State of Arkansas

Arkansas Resources And Development Commission

Hendrix Lackey, Executive Director

DIVISION OF GEOLOGY

Harold B. Foxhall, Director

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MOLYBDENUM IN MAGNET COVE, ARKANSAS

By

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Little Rock, Arkansas

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ABSTRACT

A small molybdenite vein deposit has been explored by recent excavating and diamond-drilling operations at Magnet Cove, Hot Spring County, Arkansas. The molybdenite-bearing veins occur in a fractured pyroxenite country rock and are composed mainly of orthoclase and pyrite with minor amounts of quartz, apatite, plagioclase, molybdenite, and brookite. The veins vary in true thickness from less than half an inch up to 5 feet, trend approximately northwest-southwest, and dip sharply to the northeast. The larger veins are exposed in an area about 225 feet long and 10 to 35 feet wide at the northwest end of the main pit. Trenching on the north side of Cove Creek indicates that the total strike length of the deposit is about 400 feet. The pyroxenite adjacent to the veins has been hydrothermally altered to a soft, green clay-like rock. The unaltered pyroxenite is a hard black coarse-grained rock composed mainly of diopside and magnetite. Surface sampling indicates that the average grade of the vein material in the larger veins at the northwest end of the main pit is about 1.07 per cent molybdenum sulfide. Because of the unreliability of the samples obtained by diamond-drilling, however, no tonnage estimates of molybdenum ore were made. The best possibilities for extending the present known deposit appear to be to the northwest along the strike and down-dip to the northeast.

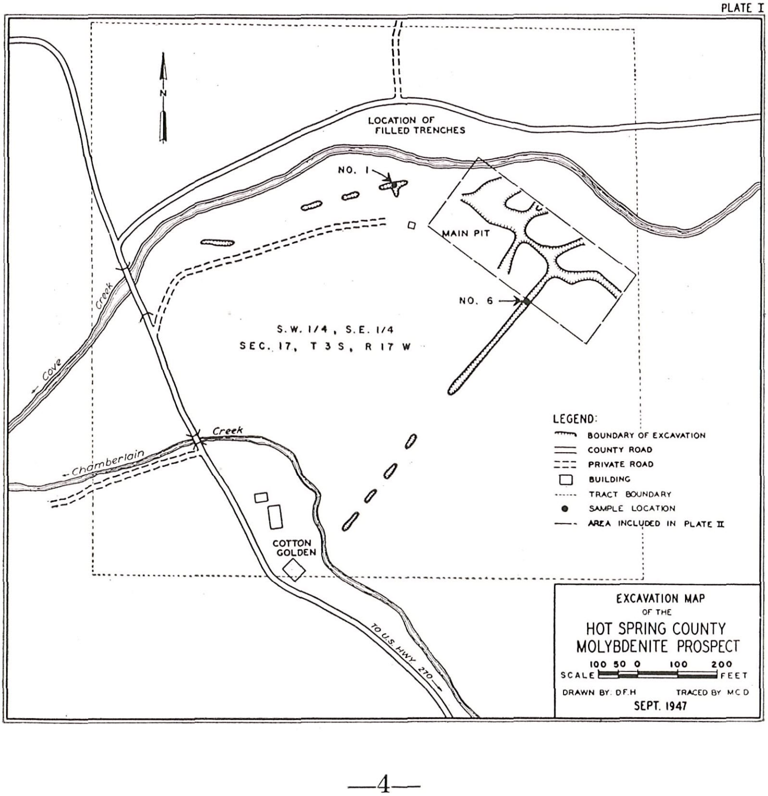
INTRODUCTION

Although the occurrence of molybdenite at Magnet Cove, Hot Spring County, Arkansas has been known since 1939, no appreciable amount of development work had been done at the prospect until the winter of 1946-47. Molybdenum is a metal used primarily as an alloy in hardening iron and steel. Present production comes chiefly from deposits in Climax, Colorado. It was considered advisable for the Division of Geology to take advantage of the exposures and drill cores resulting from this development work and make a field and laboratory study of the deposit. This report briefly presents the results of the investigation. Acknowledgment is made to the officers of the Mo-Ti Corporation for their assistance, particularly in furnishing base maps and aerial photographs of the area.

LOCATION AND ACCESSIBILITY

The molybdenum prospect is located just south of Cove Creek on the Cotton Golden farm in the NW¼ of sec. 17, T. 3S, R. 17W, at Magnet Cove, Hot Spring County. U. S. Highway No. 270 is about 1½ miles southeast of the deposit by gravel road and the highway intersection is about 6½ miles northwest of the city limits of Malvern, Arkansas. At present, the nearest rail transportation available is the Rock Island Railroad at Butterfield station about four miles southeast of the deposit on Highway No. 270.

PLATE I



HISTORY AND DEVELOPMENT OF THE PROSPECT

The molybdenum prospect first attracted attention because of the abundance of associated pyrite. During the winter of 1929-30, the Southern Acid and Sulphur Company conducted a systematic program during which time thirty-three churn drill holes were drilled in the area. Apparently the pyrite values were considered uneconomic, as the work was not carried beyond that stage. Molybdenite was not identified in the prospect until March 1939 when Howard Millar, then a member of the State Mineral Survey, recognized the mineral. Up to that time, the mineral had been identified as graphite. In 1940, V. C. Sleight[1] wrote the first published account of the molybdenite occurrence after examining an outcrop on Cove Creek opposite the present open pit. The prospect was first investigated for its molybdenum possibilities by Mr. W. W. Sheldon of Hot Springs, Arkansas, who obtained leases and started shallow trenching in 1942. In 1944 a geophysical survey was begun at the prospect by the U. S. Bureau of Mines, two shallow holes were core-drilled, and several trenches were dug. The work, however, was not completed and a formal report on the project was not published.

In 1945, the Mo-Ti Corporation was incorporated for the specific purpose of developing the molybdenum and titanium minerals in that portion of the prospect located south of Cove Creek. An elongated open pit was excavated roughly paralleling the trend of the mineralization. This pit (see Plate I) has several access ramps and beginning at Cove Creek extends 400 feet in a southeasterly direction, averaging about 8 feet in depth. Late in 1946, a diamond drilling project was undertaken at the prospect and eight holes were drilled, varying in depth from 6½ to 145 feet. In 1947, surface excavation was continued and two lines of trenches (see Plate I) were completed to bedrock depth in an attempt to locate additional molybdenite mineralization. One line of pits begins near the northwest end of the main pit and roughly parallels Cove Creek, while the other

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[1] Sleight, V. C., Molybdenite at Magnet Cove, Arkansas: Amer. Mineral Vol. 26, p. 132-33, 1941.

line beginning near the southeast end of the main pit extends southwest almost to Chamberlain Creek. A series of small trenches have been dug within the main pit approximately at right angles to the trend of the main mineralization. No further development work has been completed to date.

GENERAL GEOLOGY

The sedimentary rocks of the Magnet Cove region are shales, sandstones, and novaculite, all of Paleozoic age. The character and attitude of these beds were changed by folding and metamorphism believed to have occurred near the end of the Paleozoic era. The igneous rocks of the region are of Cretaceous age and are alkalic in character. These igneous rocks form a nearly continuous, roughly circular rim within which is a basin-like area about two miles across, composed of alkalic igneous rocks and metamorphosed sediments, which is known as Magnet Cove. The molybdenum prospect is situated in the igneous rocks that occur near the northern edge of this Magnet Cove basin.

DESCRIPTION OF THE PROSPECT

The molybdenum prospect lies on the flood plain of Cove Creek, and, therefore, is almost entirely covered with alluvium, the only natural exposure of the mineralization being in the creek bed. This alluvial cover is about 6 to 8 feet thick and is composed of sand, gravel and an abundance of large cobbles. It contrasts sharply with the underlying, fractured igneous rock since the contact between the two is the lower limit of the zone of weathering.

The molybdenum mineralization is best exposed in the main pit of the Mo-Ti Corporation south of Cove Creek. On the north side of the creek, however, between the creek and the road there are a few shallow trenches now filled with alluvium (see Plate I). Vein material from the dumps of these trenches is essentially similar to that found in the main pit, indicating that the mineralization extends across Cove Creek in a northwesterly direction from the main pit with a total strike length of about 400 feet. In the main pit

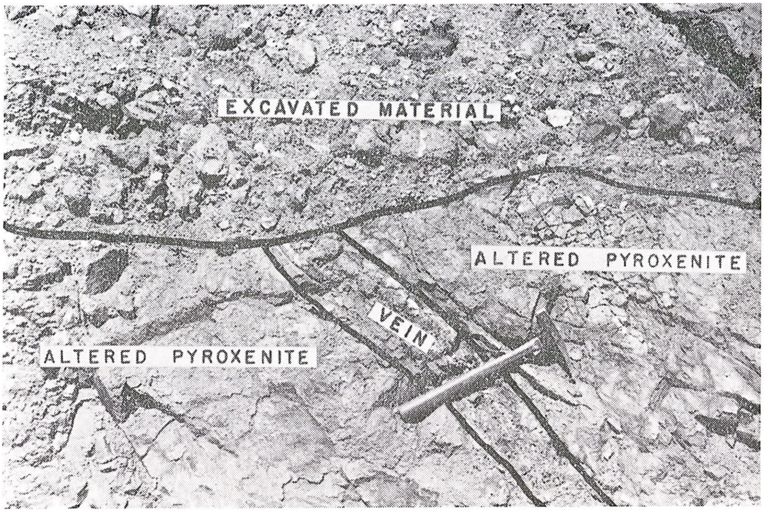

Fig. 1

A narrow molybdenite-pyrite-feldspar vein exposed in a trench wall in the main pit. The slabby layers parallel to the vein-wall rock contact are composed mainly of feldspar with some molybdenite while the center of the vein is pyritic.

the mineralization consists essentially of feldspar-pyrite-molybdenite veins that occur in fractures in igneous rocks. The vein-wall rock contacts are usually well defined and the smaller veins, particularly, are banded parallel to the contact. Individual veins vary considerably in true thickness from less than half an inch up to 4 and 5 feet. The smaller veins (less than 6 inches in width) are sparsely distributed through most of the main pit as well as in the access ramps. The larger veins, however, which are the ones carrying significant molybdenite mineralization, are concentrated in an area about 225 feet long and from 10 to 35 feet wide. This well mineralized area extends from Cove Creek southeast down the center of the main pit (see Plate II). The general strike of these veins is about N 45° W with an average dip of about 50° to the northeast. A prominent feature of the vein material is its very friable character. Even where freshly exposed, the material is so loosely consolidated it resembles gravel. The igneous rock adjacent to the veins has been intensively altered, and it is this altered

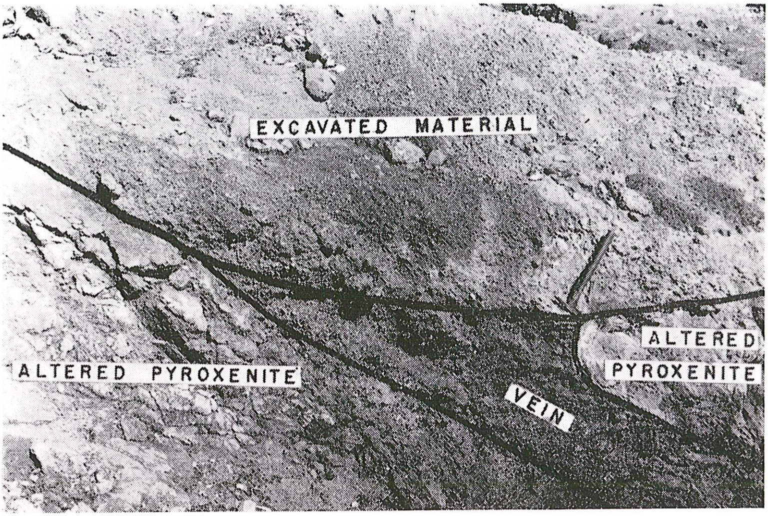

Fig. 2

A larger vein exposed in a trench wall composed almost entirely of unconsolidated coarsely crystalline pyrite. The dip of the vein to the northeast is characteristic.

igneous rock that makes up the bulk of the rock exposed in the main pit.

MINERALOGY OF THE VEINS

The mineralogy of the veins is relatively simple, and all minerals that have been identified are listed in the following tabulation:

Gangue Minerals	*Ore Minerals*
Pyrite	Molybdenite
Orthoclase	Brookite
Plagioclase	
Apatite	
Quartz	
Calcite	

Pyrite and feldspar are the predominant vein minerals. The pyrite usually occurs as individual cubes and as irregularly shaped masses. It varies in grain size from .08 mm. to 10 mm. The feldspar is chiefly orthoclase and occurs as solid fine-grained masses as well as fairly coarse (one-eighth inch) individual crystals and crystalline aggregates. Minor amounts of plagioclase feldspar were found associated with quartz in the small veins. Apatite has been observed only in thin sections under the petrographic microscope as very fine inclusions (.009 to .3 mm.) particularly in the feldspar. Quartz has been found especially in the smaller veins that occur in the southeastern end of the pit. It generally is coarsely crystalline, and well terminated crystals have been found in vugs. Calcite has been observed only in small veins in the igneous country rock.

Of the ore minerals, the molybdenite is the most readily detected by the naked eye. It has a steel-blue color and is very fine-grained, occurring in thin, elongated seams and as small pods that are irregularly scattered through the veins. There is one persistent seam, however, that parallels and occurs within a few inches of the footwall of the orebody. It is particularly well exposed at the southwest end of the trenches represented by samples 11, 12, 13, 17, and 19. (See Plate II.)

Brookite is most commonly associated with the feldspar and is generally so fine grained that it appears as gray bands or streaks in the feldspar masses and can easily be mistaken for molybdenite. Microscopic examination disclosed grains as small as .03 mm. In a few places brookite occurs as black, well-formed crystals large enough (one-eighth inch) to be readily detected by the naked eye.

An occurrence of the tungsten mineral, ferberite, in the deposit was reported by the Mo-Ti Corporation in a drill core from Hole No. 6 at a depth of 84½ feet. Their identification of the mineral was based on a chemical analysis of the core fragment. To check the possibility of extensive tungsten mineralization, several of the vein samples taken in the open pit were analyzed for that element. No significant amount of tungsten was indicated, however, in checking these samples.

THE ASSOCIATED IGNEOUS ROCKS

As previously noted, the molybdenite-bearing veins are apparently fracture fillings in igneous rock. Two principal igneous rock types have been noted in the excavations; a magnetite pyroxenite and a monchiquite dike. The pyroxenite is the more abundant of the two and may properly be considered the country rock of the molybdenite prospect. Microscopically, the pyroxenite is a medium to coarse-grained rock of granitoid texture and black in color. Several thin sections of the rock from both surface samples and drill cores were examined and the mineralogy was found to be fairly uniform with some variation in the proportions of the various minerals. An estimate of the mineralogic composition of the rock follows:

	Per Cent
Pyroxene (Diopside)	60
Biotite	8
Magnetite	10
Perovskite	8
Apatite	8
Accessory Minerals	
Pyrite, Calcite, Epidote, Titanite, Analcite, Ilmenite, Garnet	6

The pyroxenite is probably the same rock as the jacupirangite of H. S. Washington.[2]

Bordering the molybdenite veins is a zone of hydrothermally altered pyroxenite varying from 10 to 30 feet in width.[2] The altered pyroxenite is gray-green, soft, clay-like material. It is composed largely of hornblende and chlorite with lesser amounts of clay minerals, apatite, pyrite, biotite, and leucoxene.

The monchiquite dike rock probably penetrates the pyroxenite. It has been seen at only two localities in the main pit but a similar rock occurs in the drill core from Hole No. 5 at a depth of 51 feet. Hornblende and diopside occur as phenocrysts in a ground mass composed largely of analcite in the dike rock, the accessory minerals being magnetite, ilmenite, titanite, chlorite, epidote, nepheline, calcite, and pyrite.

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[2] Washington, H. S., Igneous complex of Magnet Cove, Arkansas: Bull. G. S. A., Vol. II, p. 389-416, 1900.

SAMPLING TECHNIQUE AND RESULTS

Since the molybdenite-bearing veins were rather sharply defined, it was decided to limit sampling to the veins themselves rather than sample the full length or breadth of the various excavations. Two samples, however, No. 27 and No. 28, were taken of the altered igneous rock to check for possible values in that material. All samples were cut horizontally, so that their lengths could be accurately plotted on the pit map. The sample lengths in most cases are greater than the true thicknesses of the vein at a particular point since most of the veins dip to the northeast. Wherever possible, samples were cut from the walls of trenches that were distributed throughout the pit. The walls of these trenches were first cleaned and the samples were taken from a channel cut from 1½ to 2 inches in depth. In all, 28 samples were collected and of these Nos. 1 through 8 and Nos. 21 through 28 were analyzed by T. W. Carney, Chief Chemist of the Division of Geology, and Nos. 7 through 20, inclusive, were made by the Van Trump Testing Laboratory, a commercial laboratory located in Little Rock. Mr. Carney made all the tungsten determinations. (See Table I).

Several significant results of the sampling should be pointed out. For example, values in molybdenum or titanium are not as a rule as high in the smaller scattered veins as in the larger veins at the northwest end of the main pit. The results obtained from the two analyses of altered igneous rock, sample Nos. 27 and 28, are interesting, particularly since they show some molybdenum content. This is probably due to the presence of small molybdenite-bearing veins within the altered rock. A certain percentage of titanium, however, would be expected in the altered pyroxenite since the unaltered rock contains the titanium minerals, ilmenite, perovskite, titanite, and leucoxene. Of the four minerals listed above, only ilmenite is known to be produced commercially as an ore of titanium. It is believed from a study of partially and completely altered pyroxenite samples that in the process of alteration the ilmenite in the fresh pyroxenite has partially or completely altered to leucoxene, a very finely divided form of titanium dioxide, and hence it is unlikely that the soft, greenish altered

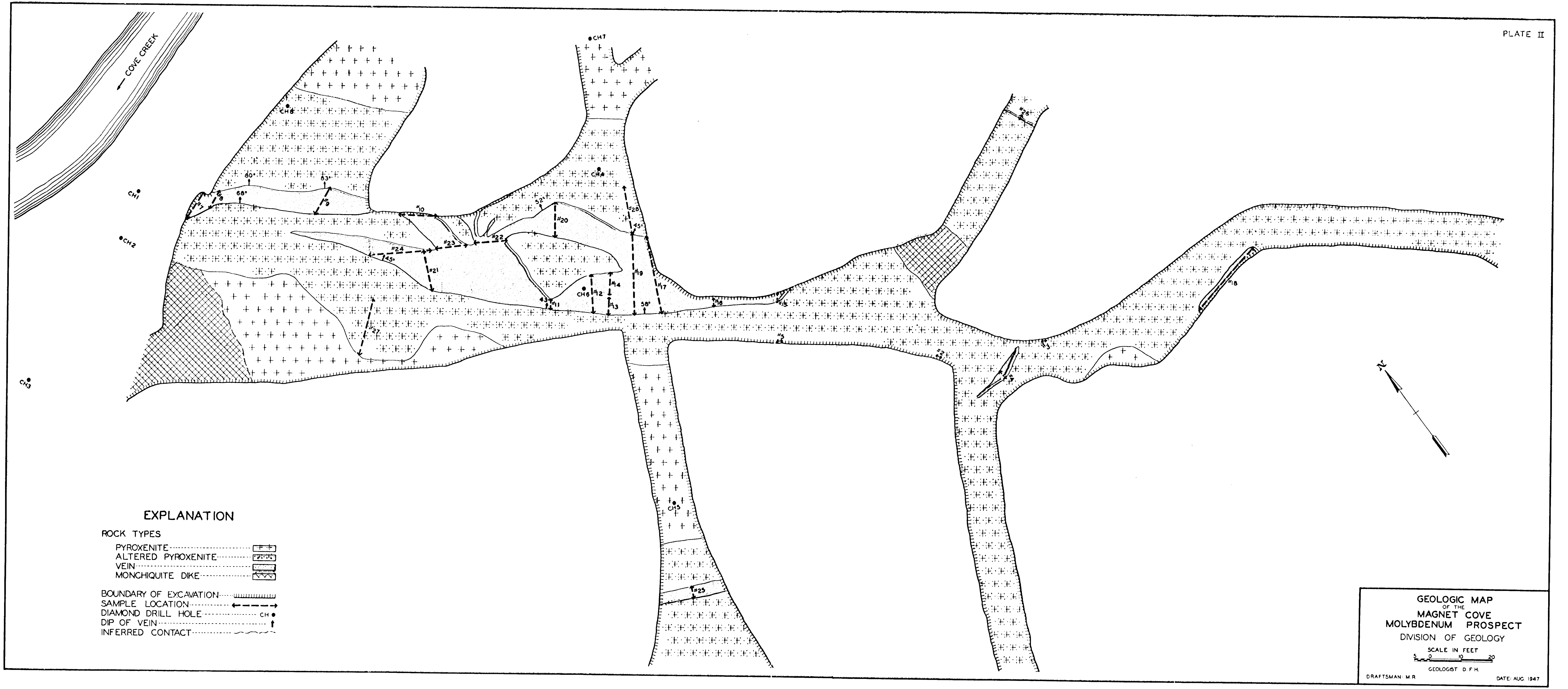
PLATE II
COVE CREEK
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
N
EXPLANATION
ROCK TYPES
PYROXENITE
ALTERED PYROXENITE
VEIN
MONCHIQUITE DIKE
BOUNDARY OF EXCAVATION
SAMPLE LOCATION
DIAMOND DRILL HOLE CH
DIP OF VEIN
INFERRED CONTACT
GEOLOGIC MAP
OF THE
MAGNET COVE
MOLYBDENUM PROSPECT
DIVISION OF GEOLOGY
SCALE IN FEET
5 0 10 20
GEOLOGIST D. F H.
DRAFTSMAN: M.R
DATE: AUG. 1947

pyroxenite contains titanium ore minerals that can be economically recovered.

TABLE I

Analyses Molybdenum Samples

Sample Number	*Sample length in feet*	*Molybdenite MoS_2*	*Titania TiO_2*	*Tungsten W*
1*	4.0	0.27	2.0	
2	0.8	0.25	2.0	
3	0.4	Nil	1.2	
4	3.0	0.07	3.3	
5	0.7	0.09	1.7	
6*	1.5	0.34	1.6	
7	10.0	0.73	0.6	Nil
8	4.0	1.09	0.6	
9	9.0	1.01	.59	
10	12.0	1.08	.55	
11	3.5	1.77	.61	
12	12.0	1.25	0.80	Nil
13	5.0	1.84	0.73	
14	7.0	0.87	1.20	
15	4.0	1.65	0.90	
16	2.5	0.60	0.65	
17	24.0	1.69	0.70	Nil
18	25.0	0.28	2.45	
19	25.0	1.14	1.20	
20	12.0	1.09	1.40	
21	13.0	0.34	.66	
22	9.0	0.94	1.43	
23	10.0	0.85	0.68	
24	20.0	0.68	0.47	Nil
25	4.0	0.53	0.90	
26	0.5	2.75	3.20	
27	18.0	0.18	5.2	
28	15.5	0.11	4.6	

Location of samples 1 and 6 are plotted on Plate I.
All other samples are plotted on Plate II.

EXTENT OF THE MOLYBDENUM VEINS

Surface excavations have placed certain fairly definite limits on the lateral extent of the molybdenite veins. Plate II shows clearly the disappearance of the large veins in a southeasterly direction. The excavations to the southwest and west of the main pit failed to expose significant mineralization and massive unaltered igneous rock is exposed to the northeast of the main pit. The mineralization, however, can safely be extended across Cove Creek in a northwesterly direction at least to the county road immediately north of Cove Creek. The possibilities of further extension in that direction would justify some trenching.

The 1946-47 diamond-drilling program was intended to investigate the persistence of the molybdenite mineralization at depth. Information obtained from this drilling was not entirely satisfactory, however, because there was little or no core recovery in either the altered pyroxenite or the vein material. The sludges that were recovered in the vein material and altered pyroxenite are in most cases of doubtful accuracy because of the tendency of these two materials to slough off the sides of the uncased portion of the drill hole. The maximum known depth of vein material as determined from microscopic examination and chemical analyses of sludges and recovered core was 145 feet (drill hole No. 8). The exact position and grade of the vein material encountered in this as well as the seven other drill holes, however, cannot be stated definitely because of the unreliability of the recovered sludge samples.

ECONOMIC DATA[3,4]

Uses

More than 95 per cent of all the molybdenum consumed in the United States is used to impart hardness and toughness to special steels. In steel it acts like tungsten, but more powerfully, requiring only one-half to one-third as much to produce similar results. Small quantities of molybdenum usually less than 2 per cent, are needed in most alloy steel

[3] Bateman, A. M., Economic mineral deposits: p. 592, 1942.

[4] Staffs of the Bureau of Mines and U. S. Geological Survey. Mineral resources of the United States: pp. 143-146, 1948.

applications. Molybdenum steels are widely used in aircraft, automobile, high-speed tools, guns, armor plate and many other types of machinery and metal supplies. Only minor amounts of molybdenum are used in chemicals and dyes.

Production

Reversing a downward trend that had persisted for three years, the 1947 output of molybdenum concentrates in the United States showed an increase of 48 per cent over that of the previous year. The increase was due to the greatly accelerated activity in the steel industry.

The following table[5] shows the trend in U. S. molybdenum production from 1942 to 1947:

Year	*Pounds of Molybdenum*
1942	56,942,000
1943	61,667,000
1944	38,679,000
1945	30,802,000
1946	18,218,000
1947	27,047,000

Molybdenum concentrates were produced in six states in 1947, Utah leading, followed in order by Colorado, New Mexico, Arizona, Nevada and California. The principal sources of molybdenum in the United States fall into two categories: (1) those which yield molybdenum alone, represented by the deposits at Climax, Colorado, Questa, New Mexico, and Urad, Colorado; and (2) the by-product sources from deposits worked for copper and tungsten. Until recently the major part of United States molybdenum production came from molybdenum mines, however, in 1947 the trend was reversed, the by-product sources contributing 53 per cent of the total production. The largest by-product molybdenum production comes from the Kennecott Copper Corporation mine at Bingham Canyon, Utah.

The United States produces about 94 per cent of the world's molybdenum. The foreign sources that produce the

[5] U. S. Bureau of Mines, Mineral Market Surveys No's 1520 & 1590, 1947-1948.

remaining 6 per cent are the copper deposits of Mexico and Chile, and the molybdenite deposits of Peru.

Grade, Price and Treatment of Ores

Practically all the molybdenum produced occurs in ores as molybdenum sulfide (molybdenite, MoS_2). The grade of ore that can be economically treated depends to a large extent on the size of the deposit and whether or not molybdenum is a by-product or the main mineral value in the ore. The large tonnages treated at the Climax molybdenum mine in Colorado permits the milling of ore averaging between 0.6 to 0.7 per cent molybdenum sulfide, while in some of the smaller ore bodies, the ore will average from 1 to 3 per cent molybdenum sulfide. Where molybdenum is a by-product of copper mining as at Bingham Canyon, Utah, the ore may contain as low as .02 per cent of molybdenum sulfide and still be worth processing for its molybdenum.

Market quotations are usually based on molybdenite concentrates rather than on the raw ore. The June 1948 quotations on molybdenite concentrates was 45 cents per pound of molybdenite contained in concentrates having a minimum molybdenite content of 90 per cent.

Molybdenite ores are mined by both underground and, in the case of by-product molybdenite, open-pit mining methods, and the molybdenite is concentrated by differential flotation. The product is generally marketed in the form of molybdenite concentrates. For adding to steel the concentrates are roasted with lime to make calcium molybdate, are converted to ferromolybdenum, or are made into briquettes of molybdenum oxide.

Reserves

The molybdenum resources of the United States comprise a larger proportion of known world resources than that of any other metal in common use. The accompanying table shows the known measured, indicated, and inferred reserves of molybdenum as of 1943 by commercial availability.

Availability:	Molybdenum content in pounds
1. Commercial under conditions similar to those of 1943	2,600,000,000
2. Potential, commercial, and marginal	900,000,000

In group 1 above the grades of ore generally exceed 0.5 per cent of molybdenite except for the by-product molybdenum in copper mining in which the grades range from 0.02 to 0.2 per cent of molybdenite. Although the grade of some ores included in group 2 exceed 0.5 per cent molybdenite, most of the ore is below this grade, but none with a cut-off less than 0.25 per cent of molybdenite is included in the by-product class.

The commercial, potentially commercial and marginal reserves of molybdenum in the United States are equivalent to the output of about 140 years at the prewar rate of production.

Up to the present the United States has dominated world production and consumption of molybdenum and its production facilities are flexible enough to meet any anticipated demands.