UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

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Short papers and preliminary reports by
EUGENE CALLAGHAN, S. W. HOBBS, L. R. PAGE
and others

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TUNGSTEN RESOURCES OF THE BLUE WING DISTRICT, LEMHI COUNTY IDAHO

BY

EUGENE CALLAGHAN

AND

DWIGHT M. LEMMON

Strategic Minerals Investigations, 1941
(Pages 1-21)

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ILLUSTRATIONS

TUNGSTEN RESOURCES OF THE BLUE WING DISTRICT, LEMHI COUNTY, IDAHO

By Eugene Callaghan and Dwight M. Lemmon

ABSTRACT

The Blue Wing district, Lemhi County, Idaho, is not only the principal tungsten mining district in the State but it has recently become one of the leading producers of tungsten in the United States. So far only one mine in the district is productive, but other prospects are being actively developed.

The veins fill a complex group of fractures in quartzite of the Belt series near the border of a granite mass that does not crop out but is exposed in underground workings. The vein filling is mainly quartz, which encloses fluorite, orthoclase, rhodochrosite, huebnerite, pyrite, tetrahedrite, molybdenite, and minor amounts of other minerals. The minerals other than quartz have a rough zonal arrangement with reference to the granite. The ore mined has an average content of about 0.72 percent of huebnerite (manganese tungstate). This mineral occurs mainly in the wider parts of the veins, and ore shoots are confined to the relatively large veins close to the granite. The more numerous minor veins farther away are not regarded as of much promise.

The Ima mine has thus far yielded roughly 175,000 tons of ore. An estimated 50,000 tons remains in sight above the lower or main level; and, although the veins probably pinch downward, there may be 40,000 tons more below the present workings. Some ore has been found on adjacent ground, but here and in outlying parts of the district the present development is not enough to permit estimates of reserves.

INTRODUCTION

The Blue Wing district, in southeastern Lemhi County, Idaho, is the principal tungsten mining district in the State and in recent years has become one of the leading producers in the United States. The present report summarizes the results of an examination of the district made by Eugene Callaghan, assisted from Sept. 8 to 22, 1940, by Charles Vitaliano and from October 12 to November 5 by D. M. Lemmon, Donald Wyant, and James Pollock.

The staffs of both the Ima Mines Corporation and the Incandescent Lamp Department of the General Electric Co. cooperated to further the work in every possible way. Both companies supplied accommodations for the field party, as well as maps, reports, information, and actual help with the field work. Mr. W. P. Barton, general manager, Owen Hickey, mine superintendent, Carl Dice, engineer and mill superintendent, and Floyd Harper, bookkeeper, of the Ima Mines Corporation, and H. H. Barrows, manager, tungsten mine division, Incandescent Lamp Department, and Floyd Elliot, superintendent, of the General Electric Co., deserve particular mention.

The district is on the west slope of the Lemhi Range (fig. 1) in T. 14 N., R. 23 E. Its sole producing mine, the Ima, is in sec. 23 on the north side of Patterson Creek, a mile upstream from the small settlement of Patterson, which is at the mouth of the canyon and on the east side of Pahsimeroi Valley. Mackay, the shipping point and the terminus of a branch of the Union Pacific Railroad, is 56 miles distant via Double Springs Pass, or 100 miles distant through Challis, the route used when Double Springs Pass is closed by winter snows. Salmon, the county seat, is 68 miles northwest of Patterson. Most of the roads between these different points are graded and parts of some are paved.

The Lemhi Range, which has a northwesterly trend, reaches altitudes of more than 11,000 feet, or more than 5,000 feet above the broad Pahsimeroi Valley. In the vicinity of Patterson the western slope of the range, up to an altitude of 8,000 or 9,000 feet, is remarkably smooth and even, with an average gradient of 25°, and is little dissected between the V-shaped major canyons. The sides of Patterson Canyon near the Ima mine have an average gradient of 35°. Jutting cliffs rise in irregular succession on the canyon walls and are separated by steep shallow gulches, which contain long talus slides and have alluvial

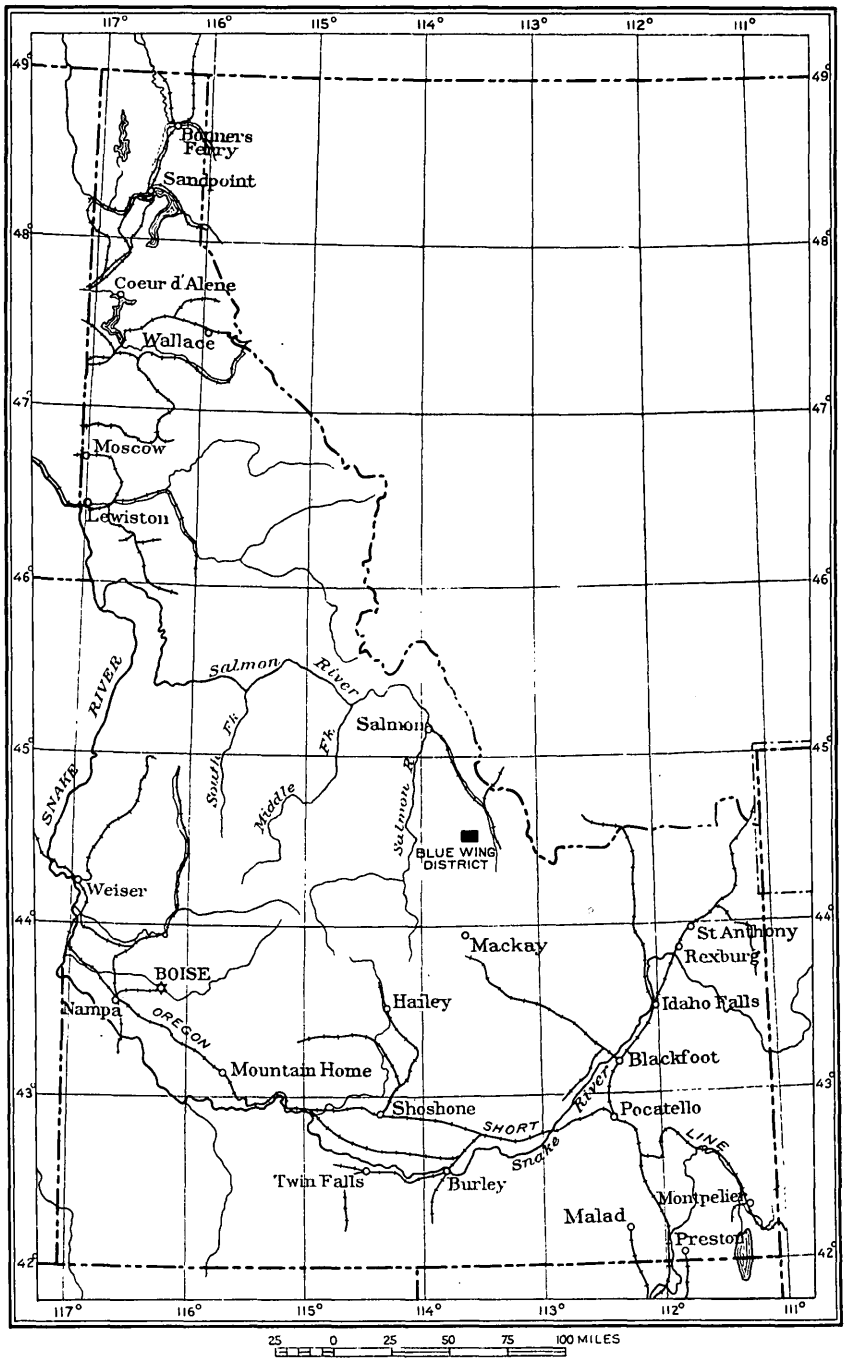

Figure 1.--Index map of Idaho showing the location of the Blue Wing district.

cones at their mouths. The canyon bottom averages between 300 and 500 feet in width. Patterson Creek and the other large streams entering Pahsimeroi Valley have built huge alluvial fans that reach nearly to the middle of the valley.

The Ima mine has been visited by several geologists and engineers. The deposit was described in some detail by Umpleby [1] and Livingston,[2] and some facts regarding its minerals were recorded by Shannon.[3] The mine has been mentioned briefly by Bell,[4] and recent developments have been described by Barton and Arentz.[5] Development and production are briefly described in the various chapters of Mineral Resources of the United States from 1910 to the present and in the reports of the State Mine Inspector of Idaho. An unpublished report on the Ima mine by C. B. Pollock, of the American Smelting & Refining Co., illustrated by detailed geologic maps and sections with assay figures, and a report by Don Emigh on the reserves of the Ima mine were made available to the writers of this paper.

According to Umpleby [6] the veins in Patterson Canyon were prospected for silver and gold as early as 1881, but their precious-metal content was too low for profitable mining. Tungsten was not discovered until 1903. In 1911 the first efforts were made to recover tungsten at the Ima mine; a 50-ton concentration mill was operated in 1912, and two shipments of concentrates were made in 1913. At that time 2,000 feet of development work had been done in all, on the upper and lower levels, and the upper tunnel was 900 feet long. In 1914 [7] J. Nolan leased the

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1/ Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 73-74, 77, 79, 109-112, 1913.

2/ Livingston, D. C., Tungsten, cinnabar, manganese, molybdenum, and tin deposits of Idaho: Idaho Univ. Bull. 2, vol. 14, pp. 21-25, 1919.

3/ Shannon, E. V., Minerals of Idaho: U. S. Nat. Mus. Bull. 131, pp. 467-468, 1926.

4/ Bell, R. N., Idaho rare metals: Min. and Contracting Rev., vol. 37, no. 47, p. 5, 1935.

5/ Barton, W. P., and Arentz, S. S., Mining and milling tungsten at the Ima mine: Min. Cong. Jour., vol. 25, no. 8, pp. 16-19, August 1939.

6/ Umpleby, J. B., op. cit., p. 109.

7/ Livingston, D. C., op. cit., p. 21.

mine but sold his interest to Callahan and Duffield, who mined tungsten with little success in both the upper and lower tunnels. They in turn sold to Jeffs and Johnson, who sunk a 70-foot incline, near the entrance of the lower tunnel, from which they are said to have recovered 8 tons of tungsten concentrate in one month in 1916. From May 1917 until January 1918 the mine was operated by Nolan and D. R. Wheelwright. In 1927 and 1928 some work was done by the Patterson Mines Corporation under lease from the Ima Consolidated Mining & Milling Co.,[8/] but the work yielded only a small output.

In 1934 the Ima Mines Corporation took over the property and produced 2,300 pounds of concentrates averaging 56 percent of WO_3. During 1935 development work was actively carried on, but there was no production. Late in 1936 about 800 tons of ore was mined and milled, and production has continued to the present. Late in 1939 and early in 1940 the American Smelting & Refining Co. investigated the deposit both by geologic mapping and by diamond drilling. The mill recently has been enlarged to treat 120 tons daily. The metallurgical treatment involves crushing, jigging, and grinding to 35 mesh in a ball mill, followed by another jigging, flotation, and tabling of concentrates. The jig and table concentrates are dried and passed through a magnetic separator to take out metallic iron and then huebnerite. The remaining concentrates, which consist mainly of sulphides, are shipped to the smelter, and the huebnerite concentrate, which averages 67 percent of WO_3, eventually reaches the incandescent-lamp plant of the General Electric Co. In the fall of 1940 there were 20 men employed in the mill and 40 in the mine.

8/ Campbell, Stewart, Annual reports of the mining industry of Idaho for the years 1927 and 1928, pp. 160 and 154, respectively.

Recent production of the Ima mine is given in the table below. The mill heads have averaged 0.55 percent of WO_3, or very roughly 0.72 percent of huebnerite, and of this the mill recovers about 75 percent. The ore has an average content of 1.75 ounces of silver to the ton, of which 80 percent is recovered in the sulphide concentrates. The sulphide concentrates recovered average 4 percent of the ore treated and contain about 42 ounces of silver to the ton, 0.01 ounce of gold, 3.75 percent of copper, 7 percent of lead, 28 percent of iron, 5 percent of zinc, 37 percent of sulphur, 1 percent of lime, 12 percent of insolubles, and 0.5 percent of WO_3.

The ore also contains a variable amount of molybdenite, averaging about 0.08 percent, but at present this is not saved.

Recent production of the Ima mine

	Huebnerite Concentrate (pounds)	Percent WO_3	Sulphide Concentrate (pounds)
1937 [1]	174,800	.....	667.4
1938	277,000	66.54	1,356.0
1939	398,828	66.19	1,431.0
1940 [2]	360,177	67.00	1,215.0
Total	1,210,805		4,669.4

1/ Includes 16,000 pounds of huebnerite produced in November and December 1936.

2/ For 10 months, January to October.

In December 1938 the General Electric Co. purchased some claims from W. E. Miller and staked additional claims. This ground has been actively prospected since March 1940.

GEOLOGY

The areal geology of the Blue Wing district shown on plate 1 is simple. The exposed rocks are pre-Cambrian quartzites of the Belt series. These are rather gently folded, the main fold

being an anticline of northwesterly trend, traversed by the canyon of Patterson Creek. No igneous rocks are exposed within the area shown on plate 1, but granite has been reached in the workings of the Ima mine and small masses of quartz diorite and other granitic rocks crop out in neighboring parts of the Lemhi Range. The fracture system that controlled the distribution of the veins is very complex in detail. The Ima vein zone has a northwesterly trend, apparently parallel to the trend of the arch in the quartzite, and is closely associated with the granite.

Sedimentary rocks.--The Belt rocks in the district were all formed by the metamorphism of somewhat feldspathic sandstones and shales. They mostly consist of beds of micaceous quartzite 6 inches to 2 feet thick alternating with thin slaty layers. Some of the quartzite beds are finely laminated, and some show cross lamination. The rocks are in general brownish to greenish gray on weathered surfaces but light greenish gray to black where fresh. Because of their micaceous character and numerous minor fractures, the rocks break down where weathered more readily than most quartzite rocks. Within the mapped area the rocks are uniform in character and lack beds of sufficiently distinctive appearance to be used as markers. In other parts of the Lemhi Range these same quartzitic rocks locally contain lenses of purple, maroon, and white to pinkish quartzite, especially in the upper part of the unit.

These rocks have a cleavage, which in most parts of the mapped area is parallel to the bedding, but in some places the angle between the two is 20° to 30°. Closely spaced shear planes have locally obliterated the bedding, and in a few places there are small drag folds of about 10-foot radius. Near faults and vein zones the bedding is obliterated in much of the hackly structure of the rocks. Most of the metamorphism in the Belt rocks is regional and antedates the intrusion of the granite

and the formation of the veins, but in a zone a few inches wide on the granite borders fine-grained biotite has been developed in the quartzite.

Igneous rocks.--The only igneous rocks visible within the mapped area are the granite, and the small pegmatite veins that locally accompany it, on and near the intermediate and lower levels of the Ima mine, more than 300 feet beneath the surface. The granite is pink and consists largely of orthoclase, with abundant quartz, some plagioclase, a little biotite, and probably some muscovite. All the granite so far revealed in the mine workings contains quartz veinlets and disseminated sulphides and fluorite. The orthoclase and quartz seem to have been unaffected by the mineralization, but the plagioclase has been largely replaced by sericite and fluorite.

As shown on the maps of the intermediate and lower levels (pl. 2) and as revealed in the adjacent stopes and raises, the contact of the granite with the quartzite is very irregular. Its average dip between the two levels is about 30° S., and drill cores indicate that its dip beneath the lower level is 18° S. The position of this contact with reference to the veins is of economic importance, as the ore shoots thus far mined have terminated at or near the contact.

Structure.--The major folds in the Belt rocks of the Lemhi Range trend nearly north. This fact was noted by Ross [9] in an earlier study of parts of the range farther north and east, and he has confirmed this fact by more recent unpublished studies of an area closer to the Blue Wing district.[10] Within the area here mapped most of the dips observed between the Ima mine and the front of the range are southwesterly, whereas east of this area most of the dips are northeasterly. Outcrops in the district

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9/ Ross, C. P., The copper deposits near Salmon, Idaho: U. S. Geol. Survey Bull. 774, p. 11, 1925.

10/ Ross, C. P., oral communication.

are not sufficient to define the structure clearly, but there seems to be a local warp or arch in the mapped area, with its axial plane parallel to the vein system.

The fracture system as revealed in the underground workings and by the distribution of veins on the surface is extremely complex. The premineral fractures that determined the course of the veins strike in general N. 20°-40° W. and dip about 60° W. One productive vein, however, at the east portal of the lower adit of the Ima mine strikes N. 42° W. and dips 35° NE. Some veins, moreover, strike northeastward, and dip either to the northwest or to the southeast, but none of these have thus far shown promise of being productive. At a few places on the surface these "cross" veins were observed to curve into the northwesterly system. The outcrop of the westward-dipping vein zone along the steep canyon slope trends about N. 10° W. Where the bedding strikes northwestward, the veins tend to follow the bedding. Such a bedding vein on the Mazda No. 28 claim of the General Electric-Miller group yielded a small shipment of ore.

In addition to the veins and the gouge seams that follow them, there are nearly flat or gently dipping fractures some of which are premineral and some postmineral. Examples of premineral fractures were observed in the long east crosscut on the lower level of the Ima mine, where a vertical vein between two nearly flat fractures had narrower but uncrushed continuations in the flat fractures. The vein is displaced, on the other hand, by eastward-trending faults, the hanging walls of which are shifted toward the west. These faults dip gently to the north, as shown especially well on the upper level of the Ima mine. The northern end of the upper part of the ore shoot on the Ima mine intermediate level has been moved 32 feet to the southeast, as indicated by the offset of the granite contact. These observations, taken together, indicate that such of the premineral fractures as were favorable in position and attitude were

mineralized and the others were not, and that there have been some relatively minor displacements since the vein was formed.

The fractures followed by the veins, as well as the veins themselves, must have been formed later than the granite intrusion, for no dikes of granite or other rocks follow the trend of the vein system. It is thought that the fractures result from disturbances during the closing stages of the granitic intrusion.

ORE DEPOSITS

The tungsten ore bodies thus far found in the Blue Wing district are limited to the workings of the Ima mine, except that exploratory work on the General Electric-Miller group has yielded enough ore for a test shipment. Only two small vein segments were exposed at the surface on the Ima ground, and these pinched out toward the northwest; the ore shoots opened in the past few years were found by underground exploration. Huebnerite, the tungstate of manganese, is the only mineral of economic importance in the district. The silver, copper, and lead minerals that first attracted the attention of prospectors have not proved sufficiently abundant to be mined alone, although they are valuable byproducts. The ore shoots in the Ima have been large; the few shoots mined have yielded roughly 175,000 tons, and 50,000 tons more is in sight above the lower level.

Mineralogy.--The ore deposits are all quartz veins with varying amounts of fluorite, orthoclase, and rhodochrosite as the principal associated gangue minerals, and huebnerite, pyrite, tetrahedrite, chalcopyrite, bornite, galena, sphalerite, molybdenite, and scheelite as the principal metal-bearing minerals. Weathering of the veins yields limonite pseudomorphous after pyrite, together with azurite, malachite, manganese oxides, cerargyrite, jarosite, molybdite, sulphur crystals, and possibly other secondary products.

Fluorite, both greenish and purple, is the next most abundant gangue mineral after quartz. It is prominent only in a zone extending 600 feet from the granite contact on the intermediate level, where it seems to bear a definite zonal relation to the granite. Rhodochrosite, the most abundant carbonate, occurs at rather widely spaced intervals throughout the veins but seems less abundant near the granite than at a distance from it. Siderite appears in the concentrates, and other carbonates occur in minute seams and vugs. Flesh-colored orthoclase occurs in the veins near the granite contact, and scattered grains of it have been found in veins at the surface. Micaceous aggregates, apparently composed mainly of sericite, are present in many of the veins, especially near the granite.

Pyrite is the most abundant of the metallic minerals. It commonly forms cubical crystals, some of which are more than half an inch in diameter. This mineral contains very little silver and almost no gold.

Huebnerite is probably the second most abundant metallic mineral in the ore. It is very widely though sparsely distributed. The ore sent to the mill has an average content of only 0.72 percent of huebnerite, and in large quantities of vein quartz the huebnerite is far less abundant. The mineral forms reddish-brown prismatic crystals that in some specimens are more than an inch long and average about a quarter of an inch in width. Some of it is so soft and easily powdered that its recovery in the mill is very difficult. Analyses of the huebnerite from the district, listed by Shannon,[11] show that it contains about 76.3 percent of tungsten trioxide, 21.5 percent of manganese oxide, and 2.2 percent of ferrous oxide. Scheelite, the calcium tungstate, is present in very minor amounts, chiefly in the veins near the granite. It is also scattered through the

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11/ Shannon, E. V., The minerals of Idaho: U. S. Nat. Mus. Bull. 131, p. 468, 1926.

mineralized granite, but so sparsely that it has no commercial value.

Tetrahedrite, the sulphantimonate of copper, is the most valuable and probably also the most abundant mineral after huebnerite. It contains most of the copper and practically all of the silver produced (see p. 6). It forms irregularly disseminated grains and masses closely associated with pyrite and with minor amounts of chalcopyrite and bornite. Galena and sphalerite occur in very small grains. Molybdenite (molybdenum sulphide) is disseminated in small grains in the granite, but it occurs chiefly in veins in or near the granite, most typically in sheets on fracture and shear planes, possibly sheared out from its original position in veinlets where its easy cleavage and softness has facilitated movement.

The secondary minerals, chiefly formed from the weathering of pyrite and tetrahedrite, are of no economic importance. Manganese oxides probably were formed from rhodochrosite or some other manganese-bearing carbonate, or perhaps in part from huebnerite, although huebnerite does not readily decompose, for it has been found intact in places where the sulphides have been completely oxidized.

The veins.--The Blue Wing district contains a complex system of quartz veins, many of which are small and lenticular. Exploration has shown that a few of these, grouped close to the borders of the granite, are relatively large. At greater distances from the granite the veins are more numerous but much smaller and less continuous. The original complexity of the vein system has been somewhat increased by minor postmineral faults.

Most of the vein quartz contains metallic minerals, but it is only in a few ore shoots, most of which were discovered recently, that the huebnerite is abundant enough to be valuable. In places the sulphides, the carbonates, and huebnerite have a banded arrangement; elsewhere they are distributed at random

through the quartz. Fluorite occurs very irregularly in large grains and aggregates. As noted above, there is a tendency to a zonal arrangement of some of the vein minerals with respect to the granite. Fluorite, molybdenite, and scheelite, for example, are relatively abundant close to the contact, and rhodochrosite is more abundant at a distance.

Locally fractures in the vein quartz are lined with micaceous minerals, apparently derived from the quartzite, and there are some relatively large micaceous aggregates within the quartz veins. Here and there angular fragments of the wall rock are included in the veins. Some of these seem more micaceous than the unaltered rock, as though part of the quartz had been removed.

Origin.--The huebnerite-bearing quartz veins are believed to have been formed by the filling of fractures that opened during the final stages of the intrusion of the granite, mainly in the quartzite adjacent to granite but also in the outer parts of the intrusive mass itself. The solutions that formed the veins followed openings outward from the core of the magma body and filled them with the vein minerals. They also soaked out through the previously consolidated border and left such minerals as fluorite, pyrite, sericite, and molybdenite disseminated through the granite. These replaced some of the earlier magmatic minerals, chiefly plagioclase. Evidence of the close genetic relation of the mineralized material to this particular body of granite is afforded by the fact that the principal filled fractures are close to the granite and that certain of the vein minerals within and near the granite have a zonal distribution.

Localization of ore bodies.--The sizes and shapes of the veins were determined by the character of the openings available at the time of deposition. As noted below, the grade of ore increases in proportion to the width of the veins, so that the ore shoots are confined to the larger parts of the veins. The

arrangement of the veins, described on page 12, appears to show that distention of the quartzite by heat late in the course of intrusion, followed by contraction on cooling, resulted in the forming of a few large fractures close to the granite mass and more numerous smaller ones farther away. Thus the valuable ore shoots are confined to the quartzite within a few hundred feet of the granite.

Size and grade of ore bodies.--All the known ore shoots are in the larger veins of the Ima mine. As shown on plates 2 and 3, the ore shoots on the main level are all in a stretch that extends 1,200 feet from the K. C. Li tunnel junction to the last ore shoot in the granite. The slope distance from this level to the top of the productive zone is 90 feet at the northwest end of the mine, 175 feet at the 10B2 raise, 250 feet at the 201 raise, and 300 feet from the K. C. Li tunnel junction to the highest stope on the surface. There are many pinches and swells. The maximum length of a stope without a pinch is 250 feet. The stopes above the lower level reach a maximum height of about 175 feet without a pinch. The shapes of the veins are shown by the section (pl. 2); in vertical section as well as in plan they show pinches and swells, and in the 10B2 vein is a wide roll where the thickness of the vein normal to the wall is 35 feet. According to Mr. Dice, the wide parts of the veins tend to be richer than the narrow parts. Near the top of the productive zone in the Bungalow 2 stope the vein averaged only 0.2 percent of WO_3, whereas from the 10A1 to the 10B1 the stopes averaged 1 percent.

Reserves.--The known reserves of blocked-out ore and probable ore are limited to the workings of the Ima mine. According to Mr. Dice, the stopes above the lower level still contain 50,000 tons of blocked-out ore, the average grade of which is probably about the same as that of the ore previously mined--0.55 percent of WO_3.

The probable ore, amounting to 40,000 tons, lies below the lower level. This level, which shows much thinning and pinching of the main vein, is evidently in the lower and narrowing part of the productive zone. It is perhaps liberal, therefore, to estimate that the probable ore body below the level in the main vein has a length of 1,000 feet, a thickness of 5 feet, and a depth of 100 feet. The depth is estimated from the results of diamond drilling, which indicates that the granite slopes 18° SE. and lies 300 feet below the lower level at the K. C. Li tunnel junction, so that it probably does not cut off the productive zone less than 100 feet below the level.

The west vein is so discontinuous or lenticular that no reliable estimate of its quantity of minable ore seems possible. It should be explored by conservatively placed crosscuts from a level 100 feet lower.

A shoot of ore may remain in the so-called Talmadge vein, which is exposed near the east portal on the lower level. Exploration of this vein may open up another shoot with an additional 50,000 tons of possible ore.

These estimates, totalling 90,000 tons of probable and possible ore, should not be expanded until justified by further exploration.

A little ore is exposed on the General Electric claims, but this ground has not been much explored and has not yet been proved to contain any appreciable tonnage of probable or possible ore.

Suggestion for further exploration.--The Ima Mines Corporation plans immediately to run another level 100 feet below what is now the lowest level in order to block out the remaining ore in the lower part of the shoot. A drift extending southeastward, on this same new level, to determine whether another ore shoot continues below and south of Patterson Creek is also planned. This would necessitate drifting 450 feet to the south-

east end of the present productive zone and driving 500 feet further to reach the area below the creek. Such work, with appropriately spaced crosscuts, should suffice to determine the possible extent of the ore shoots. Probably one or two diamond-drill holes ought to be sunk on the south bank of the creek before driving on this lower level. The work done thus far above the creek level on the south side of the canyon has not yielded results encouraging enough to warrant its being extended farther until the exploration below the creek level is completed.

The General Electric Co. plans to test its property with diamond-drill holes, placing the first holes near the Ima ground; and by correlating the results of this drilling with the information on surface and underground conditions already available the company hopes to locate the granite contact and ore shoots to the northwest. If the results of this work prove encouraging, other holes will be put down farther northwest.

The small veins and short lenses exposed on the surface have been pretty well explored, and all appear to be discontinuous and of low grade. They seemingly justify little further exploration.

The work done in the Blue Wing district was limited to the area shown on plate 1, and the possibility that deposits of huebnerite exist in other parts of the Lemhi Range was not eliminated. There are numerous quartz veins in the parts of the range that surround the area here described, and some of them are somewhat similar mineralogically to those on the Ima ground.

MINES AND PROSPECTS

Ima.--The Ima Mines Corporation holds 21 patented claims and 15 unpatented claims in sections 13, 14, 23, and 24, T. 14 N., R. 23 E. The company, which is purchasing the property from the previous owner, is at present carrying on exploration, development, mining, and milling. Many veins crop out on the property,

but production has all been obtained from a single set of veins that have been extensively explored and mined.

The geologic map (pl. 1) shows the relation of the mine workings and vein outcrops to the topographic and geologic features of the district; and the geologic maps of the levels and the geologic sections (pls. 2 and 3) show the principal features of the vein system, which, except for a few small shoots in granite, is wholly in the bedded and partly metamorphosed quartzites of the Belt series. The Ima mine has three levels (pl. 4), connected by raises and stopes, with drifts and crosscuts totalling 10,016 feet. The original portal of the main, or lower, level enters the steep canyon slope a few feet above the creek at an assumed altitude of 6,294 feet. The K. C. Li tunnel now affords a second entrance to this level. The upper adit is 200 feet higher. An intermediate level, roughly halfway between the other two, does not reach the surface. The upper level enters the mountain on the outcrop of the main productive vein zone, but a large part of its 2,265 feet of drifts and crosscuts is included in a long crosscut to explore veins that crop out to the east of this main zone. The main tunnel level consists of 5,266 feet of drifts and crosscuts, which explore one vein zone for 350 feet, near the surface, and another for 1,200 feet. The total distance from the portal to the face is 1,700 feet. The intermediate level has 2,485 feet of drifts and crosscuts. Practically no work has been done below the lower level.

One principal vein has been explored and mined throughout its length on all three levels. A second vein, which has been less productive, lies from 40 to 140 feet west of the main vein and appears on both the intermediate and the lower level. Just above the lower level the main vein assumes a gentler dip and is dropped to the east by a normal fault, so that it appears on this level as two veins, a west segment and an east segment.

The down-faulted segment probably does not extend far below the level. The general strike of the vein zone on the lower level is northwest and its average dip 60° W. The veins pinch and swell along the levels as well as up the raises, and in places they are wavy in cross section. Faults that strike N. 70° E. and dip 30°-70° N. on the upper level offset the veins from 10 to 100 feet southwestward.

The sizes and shapes of the ore bodies, the grade of the ore in them, their mineralogy, and other features have already been described (see pp. 10-15).

On the surface above the productive part of the vein system is the outcrop of a zone, roughly 100 feet wide and extending northward from the upper adit for 1,500 feet, of branching and unconnected vein lenses mainly less than 100 feet long and 3 feet wide. Some of these lenses contain a little huebnerite and sulphides. Raises above the productive ore shoots show a similar network of small veins. Most of these veins strike N. 20°-60° W. and dip 35°-70° SW., but their outcrops on the steep slope trend more nearly northward, as shown on the map. About 400 feet east of the main vein on the upper level is another vein zone that joins the first zone 800 feet above the upper tunnel. It also consists of small discontinuous veins, and the two crosscuts below this zone do not reveal any ore shoot, nor do they give promise of any. Two short drifts (Talmadge and lower Talmadge tunnels, pl. 5) show the nature of the veins in the Ima No. 9 claim. Still farther east is a parallel zone of small veins mainly dipping at angles of about 30° W. and showing a little huebnerite at an inclined shaft. A vertical vein (pl. 5) in the Ima No. 6 claim, trending N. 35° W. is explored by a drift 95 feet long. It is displaced at the base of the tunnel by a longitudinal fault dipping 30° SW. A vein in the No. 3 claim (pl. 5) is explored for 130 feet by a tunnel on the south side of the canyon. Another vein on the south side of the

canyon on the Ima No. 10 claim, opposite the Ima mine, trends N. 35° W. at the outcrop, which is 7 feet wide, but a crosscut below (pl. 5) revealed only a small unproductive vein. The Boise-Ellis tunnel in the Ima No. 1 claim follows a 2.5-foot vein that strikes N. 23° W. and dips 72° SW., samples from which contain virtually no tungsten. The tunnel in the Ima No. 2 claim shows a small vein striking N. 23° W. and dipping 75° SE. In the Ima No. 8 claim two cuts and a 40-foot incline shaft for a length of 200 feet expose a 2-foot vein that strikes N. 60° E. and dips 40° NW.

Nearby, in the Ima No. 14 claim, is another vein striking N. 18° W. and dipping 51° SW. It is 1.5 feet wide and contains a little huebnerite and tetrahedrite. A group of small veins in the Ima No. 19 claim follows the bedding, which strikes N. 15°-30° W. and dips 11°-20° SW.

General Electric-Miller mine.--The General Electric Co. has acquired 48 lode claims northwest of the Ima Mines Corporation ground. Those surveyed for patent, totalling 24, are shown on plate 1. Ground for a millsite and for water rights has been acquired near Patterson.

Only an experimental shipment of 40 tons of ore, taken from a prospect pit in the Mazda No. 28 claim, has thus far been produced on this property. This ore came from a bedding vein, exposed in a large pit, which strikes northwest and dips about 30° SW. A tunnel nearby shows a 2-foot vein, probably the same one, striking N. 40° W. and dipping irregularly 25° SW. (fig. 2).

A short tunnel (fig. 2) below the twin shafts shows a vein containing much manganese and copper stain and some huebnerite. The vein strikes N. 33° W. and dips 80° NE. A lower crosscut (fig. 2) shows no vein, and the quartzite is very slightly disturbed.

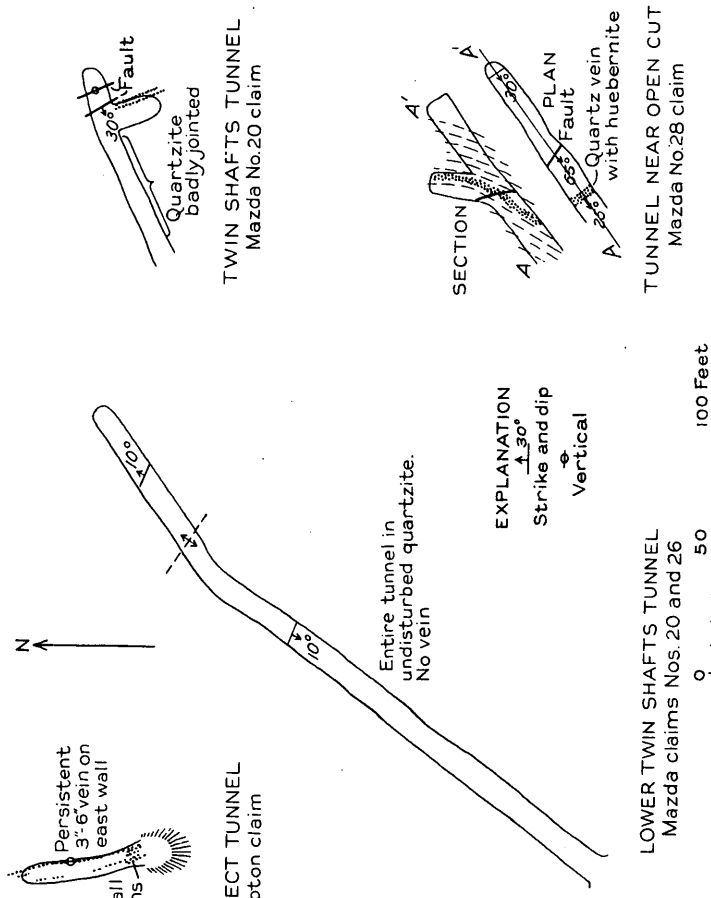
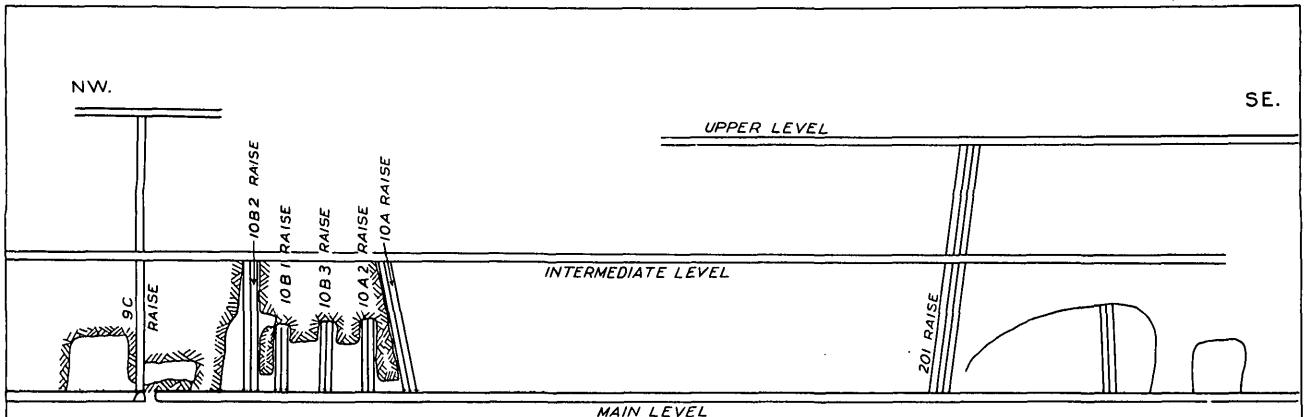
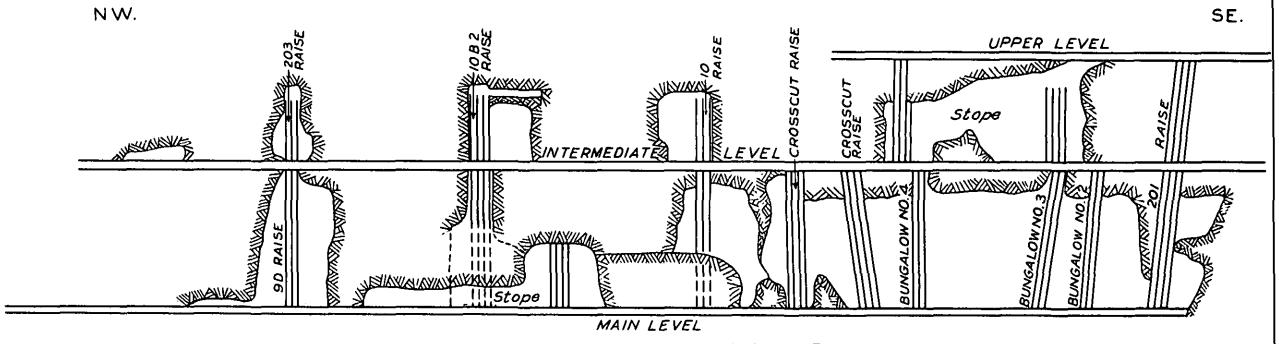


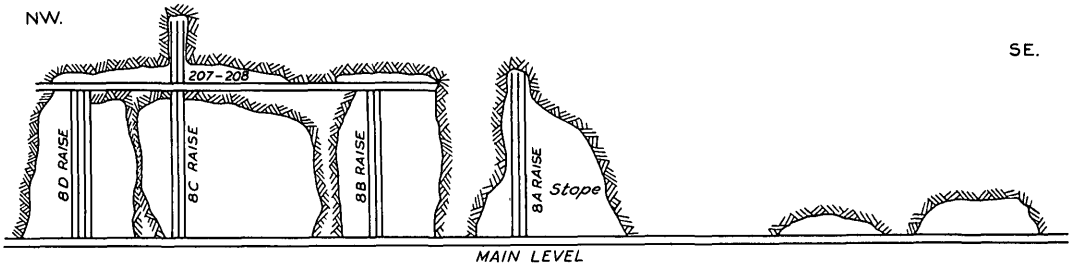
Figure 2.—Maps of prospect tunnels, General Electric-Miller group and Compton claim.



PROJECTION ALONG EAST SPLIT OF MAIN VEIN



PROJECTION ALONG WEST SPLIT OF MAIN VEIN



PROJECTION ALONG WEST VEIN

50 0 50 250 Feet

Prepared by Carl Dice, of Ima Mines Corporation

LONGITUDINAL PROJECTIONS OF THE IMA MINE

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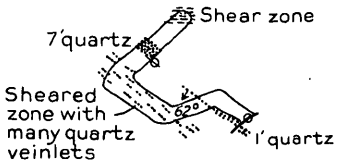
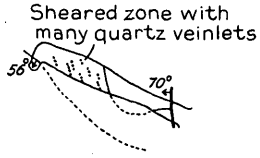
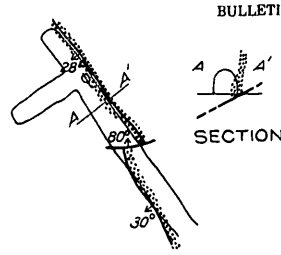


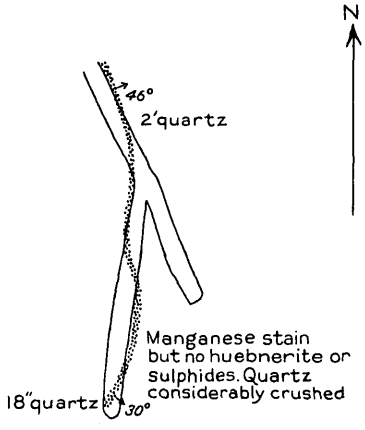
TALMADGE TUNNEL
Ima No.9 claim



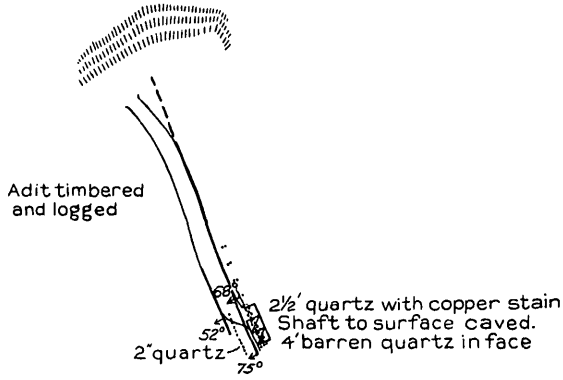
LOWER TALMADGE TUNNEL
Ima No.9 claim



IMA No.6 CLAIM TUNNEL



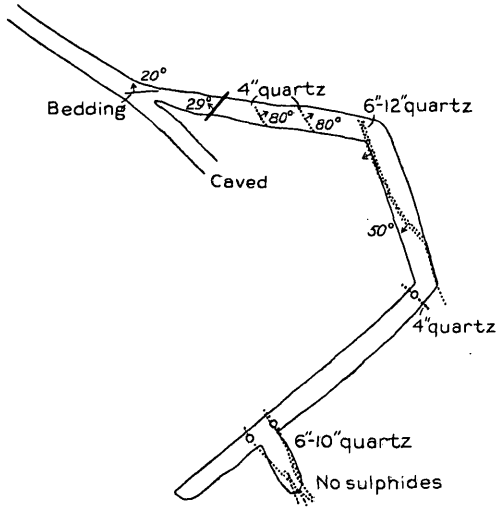
IMA No.3 CLAIM TUNNEL



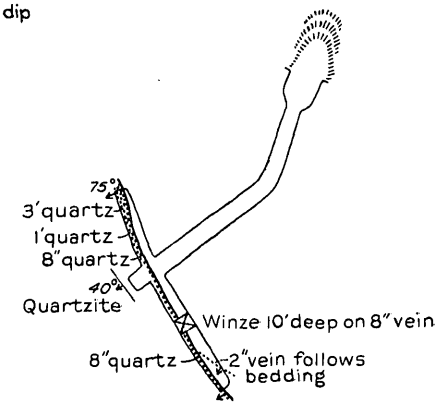
BOISE ELLIS TUNNEL
Ima No.1 claim

EXPLANATION

Fault
Vein
30°
Strike and dip
Vertical



IMA No.10 CLAIM TUNNEL



IMA No.2 CLAIM TUNNEL

0 50 100 Feet

MAPS OF PROSPECT TUNNELS, IMA MINE

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On the slope above the Ima mine in Patterson No. 2 claim are a long trench and a short tunnel showing several bedding veins mostly less than 1 foot wide and dipping gently to the southwest.

The Cowboy tunnel in Mazda No. 13 claim reaches two veins at right angles to each other 120 feet from the portal. Two pits immediately above show the same or similar veins. The larger vein is 1 foot wide, strikes N. 80° E., and dips 62° NW. The smaller strikes N. 20° W. and dips 60° SW. A short tunnel and a pit on the south side of the gulch northeast of the cabins in the Mazda No. 6 claim show a 1-foot vein striking N. 45° W. and dipping 50° SW.

Several other small veins have been prospected to a slight extent on the property.

The company is actively exploring the Mazda No. 20 and Patterson No. 2 claims by means of trenches and by a crosscut tunnel, now 700 feet long, starting in the Mazda No. 33 claim and aiming N. 50° E. for the mineralized ground on Mazda No. 20, which will be reached at a depth of 650 feet. Diamond drilling is also contemplated. Numerous pits and tunnels excavated on the property by earlier prospectors reveal several small veins, some of which contain huebnerite.

Other prospects.--Alex Compton holds some claims on the north side of Patterson Canyon, east of the Ima ground. A small vein containing huebnerite has been followed for 48 feet by a small drift trending N. 10° W.

Huebnerite occurs in vein-quartz float on the Rosebud claims on the northwest edge of the mapped area, beyond the General Electric ground. The vein has not been found in place, although several pits and a short adit have been dug in search of it.

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