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TUNGSTEN DEPOSITS OF BOULDER COUNTY, COLORADO

BY

T. S. LOVERING

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TUNGSTEN DEPOSITS OF BOULDER COUNTY, COLORADO

By T. S. Lovering

ABSTRACT

The tungsten district of Boulder County, Colo., is a narrow belt trending west-southwest and about 10 miles long, in the pre-Cambrian terrane west of Boulder. Mining began in 1900, and the total production of ferberite concentrate through 1938 has been equivalent to 20,650 tons containing 60 percent of WO_3. The country rock is chiefly pre-Cambrian schist and gneissic quartz monzonite, which is cut by andesite and latite dikes of Laramide (late Cretaceous and early Tertiary) age. The ore occurs in veins that trend east to north-northeast, but much of the production is localized in areas close to a few persistent quartz-hematite reefs of northwesterly trend. The ore, which is essentially ferberite-bearing quartz, was deposited in pre-mineral fault fissures where open spaces were formed during the fault movement. The alteration of the wall rock and the paragenesis of the minor constituents indicate deposition from slightly acid hypogene solutions. Most of the ore shoots are from 6 inches to 3 feet wide and extend to depths that rarely exceed 300 feet. Much of the ore mined averaged about 7 percent of WO_3, and the lower limit of commercial grade is regarded as about 1½ percent of WO_3.

It is probable that very few outcrops of ore shoots have remained undiscovered in the district, and though many blind shoots may exist the cost of finding them would be high. A small annual production may be expected to continue for many years but is unlikely ever again to reach 1,000 tons a year.

INTRODUCTION

In 1930 the United States Geological Survey, in cooperation with the State of Colorado and the Colorado Metal Mining Fund, began a geologic study of the Boulder County tungsten district. Since that time this work has been subject to many interruptions, but the final report is now in preparation. E.B. Eckel, James Boyd, Vernon Sheid, and Lamphere Graff assisted in the field work. I wish also to acknowledge my indebtedness to the many individuals in the tungsten belt who gave their full cooperation. Without exception the miners freely provided available information concerning production, and in no case was permission to visit a property withheld.

The Boulder County tungsten district is close to the eastern edge of the Front Range and just west of Boulder (pl. 24). The tungsten deposits occur in a narrow belt, 9½ miles long, that trends west-southwest from Arkansas Mountain, about 4 miles west of Boulder, to Sherwood Flats, 1½ miles northwest of Nederland.

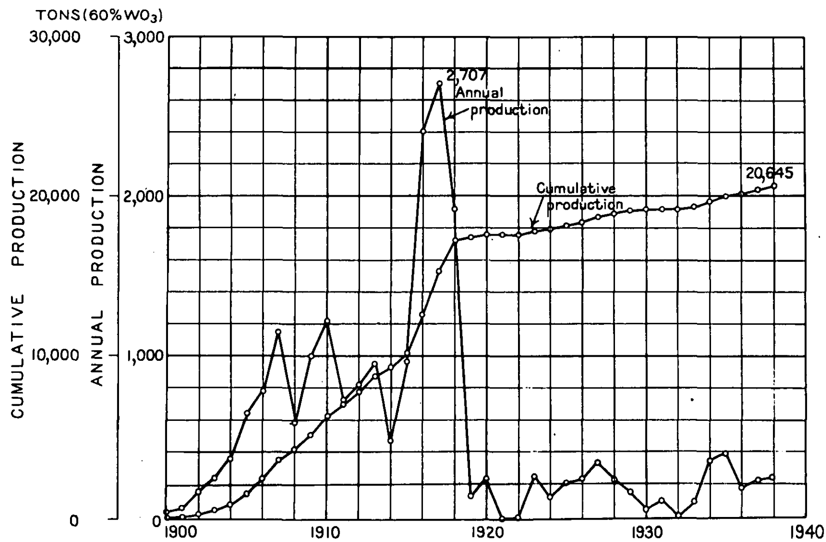

Figure 25.--Ferberite concentrates (reduced to equivalent of 60 percent of WO_3) produced in Boulder County, 1900-1938.

Tungsten ore was first recognized in the district by Mr. H. H. Wanamaker in 1900, and from that year to the present the district has been continuously productive except in the years 1921, 1922, and 1932 (fig. 25). The production figures for 1900 through 1906 are less accurate than those for the succeeding years, but during that time the district produced 2,325 tons of concentrate,[1] probably equivalent to about 2,300 tons of concentrate averaging 60 percent of WO_3. The grade of the concentrates ranged from 50 to 71 percent of WO_3 but was mostly between 55 and 65 percent. From 1907 to 1938 inclusive the district produced 18,345 tons. It is safe to say that the total production through 1938 has been approximately 20,650 tons of concentrate averaging 60 percent of WO_3, a total production more than 50 percent greater than that of any other tungsten district in the United States. Since 1918, however, production from Boulder County has averaged only about 200 tons a year. In contrast to this decline the Nevada contact metasomatic deposits have become more and more productive, and for several years they have been the chief source of tungsten within the United States.

GEOLOGY

Rocks

About three-quarters of the district lies within a small batholith of pre-Cambrian gneissic quartz monzonite that extends westward from Boulder nearly to Nederland. This rock is known as the Boulder Creek granite. A very productive part of the district lies within the area of metamorphic rocks bordering the batholith on the west, where quartz-biotite schist of the Idaho Springs formation has been intimately intruded by aplite and pegmatite related to the batholith. These small intrusive masses are irregular in outline, but in general their long dimensions are north-northwest, parallel to the schistosity of the Idaho Springs formation and to its contact with the

1/ George, R. D., The main tungsten area of Boulder County, Colorado, with notes on the intrusive rocks by R. D. Crawford, First report, 1908, Colorado Geological Survey, p. 86, 1909.

Boulder Creek granite. The pre-Cambrian rocks are cut by dikes of Laramide (late Cretaceous and early Tertiary) age. Dikes of hornblende monzonite porphyry and hornblende diorite porphyry are common in the western half of the district, and biotite monzonite porphyry dikes, associated with biotite latite intrusion breccia, are found in several localities in the eastern part of the district.

Structure

Foliation and related pre-Cambrian structure in the Idaho Springs formation and in the Boulder Creek granite near the western edge of the batholith has a general north-northwesterly trend and a steep dip to the northeast. Farther east the strike of the foliation swings to east-northeast, and the dip in the eastern half of the tungsten district is to the north at a moderate angle. The Laramide structure, however, is of most importance in localizing the tungsten ore. Two major fracture systems of this age stand out conspicuously on plates 24 and 25. The earlier but more persistent fractures trend northwestward and are nearly barren, though they are apparently of considerable importance in localizing the ore. The later system, which trends from east-northeast to north-northeast, contains nearly all of the tungsten veins.

The faults of northwesterly trend can be traced for many miles through the pre-Cambrian terrane, and many of them have been followed into the foothill belt, where they pass into folds in the Paleozoic and Mesozoic sediments. Members of this persistent fracture system are found throughout the tungsten belt spaced from 2 to 3 miles apart. In most places they are marked by a peculiar type of mineral deposit quite distinct from the later veins. Although this type of deposit differs from place to place and reflects the complex history of the faults, it is generally characterized by the widespread presence of quartz and iron oxides, which give a distinctive appearance to the outcrops of the faults.

Because of their tendency to localize ore deposits, many of the faults of northwest trend have received local names, and all are designated as "breccia reefs." Those found in the tungsten belt include, from east to west, the Hoosier reef, which marks the eastern end of the tungsten belt, the Livingston reef, the Rogers reef, the Hurricane Hill reef, and the Main-Cross reef, which marks the western limit of the productive belt. Both the Hoosier reef and the Livingston reef are strongly silicified in the tungsten belt and contain less hematite than the breccia reefs to the west. The Rogers reef, where it crosses the ridge between North Boulder and Middle Boulder Creeks, contains abundant hematite and quartz and as much as 0.03 ounce of gold to the ton. The Hurricane Hill reef is close to the western margin and ranges from a wide, gougy, unmineralized fault zone to a strongly silicified shear zone with or without hematite. The tungsten deposits in the Beaver Creek district south of Nederland end abruptly against the Maine-Cross reef, a strong fracture showing evidence of mineralization for about a mile to the northwest. If the reef continues beyond this point, as seems probable, it is present only as an inconspicuous shear zone parallel to the schistosity of the Idaho Springs formation. In the Illinois mine, about a mile northwest of Nederland and in line with the Maine-Cross reef, there are several minor shear planes of northwesterly trend, some of which contain hematite. This mine is only a few hundred yards from the westernmost ore in the tungsten district.

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Veins

Aside from some small disseminated deposits in the western part of the district, all the tungsten ore occurs as fissure filling in veins. Some of the veins follow persistent branching fractures that can be traced for more than a mile, but others can scarcely be followed a hundred yards. The repeated brecciation of the vein filling shows that movement preceded, accompanied, and followed ore deposition. Post-mineral faults are rare, however; offset of the veins has been observed in only a few places, and nowhere was the movement more than a few feet.

All the tungsten veins follow pre-mineral faults that are later than the early movement along the breccia reefs and in large part later than the breccia-reef mineralization. Nearly all strike either north-northeast or east-northeast, although a few persistent veins in the Beaver Creek area trend eastward. As shown on plate 25, there are three rather marked zones of east-northeast-trending fractures. The strongest of them, here designated the Hurricane Hill-Comforter Mountain zone, extends eastward along the north slope of the valley of Middle Boulder Creek to the eastern edge of the district. A zone of less persistent intersecting fractures of easterly and northeasterly trends is found along Gordon Gulch, half a mile to a mile north of the Hurricane Hill-Comforter Mountain system; and a third zone lies just north of Beaver Creek in the southwestern part of the district. The Gordon Gulch zone and the Hurricane Hill-Comforter Mountain zone converge westward toward the north end of Hurricane Hill, and to the west nearly all the production has come from a single narrow belt that extends west-southwestward along Sherwood Gulch from the north end of Hurricane Hill to Sherwood Flats, the western limit of the tungsten belt. Most of the veins within this belt strike obliquely across it in a north-northeasterly direction, and although they are individually short, a substantial proportion of the output of the district has come from them.

Along both the eastward-trending and northeastward-trending fissures the relative movement of the walls has been nearly horizontal. In most places the north wall of the eastward-trending fractures and the southeast wall of the northward-trending fractures moved downward to the west at a low angle. Such a movement can be explained by assuming that the series of wedge-shaped blocks marked off by the intersection of the northeastward-trending veins with the eastward-trending fractures moved downward and to the west in response to nearly horizontal compressive forces.

ORE BODIES

Mineralogy

Most of the ore consists of small crystals of ferberite (ferrous tungstate) disseminated through contemporaneous quartz. Most of the vein filling is made up of fine-grained quartz of many generations, a few of which contain ferberite and a minor amount of other minerals. The fine-grained quartz, known locally as "horn," is of many different colors. White, gray, and black are the most common, but red, brown, and green are also found. The ferberite commonly forms the matrix of a breccia of country rock and early vein quartz, and seams of nearly pure massive ferberite several inches thick occur in places. Less commonly, brecciated masses of ferberite cemented by later quartz are found. Drusy openings are common, and the district is famous for beautiful specimens of sparkling black ferberite crystals that line open spaces in some of the veins. The ore as mined averages from 2 to 20 percent of WO_3.

Some of the tungsten-bearing veins occur in fresh, almost unaltered granite, but the wall rocks of most of them are strongly altered. Usually a narrow casing of sericitized and slightly silicified rock adjacent to the ore passes abruptly into an outer envelope in which the rock has undergone an intense argillitic (clay mineral) alteration. The minor constituents of the veins, named in approximate order of deposition, include hematite, magnetite, fluorite, dickite, ankerite, siderite, barite, pyrite, marcasite, calcite, galena, sphalerite, freibergite, tetrahedrite, miargyrite, adularia, montmorillonite, halloysite, beidellite, scheelite, and opal. The relation of the ferberite to these minerals and to the character of alteration in the country rock throws much light on the origin and chemistry of the ferberite deposition, but space does not permit its full discussion here. For a fuller treatment of the problem, and for details of mineralogy, the reader is referred to a forthcoming paper in Economic Geology. Some of the more pertinent conclusions, however, concerning the origin of the deposits are summarized below.

Origin

The argilliferous altered rock bordering the veins indicates attack by acid solutions, and the narrow inner sericitized casing shows a change to neutral and alkaline solutions at a later stage. Within the veins the formation of dickite and marcasite immediately preceded the deposition of pyrite and ferberite. Hypogene brown iron hydroxide was formed later than the ferberite, and barite and adularia later still. This sequence indicates a progressive change from acid to alkaline solutions and harmonizes with the evidence of wall-rock alteration. Ferberite was apparently precipitated in very slightly acid solutions. Sphalerite, galena, tetrahedrite, chalcopyrite, and miargyrite are later than the ferberite and brown iron hydroxide and were presumably precipitated in alkaline solutions.

Field evidence suggests that the source was a biotite latite magma heavily charged with volatiles. This conclusion is supported by the discovery of small amounts of tungsten in the latite by Mr. Joseph Bray, who kindly made a spectroscopic examination of some fresh biotite latite and latitic intrusion breccia from the Yellow Pine and Logan mines. It is suggested that emanations from the underlying latite magma rose through the hot porous explosion breccia with little change in character, that by reaction with the monzonitic wall rock of fissures higher up they became neutralized and finally alkaline through the acquisition of bases, and then deposited their loads in these fissures. (Fig. 26.) It seems probable that the deposits were formed at temperatures between 200° and 300° C. and under pressures of not much more than 100 atmospheres.

Changes with depth

There is little direct evidence of a relation between character of alteration and depth, but in the Cold Spring mine the ratio between the width of the sericitized casing and that of the argillized envelope seems much less on the upper levels than on the bottom levels. Since, however, this ratio varies greatly on the same level and is in general much smaller near ore than along the barren stretches of the vein, the reality of the apparent change of the ratio with depth is open to question. The Madeline vein--a vein chiefly noteworthy for the extensive exploration carried on in spite of the lack of return on the money spent--has one of the most strongly argillized envelopes in the district but no sericitized casing, and within the vein almost no ferberite was found. At several places in this vein there is barren quartz a foot or more in width, but it was found to bottom abruptly, giving way to a strongly argillized vein filling beneath. Although the Madeline vein itself is nearly barren, some profitable ferberite ore bodies were found in small branch veins near their intersection with it. This relation suggests that the Madeline may have acted as a trunk channel for the mineralizing solution. The observations cited harmonize with the theory that alteration to clay minerals increases with depth and proximity to the source of the mineralizing solution.

The substantial amount of silica removed from the granite, in the zone of argillitic alteration, by the attack of acid waters was probably deposited in large part as a vein filling in places where the solution became cooler or less acid. The constant shifting of the major channels of circulation, owing to intermittent movement along faults during the period of mineralization, was probably an important factor in the precipitation, as it would allow the alternate cooling and heating of different areas of a vein. The quartz is pictured in figure 26 as deposited in a shifting but gradually descending zone of precipitation along intermittently active fault zones. If the decrease in acidity of the solution was due in large part to reaction with country rock and if ferberite was deposited from neutral or only slightly acid solutions, it follows that sericitic alteration would be at a maximum and argillization at a minimum near the upper limit of the zone of ore formation, and that, conversely, the one would decrease and the other increase downward, to or below the lower limit of that zone. Along the major channels of mineralization the ferberite-bearing vein quartz should give way downward to a zone of intense argillization such as is found along the Madeline vein.

As a delicate balance of conditions was essential to its deposition, the tungsten ore was deposited in a relatively narrow zone, but the bottom of this zone would be at different altitudes along different veins. It is thus impractical to try to fix any definite altitude below which tungsten ore would not be

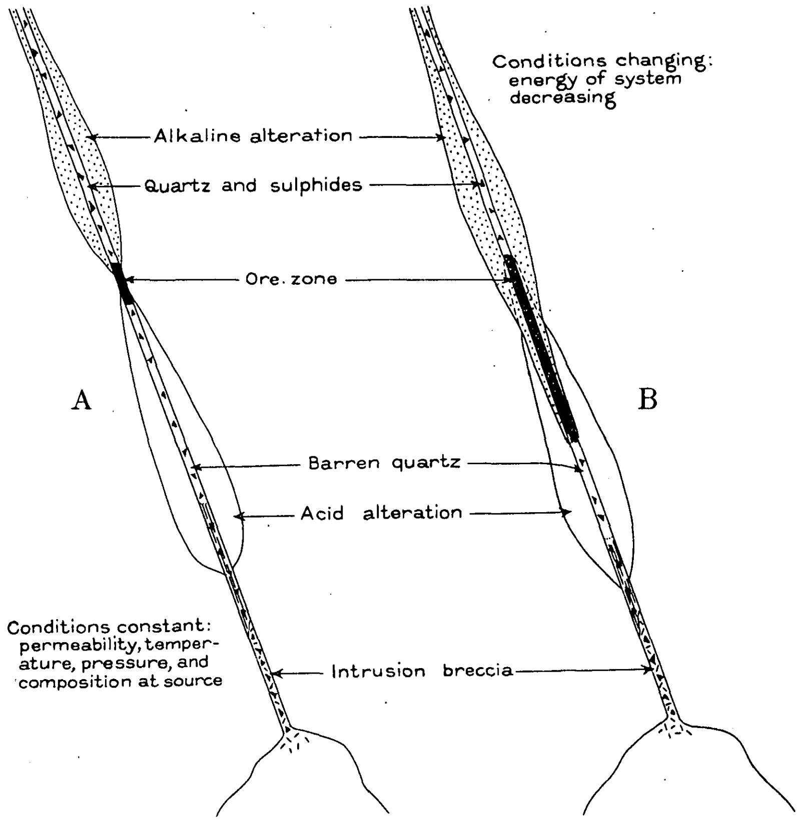

Figure 26.—Diagram representing conditions of mineralization. A, Early state of mineralization; B, Dying stage of mineralization.

found and above which it might be expected, though a change in the character of the alteration of the wall rock may help the miner to judge whether or not the termination of an ore shoot coincides with the bottom of the zone of ferberite precipitation in a given vein.

In the southwestern part of the district, ore has been mined between altitudes of 8,200 and 8,800 feet; in the northwestern part, ore cropping out at the surface at an altitude of 8,700 feet has been mined to a vertical depth of 700 feet; and at the extreme eastern edge of the district, ore has been mined between altitudes of 6,400 and 7,100 feet. In general, it may be said that ore has been found at many places in the district through a vertical range of about 700 feet. It is noteworthy that at each place this depth corresponds rather closely to the local topographic relief--a fact whose significance will be discussed presently. Most of the individual ore shoots have been followed to a depth of less than 100 feet, though a few, notably the Conger and the Cold Spring, have been followed much deeper.

The shape of the ore shoot depends almost entirely on the shape of the open spaces available within the vein at the time of tungsten mineralization. As shown by the longitudinal section of the Cold Spring mine (fig. 27), ore shoots whose sections in the plane of the vein are vertically elongate, elliptical, or highly irregular may occur in the same vein within a short distance. Several profitable ore bodies have been found during underground development, though no sign of them had been observed at the surface. It seems probable that many blind ore shoots of this type exist within the district, but with the price of tungsten as low as $15.00 per unit, the cost of discovering most of them is prohibitive. The small extents of most of the individual ore shoots and the fact that by far the greater number of ore bodies mined thus far cropped out at the surface, suggest that the correspondence between the range in depth of the ore and the topographic relief largely reflects the ease with which ore bodies can be discovered, rather than the vertical extent of the zone of deposition of the ferberite.

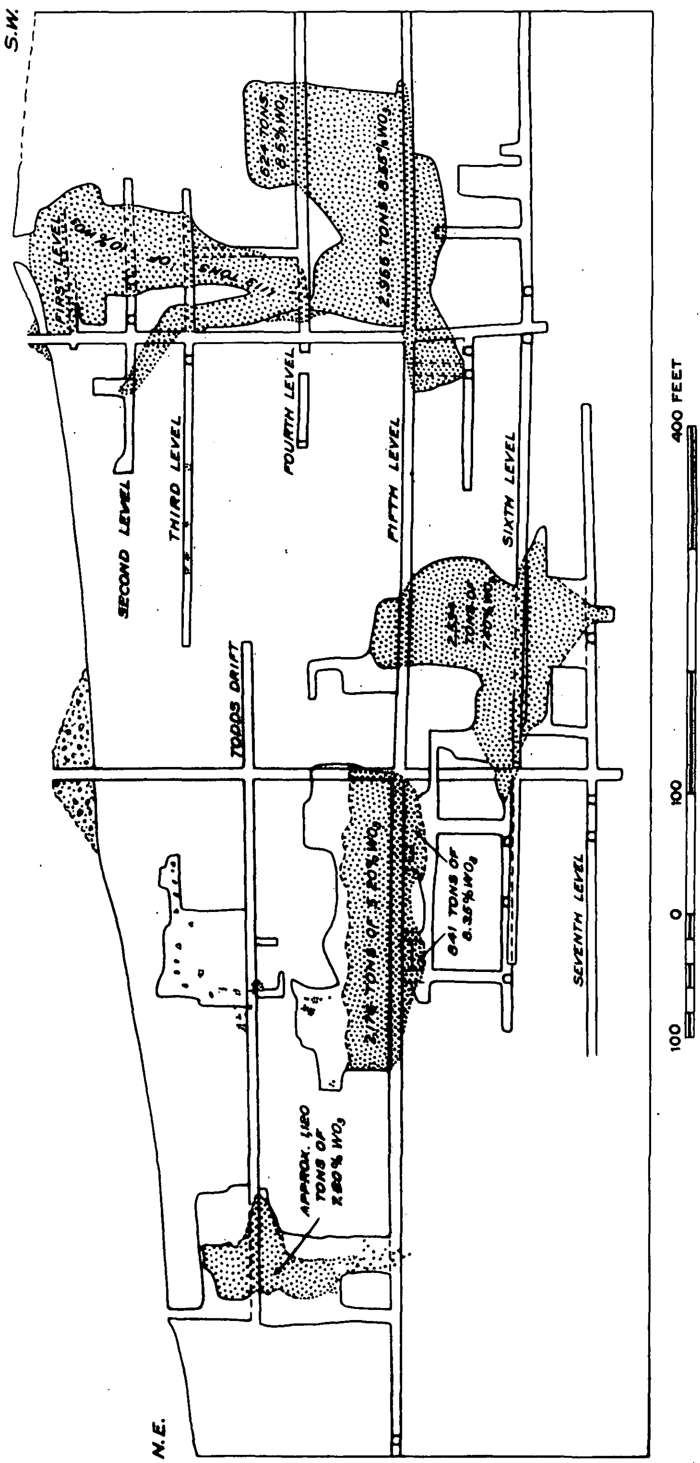

Figure 27.--Longitudinal section of the Cold Spring mine showing stopes and ore bodies.

The deepest continuous ore shoot--that of the Conger mine--was found close to the western edge of the district. It had a vertical depth of a little more than 700 feet. The shaft was sunk 300 feet deeper without finding more ore, but very little exploration was carried on below the seventh level. If exploration in the Cold Spring mine had been similarly restricted, three profitable blind ore shoots would have been missed.

Localization of ore shoots

The localization of an ore shoot was primarily controlled by the relative permeability of the different parts of the fissure during mineralization. This depended in part on the character of the wall rock. Schist and altered granite were readily reduced to impermeable gouge, whereas silicified rock, "horn" filling, fresh granite, and pegmatite were merely fractured to form open rubble. In the metamorphic area west of Hurricane Hill, tungsten ore is rarely found between schist walls but commonly occurs where a rib of pegmatite or aplite within the schist has been broken by a pre-mineral fault. Within the Boulder Creek granite batholith, the granite is more extensively altered than aplite or pegmatite. Movement of fissure walls tended to make more gouge in granite than in dikes of aplite or pegmatite, and this fact is reflected in the occurrence of the ore.

Nearly all the ore shoots show, in addition, a structural control directly related to the movement of more or less irregular fissure walls and to changes in the course or the dip of the fissure. In most of the tungsten veins there is a strong horizontal component of movement, and in those veins in which, let us say, the right-hand wall moved forward, there is a marked tendency for ore to occur where the vein's course swings to the left. This type of control is shown in the Cold Spring mine (fig. 28). Similarly, ore shoots occur in the steeper parts

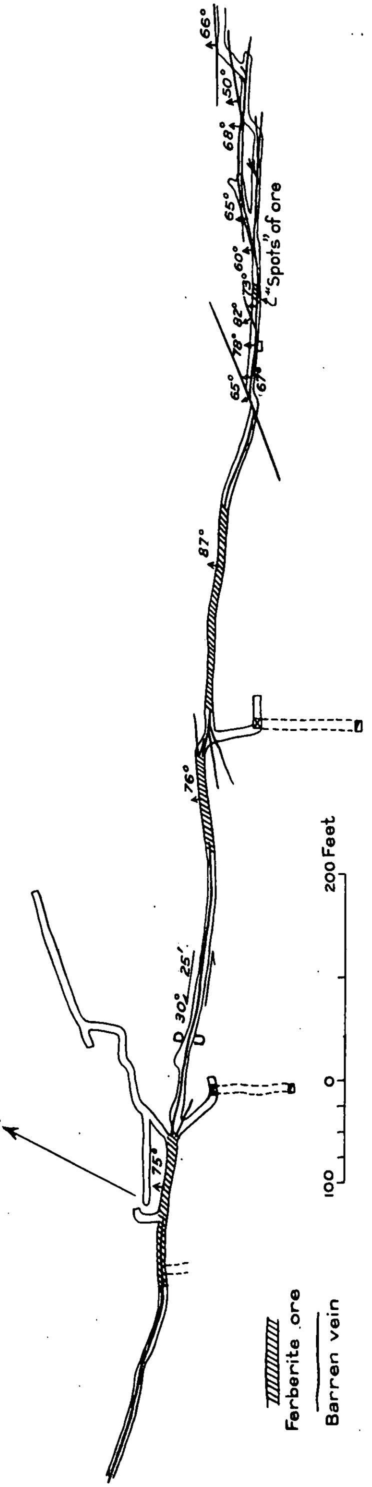

Figure 28.--Localization of ore at change in the course of a vein. Fifth level, Cold Spring mine.

of a pre-mineral normal fault. Reverse faults are uncommon, and valuable production is seldom recorded from the less steep parts of the veins. Narrow wedges formed at the intersection of two veins or where a branch vein diverges from a main vein were commonly localities of brecciation and, as such, more permeable than other parts of the vein. Many of the ore shoots in the

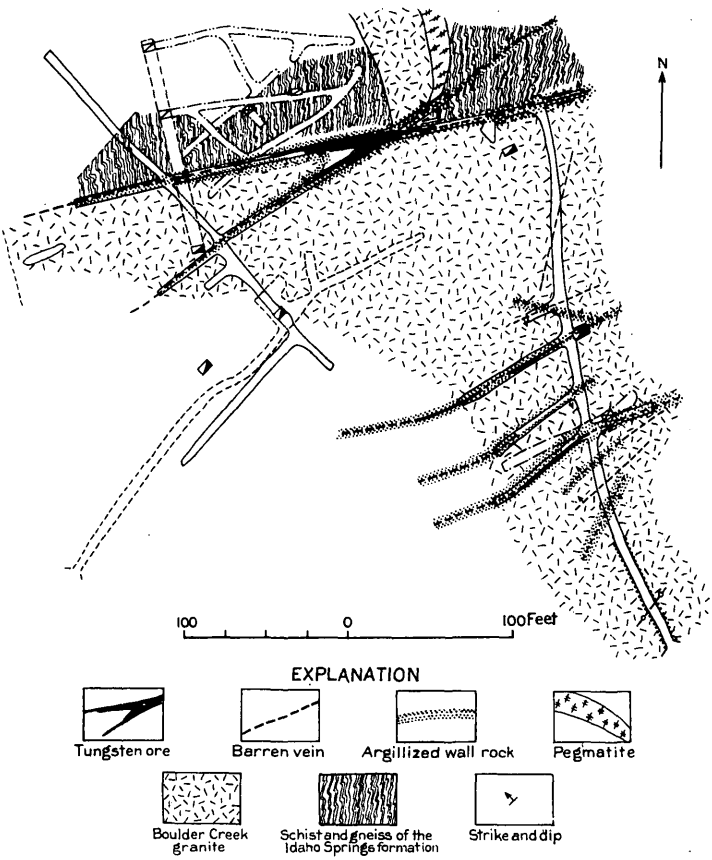

Figure 29.--Localization of ore at junction of two intersecting veins, Lily tunnel.

district are localized at the intersection of branch veins or of crossing veins. These types of structural control are well-illustrated in the Rogers No. 1 vein and the Rakoff vein of the Lily tunnel (figs. 29 and 30).

Size and grade of ore bodies

The width of the average tungsten vein ranges from 6 inches to 3 feet, but in places ore bodies from 12 to 16 feet in width have been exploited. The grade of ore as mined commonly ranges between 2 and 20 percent of WO_3. Ferberite formed by replacement or impregnations of country rock or broad shattered zones is rare, and no extensive bodies of low-grade ore are known in the district. In parts of the veins the ferberite is very

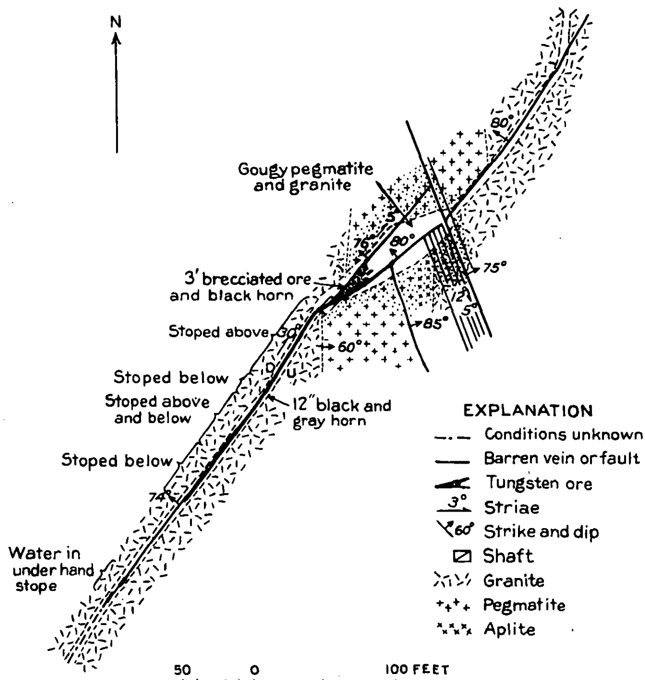

Figure 30.--Localization of ore at junction of a branch vein near intersection of a northeast vein with a breccia reef. Upper tunnel, Rogers No. 1 mine.

finely disseminated in the fine-grained quartz that makes up the bulk of the vein, and such material may assay from 0.5 to 2 percent in ferberite, but the difficulty of milling it has generally prevented its use. Bodies of this type are not abundant, but a moderately large deposit of black ferberite-bearing horn quartz has been worked, though unprofitably, in the Copeland mine, 2½ miles south of Magnolia.

Valuable information as to the size of some ore bodies mined in the past is fortunately conveyed by the intelligently recorded production figures of the Wolf Tongue Mining Co., which has been one of the most successful operators in the district since 1905. These figures were courteously made available for publication in this report. The Cold Spring mine, which is operated by this company and is one of the two most productive mines in the district, furnished most of its ore from four separate shoots, all of which have been completely mined out. The largest of these contained about 4,500 tons of ore, which averaged between 8½ and 10 percent of WO_3. Two other shoots each supplied about 3,500 tons, which averaged between 6 and 7 percent of WO_3. The fourth shoot produced 1,120 tons of ore, which averaged 7.60 percent of WO_3. The production from more than 50 other ore shoots has averaged a little more than 350 tons each, assaying about 8 percent of WO_3. This is equivalent to more than 46 tons of 60-percent WO_3 concentrate from each shoot and is believed to be a very fair figure for the productivity of the average commercial ore shoot in the tungsten belt. The grade of ore that can be worked depends to some extent upon the texture of the ferberite, as the fine-grained ores in the eastern part of the district do not concentrate as well as the coarser-grained ores found farther west. With the price of tungsten ore about $20.00 per unit, the minimum tungsten content of crude ore that can be profitably mined is probably not far from 1½ percent of WO_3.

Suggestions for prospecting

The areas believed most favorable for prospecting are outlined on plate 25. They take the form of elongate areas close to the major breccia reefs that cross the district. Most of the ore mined has come from these areas. Ore bodies are known between these favored areas, and ore bodies will presumably continue to be found outside them from time to time; however, it seems that the areas most likely to be profitably explored are those in which mineralization is known to have been pervasive and known deposits have had commercial value.

The generalizations made in the section on ore shoots should be kept in mind in prospecting. Experience through the district shows that different types of country rock offer different degrees of hospitality to the ferberite ore shoots. Within the schist area aplite, granite, and pegmatite all make excellent hosts, but within the main area of Boulder Creek granite the ore bodies, especially the smaller shoots, are likely to widen between walls of pegmatite and aplite and to become narrow where granite forms both walls. The character of alteration in the wall rock along the vein is significant. In general, strongly argillized wall rocks are unfavorable unless there is a well-developed silicified or sericitized casing along the vein itself. Branch veins in a hanging wall of strongly argillized rock are very likely places for ore if their walls are either sericitized or fresh but are unfavorable if only argillized wall rock is present. The late vein minerals barite, opal, beidellite, pyrite, and sparse galena and sphalerite are most abundant near the tops of ore shoots and may therefore serve as "leads," but conspicuous amounts of lead, zinc, and silver minerals are unfavorable. Small amounts of barite, opaline quartz, and pyrite and meager amounts of sphalerite and galena have been noted at the top of Hurricane

Hill in the Hurricane Hill breccia reef. It would seem probable that future work will prove the presence of ferberite ore bodies in branch veins hidden beneath the heavy soil cover in this locality. It is difficult to ascertain the changes in strike and dip of veins in advance of exploration, but where such structural information is available and the relative movements of the walls are known, the most favorable localities for exploration can be forecast. The intersection of branch veins and cross veins can, however, be ascertained much more easily.

Geophysical methods of prospecting for the tungsten ore have met with little success. Ferberite is an excellent nonconductor of electricity and differs very little in any of its electrical properties from the barren vein quartz with which it is associated. Its density is large, but calculations by C. A. Heiland, professor of geophysics at the Colorado School of Mines, indicate that a torsion balance would have to be set up within 25 feet of one of the largest ore bodies in the district, for example, the upper ore body of the Clyde mine, before its presence would be indicated by the instrument. Ore shoots are more open, water-bearing, and hence more conductive than other parts of the vein, and it was hoped that these permeable parts could be located by resistivity measurements. Such measurements were made by the Wolf Tongue Mining Co., and several areas of relatively high conductivity were established along different veins; but the results of diamond drilling at the points indicated proved disappointing, and no ore was discovered, though strong flows of water were found in most of the places tested.

The outcrops of the veins can easily be traced beneath a shallow cover by the use of the equipotential method, where search coils are used to discover the distortion of an electric current propagated by means of a line electrode. This method was also tried out by the Wolf Tongue Mining Co. and found to be relatively rapid and accurate. Owing to the oxidation of ilmenite, pyrite, and magnetite in the zone of argillization, such zones of altered rock show a much lower magnetic strength than the unaltered wall rock and are therefore easily traced by the negative anomaly that characterizes them; but this is a very minor aid in the search for tungsten ore shoots. Because of the difficulty of finding the ore bodies themselves by means of geophysical methods or the lore of the miner, many operatives, both large and small, have been impelled at times to seek aid from men who profess to have special spiritual guidance or supernatural ore-finding doodlebugs that do not obey ordinary natural laws. These methods have been as unsuccessful as any other form of wishful thinking.

Diamond drilling, churn drilling, and pneumatic hammer drills have been used underground in exploring the walls of known veins, but almost no surface drilling has been undertaken. Hammer drills and churn drills must be used with caution, as ferberite slimes readily, and a thin seam of commercial ore may easily be missed. Diamond drilling is the most satisfactory method, but much difficulty is had in drilling the soft argillized wall rock, which forms what the driller calls "ravelly ground." Because of the spottiness of the tungsten ore, it is easily possible to drill through a vein in a spot that shows little or no ore, although a profitable shoot may be present nearby. If ground is drilled and no ore is found in a vein, most operators remain unsatisfied until they have opened up the vein with a drift or shaft. Tests with shaft and drift are by far the most satisfactory methods of exploration for the miner, but the sparse distribution of ore shoots in a vein makes this method wasteful unless carefully directed by drilling.

Future of the district

It seems probable that most of the tungsten ore of the district has already been mined. Many undiscovered ore shoots may still be present in the district, but the cost of finding them will be considerable. Under normal conditions of exploration, and with the price of tungsten about $20.00 a unit, it may be expected that the district will continue to produce a few hundred tons of concentrate a year for many years to come. Even with the stimulus of high prices it is doubtful if the annual production will reach 1,000 tons unless an elaborate campaign of geologic exploration and diamond drilling, whose success would be uncertain, is carried forward.

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