlorite schist and gneiss alternating with dense dark-gray to black siliceous gneiss. Biotite occurs in the schist near the contact with the granite; considerable pyrite is disseminated through the schist. Thin dikes of dense pink to red aplite cut both the granite and schist. A diabase dike of probable Triassic age cuts the granite and the molybdenite-quartz vein at the Moss-Richardson prospect.

Foliation of the schistose rocks commonly strikes within a few degrees of north, and dips 60° or more to the west or east. The contact of the granite mass seems to conform in general to the schistose structure of the country rock but does transect the foliation at some places at the north end of the granite. Strong linear structures, which plunge 10° to 20° N., occur here in the schist (pl. 7). Diamond-drill cores have indicated that the north end of the granite body also plunges north, but at about 35° N. (pl. 7). No information is available about the structure of the granite intrusion at its south end.

MOLYBDENITE DEPOSITS

Molybdenite occurs most abundantly in very fine grained seams and irregular masses in quartz veins but also as disseminations and as joint coatings in granite, aplite, and schist adjacent to some of the larger quartz veins. Pyrite commonly occurs with molybdenite; chalcopyrite and fluorite are sparse accessory minerals. The quartz veins range in thickness from a fraction of an inch to about 15 feet, but are usually less than 10 feet thick; they occur in two generations: The older veins are composed of barren sugary quartz, and most strike northeast; the younger veins consist of glassy quartz, contain molybdenite and other sulfides, commonly strike northwest, and cut some of the barren quartz veins.

The sulfide minerals have been variably leached from the veins near the ground surface. The pyrite is commonly completely leached leaving limonite-stained cavities in the quartz. The molybdenite is partly altered to small clusters of yellow earthy powder that is probably ferrimolybdite. Leaching seems to be greatest on the uplands; little or none was noted on exposures in stream valleys.

BOY SCOUT-JONES PROSPECT

The molybdenum deposits at the Boy Scout-Jones prospect have been explored by 20 diamond-drill holes, a shaft 36 feet deep, and numerous shallow trenches.

Granite underlies the rounded hill where nearly all of the molybdenite-quartz veins occur. The contact between the granite and chloritic schist evidently is near the base of the northern nose of the granite hill; schist makes up most of the outcrops in the small stream that curves around the nose of the hill (pl. 7).

Much float of vein quartz, some of which carries molybdenite, occurs on the granite hill, but vein exposures are scarce. There seem to be three strong veins here, whose courses are marked by abundant quartz float. The principal vein, called the Jones vein (also known as the Crest or A vein), is marked by a persistent line of float that extends nearly 1,000 feet southeast from the contact of the schist and granite (pl. 7). The minor offsets and changes in strike of the train of quartz float suggest that the vein may be composed of several lenses; drill holes indicate that the vein dips 60° to 70° W. (Robertson and others, 1947). The Boy Scout vein is marked by quartz float extending northwestward for about 200 feet, it seems to dip 60° to 70° SW. The Ridge vein occurs in schist north of the contact; it trends northeast for about 300 feet and dips westward 65° to 75°.

Numerous thin molybdenite-quartz veins have been found in the granite by trenching and drilling near the base and on the slope of the hill just south of the contact of the granite and schist. These veins range in width from a fraction of an inch to about 5 feet; they cannot be traced on the surface by float or outcrop, nor can the vein intersections in the different drill holes be correlated. They probably form a network of veins that occurs near the contact of the granite and schist.

The north-plunging contact of the granite and schist appears to be an important structure that has controlled the localization of the molybdenite-quartz veins. All three major veins are near this contact. Shallow drill holes to depths of 100 to 200 feet beneath the projected contact cut more veins and better mineralized veins than did the two deep drill holes (*A* and *B*) that went to depths of 400 feet or more in granite beneath the contact with schist. (See drill hole sections and sample assays in Robertson and others, 1947.) Quartz veins also occur in schist in a zone about 300 feet wide and nearly half a mile long north of the granite body according to C. J. Cohen (written commun. 1943). Possibly the zone of molybdenite-bearing veins plunges northward along the contact and lies beneath the zone of quartz veins that crop out in the schist.

Analyses of eight surface samples taken from the principal veins by Koschmann (1943) ranged from 0.32 to 0.98 percent MoS_2. Analyses of the Bureau of Mines' drill-hole samples of the major veins had the same general value. (Robertson and others, 1947). Samples from the vein network and mineralized country rock ranged from a few hundredths to 0.1 to 0.2 percent MoS_2.

MOSS-RICHARDSON (DRYDEN) PROSPECT

The molybdenum deposits at the Moss-Richardson (Dryden) prospect have been explored by 12 diamond-drill holes and several shallow trenches (fig. 15).

The principal molybdenite-quartz vein here has a curving easterly trend and can be traced by float and outcrop for about 1,800 feet. The vein ranges in width from 5 to 15 feet and dips 65° to 75° N. over much of its length but seems to dip about 80° S. where it was cut by drill hole 2 near its east end (Robertson and others, 1947).

The vein is cut near its middle by a diabase dike about 20 feet wide, which trends N. 15° W. (fig. 15). The vein may have been displaced slightly by the dike because quartz float on the east side of the dike is about 30 feet north of float on the west side of the dike. This dike dips about 45° E. if the diabase that was cut adjacent to the quartz vein in drill hole 3 is part of it.

Another molybdenite-quartz vein lies about 650 feet north of the main vein. Its width ranges from about 1 to 2 feet, but its length is unknown. Several feet of diabase were also cut near this vein in drill hole 10.

The main vein may become thin and weakly mineralized at greater depth or die out altogether because no large veins were cut in the two deep drill holes (*A* and *C*) that went to depths of about 400 feet beneath the vein outcrops. If the vein does die out a few hundred feet beneath the surface, the structure of the deposit may be analogous to that of the Boy Scout-Jones deposit; that is, the contact of the granite and schist originally may have been not far above the present ground surface.

WASHINGTON

The Division of Mines and Geology of the State of Washington investigated the molybdenum occurrences in that State; Purdy (1954) has reported the results in a comprehensive descriptive report and inventory. A report by Creasey (1954) on the Starr molybdenum property and one by Cooper (1954) on the Western Molybdenum Co. mine based on U.S. Geological Survey work done in 1943 and 1944 are included in Purdy's bulletin. Properties examined by Anderson in the State include the Bi-Metallic Molybdenum deposit in Okanogan County, the Deer Trail Monitor property in Stevens County, and the Spokane Molybdenum prospect in Lincoln County. Purdy's (1954, p. 34) description of the Bi-metallic deposit is far more comprehensive than Anderson's report and includes data obtained by the U.S. Bureau of Mines in 1945. Purdy's report contains the same pertinent infor-

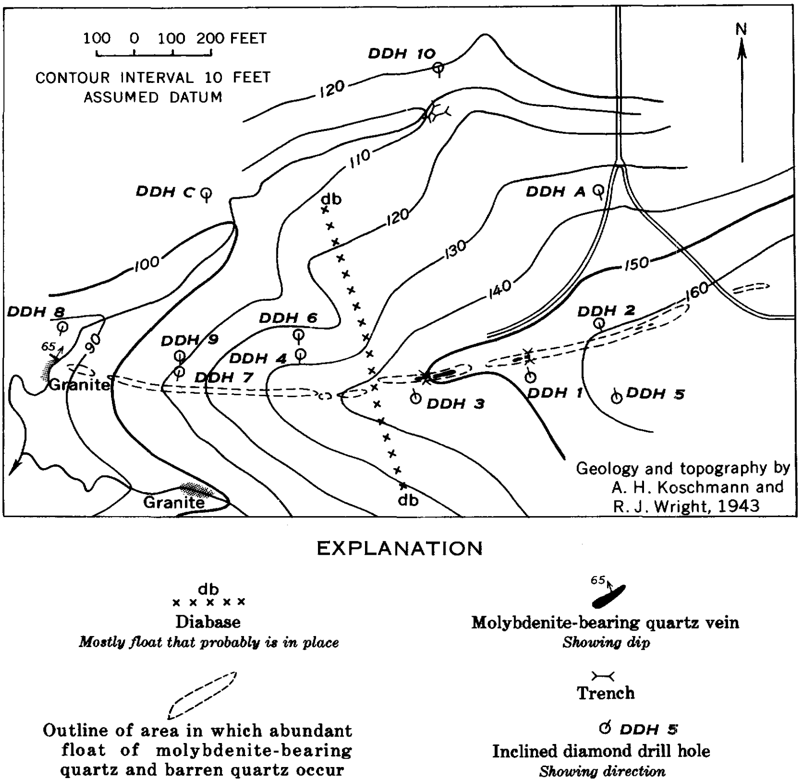


FIGURE 15.—Map of Moss-Richardson (Dryden) molybdenite prospect, Halifax County, N.C.

mation that Anderson obtained from the examination of the Deer Trail Monitor and Spokane Molybdenum properties.

Purdy also reports on several molybdenum occurrences in the Devils Canyon area, King County, that were examined by geologists of the Geological Survey and engineers of the Bureau of Mines on behalf of DMA in 1951 and the DMEA in 1954.

The locations of the properties in Washington examined by Federal geologists and engineers are shown on figure 1 of the present report, but the reader is referred to Purdy's (1954) study for descriptions of these properties.

WISCONSIN

By D. J. Fisher

FLORENCE COUNTY

PAYANT-CHRISSMAN PROSPECT

The Payant-Chrissman prospect is about 4 miles south of Aurora in the north-central part of sec. 33, T. 38 N., R. 19 E., in the southeast part of the county. The prospect was examined briefly in July 1943 by D. J. Fisher, U.S. Geological Survey. Six prospect pits on the farms of J. A. Payant and V. M. Chrissman along Fisher Creek were open for examination.

Low rounded outcrops of mica schist are separated by sand and glacial till, partly swampy in character. The foliation in the schist trends N. 45° E. to N. 85° E. and dips 25° to 60° SE. Masses of pegmatite intrude the mica schist; some of these are concordant to the foliation in the schist and others are discordant. Bands of quartz in the pegmatite locally extend into the schist as veins. Aplite occurs locally in the central parts of the pegmatite or extends as dikes into the schist.

Molybdenite flakes as much as an inch in diameter are limited largely to the pegmatite in which they occur chiefly in the quartz or in feldspar and mica spatially close to quartz. Molybdenite also occurs in narrow quartz veins. The small quantity and erratic distribution of the molybdenite observed in the pits and outcrops is typical of most molybdenite occurrences in pegmatite.

MARINETTE COUNTY

CAMP FIVE DEPOSIT

The Camp Five deposit is in the north-central part of sec. 18, T. 33 N., R. 20 E., about 4 miles northwest of the village of Middle Inlet Wis. The deposit was examined in July 1943 by D. J. Fisher and A. H. Chidester and in June 1960 by C. E. Dutton. The property was owned in 1943 by W. P. McCaskey and the Tobin heirs and in 1960 by the Moly-Four Corp. A brief geologic report by Fisher on the Camp Five deposit was placed in the Geological Survey's open file in June 1957. The following description was prepared from that report.

The deposit was originally opened up in 1937–38. In 1939 the Western Molybdenite Corp. obtained control and worked the deposit for 8 months during 1939–40. More than 6,000 pounds of concentrate containing 80 percent MoS_2 and 0.04 percent Cu was produced. Subsequently the mill equipment was sold. Before Dutton's visit in 1960, the Moly-Four Corp. dewatered one of the pits that had contained at least 20 feet of water when Fischer and Chidester examined the property in 1943.

The deposits are on the north flank of an east-trending ridge that rises about 100 feet above Middle Inlet (fig. 16). The south slope of the ridge is covered by thick vegetation, and no exploration was done south of the road shown on figure 16.

The country rock is a medium- to coarse-grained granite. East of pit 1 (fig. 16), it consists largely of quartz and albite and a minor amount of chlorite and muscovite. South of pit 4, about half of the

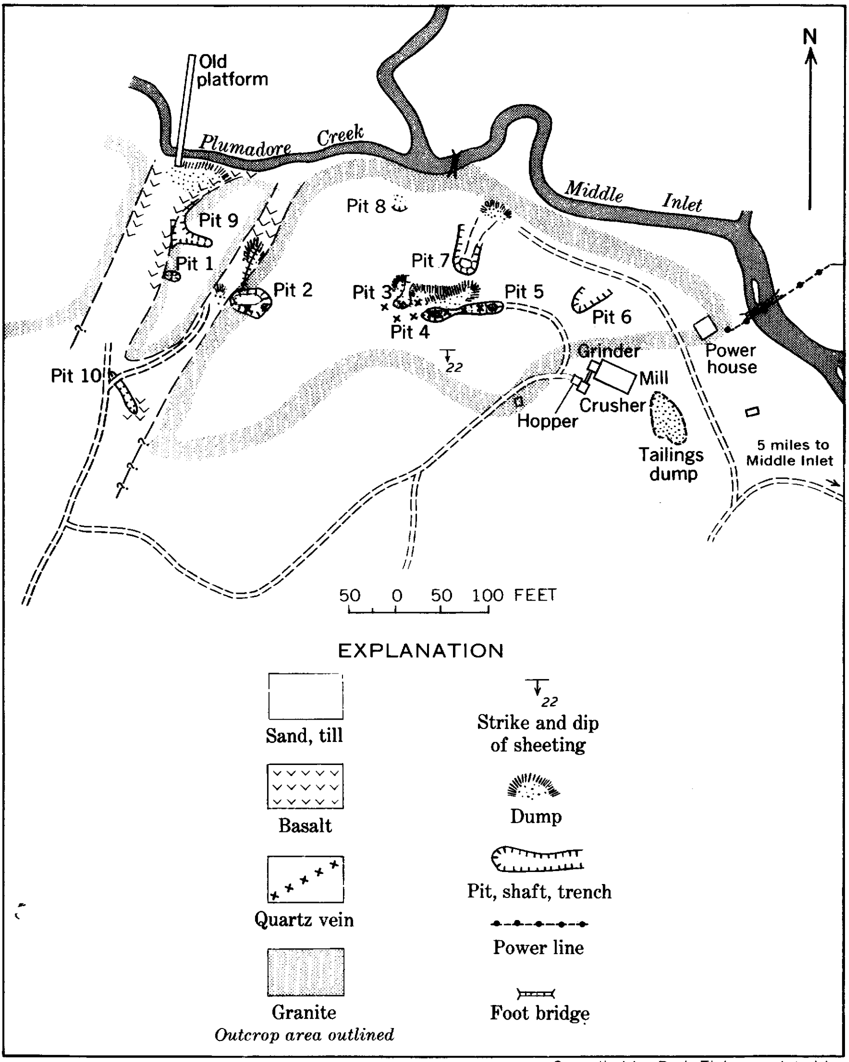


FIGURE 16.—Geologic map of Camp Five molybdenite deposit, Marinette County, Wis.

feldspar is orthoclase, and more muscovite is present than at pit 1. At the west margin of the property, prospect pits expose a basalt dike.

Molybdenite is present in quartz veins or disseminated in the granite. Some narrow (1/4-inch) quartz veins have sharp walls parallel to sheeting in the granitic rock, which strikes east and dips 20° to 25° S., and some dip vertically. These sharp-walled veins do not contain significant quantities of molybdenite. Most of the molybdenite occurs in quartz veins that pinch and swell. The molybdenite-quartz veins range in thickness from a film to 20 inches. They have gradational contacts with the granitic rock that suggest a replacement origin. In places, the molybdenite-bearing quartz forms irregular masses elongated vertically, as seen in some of the pits.

Molybdenite in the granitic rock coats fracture surfaces, reaching a thickness locally of one-half of an inch in pit 9. Purple fluorite is also present in some of the fracture surfaces in the granite.

Absence of molybdenite-bearing quartz veins in the basalt dike indicates that the dike was emplaced after the period of mineralization. The quantity of molybdenite-bearing quartz in the granitic rock on the north flank of the hill is estimated to be less than 1 percent. The grade of molybdenite, therefore, in the granite is low and the individual quartz veins contain too little molybdenite to encourage selective mining.

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