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TUNGSTEN RESOURCES

OF

WASHINGTON

By

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and

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CONTENTS

ILLUSTRATIONS

FOREWORD

For a number of years, as a part of the continuing investigations of metal mining in Washington, especial attention has been paid to properties in which appreciable amounts of ferro-alloy minerals have been reported. During 1938 and 1939 attention was focused on certain chromite and tungsten deposits that seemed to be of especial value.

By 1940 it was apparent that the tungsten and chrome resources of the state might become important in an emergency and comprehensive, state-wide studies of each were planned. This report presents the more immediately important results of the tungsten studies.

Tungsten has been reported from many places in Washington, but occurrences which seem to hold most promise of becoming sources of ore are restricted to four counties, Ferry, Okanogan, Stevens, and Yakima. From the much wider distribution of granitic rocks it would seem probable that many other occurrences are yet to be discovered and that some of these will prove to be of commercial importance. As soon as more careful search is made, particularly with the ultra-violet lamp, it is not unlikely that other districts will be added to the list.

As a part of the general search for strategic minerals, all members of the staff of the Division of Geology have participated in the examination of areas and properties in which the presence of tungsten has been either reported or suspected. As a result of several unrelated factors it has fallen to the lot of the authors to compile the rather voluminous data gathered in the course of the extended field work. Mr. Bennett[1] is largely responsible for data from Yakima County. He shares with Mr. Glover[2] credit for the data from much of southern Stevens County. The junior author has secured data from a number of districts in Stevens County and is responsible for essentially all the data from Ferry and Okanogan counties. The assistance in the field of Grant M. Valentine and Marshall T. Huntting has been greatly appreciated and we are especially indebted to Huntting for his contribution of examination data for certain parts of both Stevens and Okanogan counties.

Most of the data on tungsten for King and Snohomish counties has been generously furnished by the Division of Mines and Mining.

No such study would have been possible without the continuing cordial assistance of a host of prospectors and operators who guided, lodged, and fed the investigators on occasions too numerous to record separately. All this is most gratefully acknowledged.

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INTRODUCTION

Tungsten was reported from Washington somewhat more than forty years ago, at a time when the increasing demand for it for tool steels was supplemented by development of processes for the production of the metal. Discoveries were being made in many western states, the principal deposits being in Arizona, Nevada, and Colorado.

Small production was reported for 1904[1] and until 1918 sporadic operations were recorded; at no time were more than three operators listed. With the precipitate drop in demand for tungsten which came late in 1918 production ceased in Washington as in most of western United States for about a decade. New occurrences were reported from time to time but no development followed. In 1933 a total of 35 tons of concentrates were marketed by three producers, and from then through 1943 production ranged from 3 tons to the maximum of 328 tons in 1938. Recorded production is given below.

Production of tungsten concentrates in Washington 1933-1943, in short tons

Year	*Number of Producers*	*Production*
1933	3	35
1934	2	139
1935	1	162
1936	1	38
1937	1	63
1938	2	328
1939	2	222
1940	1	92
1941	3	121
1942	6	73
1943	1	3
	Total	1,276

In preparation for this report field study was extended to cover every mine and prospect reliably reported to show tungsten mineralization. (See fig. 1.) It is improbable that all known deposits have been examined but the work has been conducted in Chelan, Ferry, King, Okanogan, Pend Oreille, Snohomish, Spokane, Stevens, and Yakima counties. The attempt was to determine just where each deposit was, its size and stage of development, and to estimate, from the observed geologic conditions, the potential value of the occurrence.

Reports on individual deposits of tungsten have appeared in both governmental and private papers; occurrences have been noted in descriptions of deposits where tungsten appeared an unimportant constituent of the ore body. No previous paper dealing with all known occurrences has appeared, hence this presents the first state-

[1] In U. S. Geol. Survey "Mineral Resources" for 1904 (p. 331) is the following statement: "In Stevens County, Wash., near Deer Trail, wolframite occurs in the properties of C. S. Palmer, of Deer Trail, and of the Roselle Mining Company, which is mining this mineral at Roselle Camp."

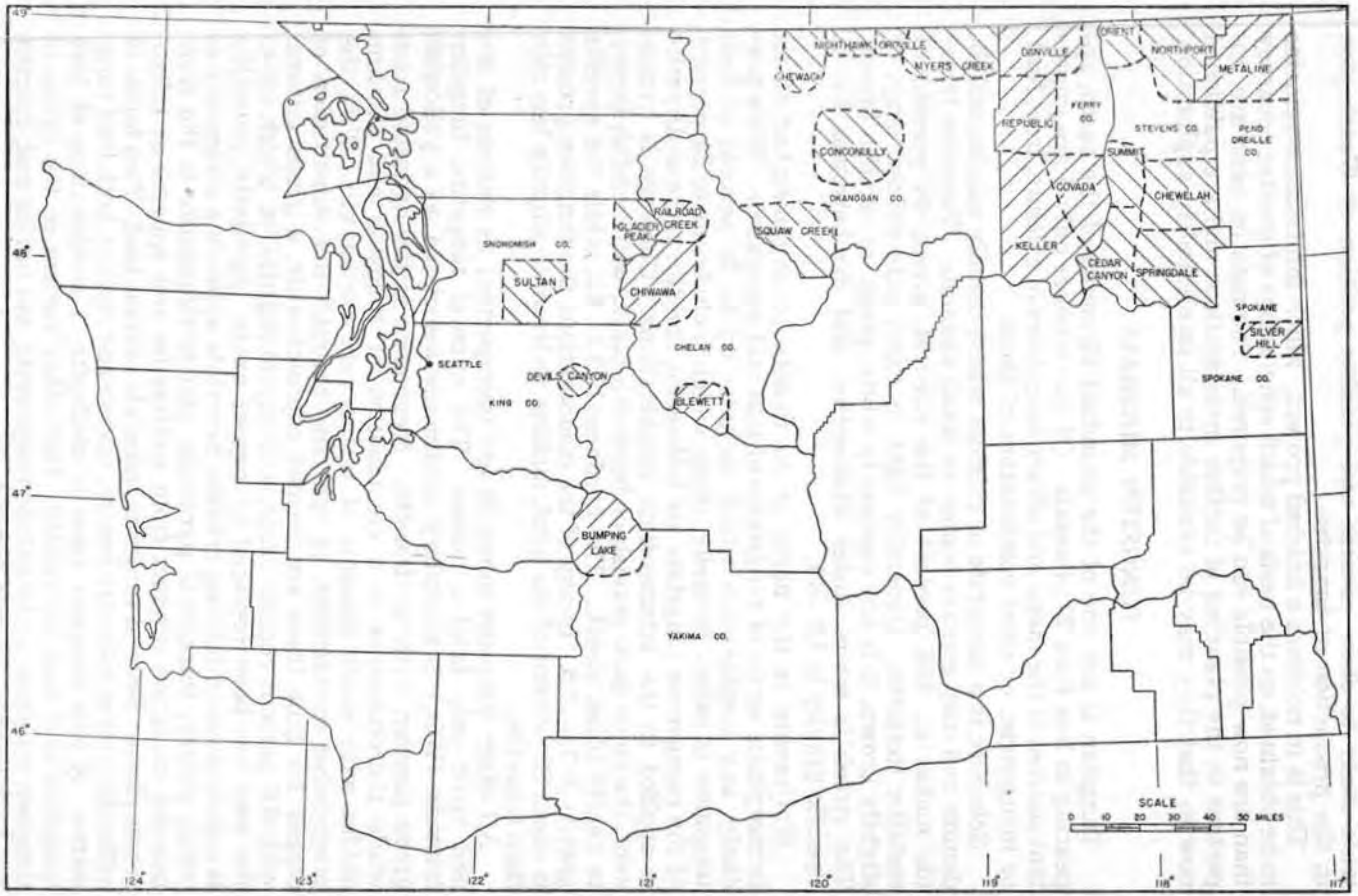


Figure 1—Index map of areas in Washington where tungsten has been recorded.

wide study to show present and possible position of Washington in the production of tungsten.

This is in no sense a finished project. Much information remains to be obtained, on the basis of which conclusions of greater accuracy than are now possible can be prepared. The data on hand are important in the planning of further investigations and are published now so that they may be available to all interested in exploration.

TUNGSTEN MINERALS

Tungsten is not one of the abundant elements of the earth, appearing in less than 20 minerals. Of this number only 4 are important sources of the metal and all are tungstates of calcium, iron, lead, or manganese, or some combination of them.

Scheelite is a tungstate of calcium which usually carries molybdenum and may contain copper in small amounts. Tungsten trioxide makes up 80.6 percent of the mineral, giving 64 percent of metallic tungsten. Generally light in color, pale yellow, gray, or slightly brown, it is less commonly white, green, or reddish brown. The streak is white, luster adamantine, and the hardness 4.5—5. Specific gravity is 5.9—6.1.

Wolframite is the name given loosely to any member of an isomorphous series of tungstates of iron and manganese. More precisely, any combination which includes up to 20 percent of iron tungstate is called *ferberite,* those which include up to 20 percent of the manganese tungstate are *hübnerite,* and the name *wolframite* is applied to the intermediate combinations. Cleavage is prominent, the color dark grayish or brownish black, with reddish brown to nearly black streak. The hardness is 5.0—5.5, while the specific gravity is 7.0—7.5. In any of the combinations the tungsten present is about 60 percent of the total, making wolframite slightly less rich than scheelite.

All other tungsten minerals are unimportant as sources of ore and merit only brief notations. The mineral *tungstite,* tungsten trioxide (WO_3) is secondary, commonly associated, as a yellowish green powder, with wolframite. *Meymacite* is the hydrated form while *thorotungstite* is a combination of tungsten and thorium oxides with small amounts of water, rare earths, etc. With the progressive modification of scheelite through the substitution of copper for lime there are formed *cuproscheelite,* a green mineral with 6.8 percent copper oxide, and *cuprotungstite,* in which all of the lime has been replaced by copper oxide. Similarly, *powellite* is a molybdenum-bearing calcium tungstate appearing commonly as small, yellow, tetragonal pyramids, and *ferritungstite* is the iron-bearing oxidation product from wolframite and appears as microscopic plates. Several tungsten minerals contain lead. Two forms of different crystal habit are known, *raspite* and *stolzite,* both lead tungstates. A less common form is *chillagite,* a combination of lead tungstate and lead molybdate. One other variant in the group of tungsten minerals is the sulfide *tungstenite,* not unlike molybdenite but both harder, 2.5, and heavier, 7.4.

NOTES FOR PROSPECTORS

A search for deposits of tungsten is more likely to be successful if the prospector is aware of the character and habits of the minerals which furnish most of the ores. Hess, in a bulletin on tungsten,[1] has given a wealth of valuable suggestions as to the occurrence and character of tungsten based on his study of ores from many parts of the world. The following notes, taken in large part from that report, will be found to be especially applicable to geologic conditions in the tungsten districts of Washington.

IDENTIFICATION OF TUNGSTEN MINERALS

The important ore minerals of tungsten are two, the wolframites and scheelite. The wolframite group comprises a gradational series of combinations of iron and manganese tungstates which are not readily distinguishable from each other in the field. All members of the group show a rather definite metallic luster, but the lighter colored hübnerite, at the manganese end of the series, shows it less than the iron-rich variety, ferberite. Cleavage faces, seen by reflection under a bright light or in sunlight, are characteristic also. The color of the powder, obtained by either crushing the mineral or by marking an unglazed porcelain with it, lies between reddish and dark brown. This color, known as the streak, is fairly easy to recognize in specimens of pure wolframites, but is commonly concealed or obscured by the presence of iron oxide. The above characteristics taken in conjunction with the noticeably high specific gravity will serve to distinguish wolframites from similar minerals, among which are magnetite, columbite, hornblende or pyroxenes of dark color, crystalline hematite, sphalerite, and some oxides of manganese.

Scheelite, the lime tungstate, has been missed by prospectors in most instances because it never looks like a metallic mineral. If unweathered specimens are examined, they will show excellent cleavage surfaces in several directions, but in color and luster scheelite looks like ordinary feldspars or quartz. It is readily distinguished from them by its relative softness and its greater weight. The readiness with which it can be scratched with a knife also separates it from epidote and garnet, while apatite, of about the same hardness as scheelite, is much lighter in weight. In case of doubt, the infallible rule is to make a chemical test for tungsten. This applies equally well to wolframite in cases where distinction from other minerals is not certain.

The simplest and most rapid test for tungsten in scheelite begins with digesting the finely powdered mineral in hydrochloric acid at boiling temperature for a few minutes. If tungsten is present a yellow powder will be produced unless it is concealed by too much iron in the solution. Metallic zinc added to the solution will produce an indigo blue color if considerable tungsten trioxide, the yellow powder, has been formed. If only a small amount has been

[1] Hess, F. L., Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652, 1917.

produced, the zinc will produce only a faint blue color, which changes soon to violet and finally to brown. In some cases, no blue color will appear but the powder will itself turn blue. If larger amount of the yellow powder is formed the color of the solution will be correspondingly deeper and the brown color will often follow the blue without showing any violet at all. Tin may be used instead of zinc in this test.

The wolframites may be tested in exactly the same manner as scheelite, but the digestion takes so long, up to half an hour, that a preliminary fusion with soda is generally to be recommended. Powdered mineral thought to be wolframite is added to a fused soda bead and thoroughly fused. The bead is then dissolved in hydrochloric acid. During this solution the bead will commonly show a bright yellow color from the tungsten trioxide being formed. The addition of either metallic tin or zinc produces the indigo blue if tungsten is present.

The most popular field test for scheelite is without doubt the application of ultra-violet or "black" light. Practically all varieties of scheelite show an intense bluish-white to yellowish fluorescence, which can be readily recognized. Some little experience, backed up by chemical tests, is necessary for accurate results, but the lamp is particularly valuable in eliminating more tedious tests of much barren material. Used out of doors at night or under cover, and especially in underground workings, an ultra-violet lamp reduces the search for scheelite to a minimum.

VEIN DEPOSITS

The outstanding feature of vein deposits of tungsten is that they invariably occur in close association with granitoid rocks. These may be true granites or may have the mineral composition of slightly more basic rocks, but they are generally light in color and show more or less free quartz. They may be equigranular or porphyritic in texture. In many instances the veins carrying tungsten lie near the contact of the intrusive granitic rock with the surrounding country rock, either in the granite itself or in the adjacent formations. In general the tungsten minerals will be found near the margin of the intrusive granite rather than deep within it. Deep erosion of a granitic mass is more likely to remove all trace of tungsten mineralization than to reveal veins. Thus in southern Stevens County all veins lie near the contact of the Loon Lake granite with the metamorphic rocks of the Stevens series. In Yakima County the veins lie largely within the granite but are clearly near the upper surface of the mass. Elsewhere the situation is essentially the same.

The application to prospecting of the principle that tungsten deposits occur in granitic rocks will eliminate much futile search among the more basic igneous formations. It must be remembered, however, that older basic formations may have been invaded later by granitic masses with the consequent formation of tungsten veins at or near the contact.

In general the tungsten veins show a relatively simple mineral assemblage. The gangue is usually quartz, and only small amounts of other minerals are present. The total list of minerals associated with tungsten ores is not extensive, probably less than fifty in all, but only rarely are more than a few found in any one vein. Some thin veins, like those at Wolframite Mountain in northern Okanogan County, show fairly high proportions of wolframite to quartz; elsewhere, especially in the wider veins, the ratio is lower. In some deposits in Washington an association of tungsten minerals, particularly scheelite, with molybdenite and chalcopyrite has been useful in prospecting.

Some pegmatite dikes carry small amounts of tungsten minerals, although no such deposits have so far proved to be of commercial importance. Nevertheless the prospector will do well to pay some attention to the occurrence of even small amounts of tungsten minerals in the pegmatites which are so abundant and widespread in the granitic areas of Washington. It should not be forgotten that such dike rocks, traced laterally, may merge into true quartz veins in many places.

The weathering of tungsten veins shows as much variation as might be expected considering the wide variety of vein compositions recorded, and the prospector must be alert if he does not pass by some deposits of value. In places the vein matter will be more resistant to weathering than the host rock and will project above the surface of the ground. Elsewhere the reverse will be true. In places, as in southern Stevens County, considerable quantities of tungsten ore lie scattered in the loose mantle above bed rock. Much of this is relatively high grade. It appears probable that the float here is largely glacial drift and represents debris transported only short distances from the upper parts of the veins cropping out in this district. Because of the ruggedness of most of the country in which tungsten deposits are found in Washington it frequently happens that the resistant tungsten ore minerals are washed considerable distances down hill from the original veins. Such veins can often be located by following up this float. In fine gravels panning gives good results. It might be expected that placer deposits would be common, but as a matter of fact they are rather unusual. Loss of the tungsten minerals through weathering very largely prevents accumulations of transported placers except near the parent veins. Residual placers may be formed on top of weathered veins, but in Washington such deposits are commonly lost by the action of glaciers which, moving over the residual deposit, scatter the accumulated tungsten over too wide an area to make recovery profitable.

CHELAN COUNTY

Tungsten has been reported from three districts in Chelan County, Blewett, Chiwawa, and Railroad Creek.

BLEWETT DISTRICT

The Blewett district, located in south central Chelan County, is bounded on the north by Wenatchee River and the crest of the Mount Stuart Range, on the east by R. 19 E., and on the south and west by the crest of the Wenatchee Mountains. The topography is marked by narrow valleys separated by steep-sided ridges with maximum elevations up to about 9,400 feet above sea level. The district is accessible up Peshastin Creek by U. S. Highway 97 and short tributary roads, and by trails.

The regional geology has been summarized by Huntting,[1] and the following passage is taken from his report:

> The rock formations of this district naturally fall into two age groups: the pre-Tertiary metamorphic and igneous rocks, and the Cenozoic sedimentary rocks, granitic intrusives, and lavas.
>
> Of the pre-Tertiary formations, the Peshastin rocks probably are the oldest. They are prevailingly very well indurated black slates and quartzites, with grit and conglomerate bands, and lenses of light-gray limestone. G. O. Smith, who originally described the formation (1903) was undecided whether it was older or younger than the closely associated Hawkins formation. However, in his columnar section (1904) he indicated it to be younger. Later work by Weaver (1911) indicates the Peshastin to be the older. Both Smith and Weaver provisionally assigned the formation to a Carboniferous or older age, and W. S. Smith (1916) concluded it to be Ordovician. A few of the gold deposits of the district are found in these rocks, as are some also in the possibly Carboniferous (Smith, 1904) Hawkins formation. The Hawkins rocks are greenstones comprising altered basalt flows and pyroclastics. Both of the above formations were intruded in Jurassic (?) time (Smith, 1904) by an ultrabasic magma which crystallized to a peridotite now largely altered to serpentine. A prominent feature of this formation is the abundance of so-called 'nickel ledges' thought by Smith (1904) to be limestone lenses of the Peshastin formation which were surrounded and altered by the peridotite magma at the time of its intrusion. The 'nickel ledges' make prominent reddish-brown outcrops which at one time were extensively prospected for gold and silver with little success. In some places they are nickel-bearing and in others they contain small amounts of mercury. The serpentinized peridotite with its associated 'nickel ledges' forms a narrow, curved, east-west band extending across the central part of the district, and in this rock are the most important of the Blewett gold deposits. The Mount Stuart granodiorite batholith which underlies and is in intrusive contact with all of these pre-Tertiary rocks crops out along Ingalls Creek and along the western border of the district. It was intruded probably in the Mesozoic era and is probably closely related to if not identical with the Chelan granodiorite of this county.
>
> Oldest of the Cenozoic formations in the district is the Swauk with its moderately- to well-consolidated sandstones, shales, and conglomerates of continental origin. This formation is gently to strongly folded, and it uncomformably overlies pre-Tertiary rocks in the southern and eastern portions of the district. Its age was regarded as Eocene by F. H. Knowlton (Russell, 1900), (Smith, 1904) on the basis of admittedly insecure fossil leaf evidence. Later paleo-stratigraphic developments among the formations with which the Swauk was tentatively correlated have made

[1] Huntting, Marshall T., Inventory of mineral properties in Chelan County, Washington: Washington Div. Geology Rept. of Inv. 9, 1943.

the Eocene age of the whole of the Swauk formation even less sure. Cutting the Swauk and pre-Tertiary rocks are swarms of generally northeastward-trending diabase dikes from a few inches to several hundred feet wide. Smith (1904) considered them to be feeders to the Eocene Teanaway basalt which overlies Swauk south of this district. Gabbro, outcropping as a narrow belt nearly in the middle of the peridotite area, is intrusive into the pre-Tertiary rocks but it is not cut by the diabase dikes. For this reason Smith (1904) considered the gabbro younger than the Teanaway basalt and its diabasic feeder dikes, but Weaver (1911) in his later report called the gabbro older than the dikes. Pleistocene glacial drift forms areally unimportant deposits along Ingalls Creek and lower Peshastin Creek. The terrace gravels occurring along Peshastin Creek and stream gravels covering most of the valleys have furnished the district's placer gold.

The only known occurrences of tungsten in the district are in the old Culver Gulch properties just west of the town of Blewett. (See pl. 1.)

Culver Gulch

Culver Gulch extends for about one mile westward from Blewett to the top of the Nigger-Peshastin creek divide. Elevations range from about 2,330 feet to about 4,150 feet above sea level. It is accessible by a truck road that joins U. S. Highway 97 at Blewett.

Development work consists of numerous old and more or less caved adits on both the north and south sides of the gulch along its entire length. The locations and descriptions of these old workings have been given by Weaver[1] and will not be repeated here. Timber and water in the vicinity of Culver Gulch are adequate for mining purposes.

The Culver Gulch ore occurs in three parallel veins striking about N. 75° W. and dipping from 75° to 90° S. These veins cut serpentine and are composed essentially of quartz, calcite, and talc with minor amounts of free gold, pyrite, arsenopyrite, chalcopyrite, galena, stibnite, and scheelite. The veins vary in width from a few inches to 16 feet and are characterized by frequent "pinches" and "swells". The scheelite occurs in the vein quartz as individual crystals ranging in size from minute specks up to half an inch across. Although the scheelite crystals are common they do not appear to be abundant and probably do not make up more than a fraction of one percent of the vein material. It was possible to examine only a small part of the old workings with the ultra-violet light and no high-grade tungsten ore was seen. However, it is possible that the veins contain some commercial bodies of tungsten ore, and future work on these veins should be done with this possibility in mind.

No tungsten ore has been produced from the Culver Gulch properties.

[1] Weaver, Charles E., Geology and ore deposits of the Bewett mining district: Washington Geol. Survey Bull. 6, 1911.

CHIWAWA DISTRICT

This district includes about 450 square miles in west central Chelan County. The drainage area of the Chiwawa was once included in the Leavenworth district (1897). The present Chiwawa district is limited on the west by the crest of the Cascade Range, on the north and east by the Entiat Range, and on the south by an arbitrary line south of Wenatchee Lake which separates the Chiwawa and Leavenworth districts.

Three streams, the Little Wenatchee, White, and Chiwawa rivers rising on the east slope of the Cascades have cut sharp valleys in the mountainous western part of this district. Elsewhere the topography is relatively subdued.

The district as a whole exhibits a variety of geologic formations, but only a few are seen in the vicinity of the Royal property, the only one from which tungsten has so far been reported. (See pl. 2.) Most important are the Chiwawa gneiss and the Cloudy Pass diorite along the contact of which is the extensive zone of brecciation which includes the ore deposits.

Royal

This property is located in the SE¼ sec. 21 (30-15 E.)* It is essentially confined to "Red Mountain," a name given locally to Phelps Ridge, the northward-trending divide between Phelps Creek and Chiwawa River.

The Royal Development Company which opened this property is now in receivership but still maintains a small caretaker force.

The terrain included in the company's property is rugged and mountainous, lying only about 5 miles from the crest of the Cascades. Elevations range from 2,800 feet at the camp site to 6,300 at the crest of "Red Mountain". Timber suitable for mining uses is abundant and the water supply is quite adequate. Some power has been developed on Phelps Creek and expansion might include the Chiwawa.

The rock formations encountered are the Chiwawa gneiss and the Cloudy Pass diorite, together with minor igneous dikes. No sedimentary formations are reported, although Richarz① has suggested, on rather slender evidence, that the gneiss (Chiwawa) is a metamorphosed argillaceous sedimentary rock. The outstanding structural feature of the rock formations is a wide breccia zone which occupies the contact zone of the gneiss and the diorite. As seen in most of the workings the fractured zone is about 250 feet wide and appears in openings at all levels.

The main workings comprise two adits, the 700-foot St. Francis, driven from the east slope of Red Mountain at an elevation of 3,650 feet and the Trinity, 850 feet lower and driven from the nose of Phelps Ridge northeastward for nearly 11,000 feet to reach the ore zone directly below the St. Francis. From the main St. Francis

* T. 30 N., R. 15 E.

① Richarz, Stephen, Peculiar gneisses and ore formation in the Eastern Cascades, Washington: Jour. Geology 41, pp. 757-768, 1933.

a subordinate drift was driven some 300 feet to the northwest. From the Trinity several thousand feet of workings have been opened at different levels. Short openings and scores of test pits have been made along the mineralized crest of "Red Mountain" for a distance of several miles.

The mineralization appears to be largely confined to the brecciated zone along the contact of the gneiss and the diorite. Ore minerals, largely pyrrhotite with some chalcopyrite, are reported, in minor amounts, from porphyritic dikes which cut the older gneiss well outside the breccia zone. Tungsten has not been found in this situation. Scheelite, the only tungsten mineral reported, is found in the main ore body of pyrrhotite and chalcopyrite. It appears in grains, minute stringers and small masses closely associated with the sulfides. Main gangue minerals are chlorite, biotite, calcite, quartz, and sericite. Although revealed by the lamp rather widely throughout the openings in the ore zone (pl. 3), no masses or concentrations were noted that suggested commercial possibilities except as a by-product.

There has been no production from the Royal property.

RAILROAD CREEK DISTRICT

This mining district lies west of Lucerne on Lake Chelan and comprises the area drained by Railroad Creek. In the early days this region was considered part of the Lake Chelan district, which term was loosely used to include all mineral deposits south of the Stehekin. As now delimited Railroad Creek district includes less than 50 square miles.

Topographically mountainous, this small district shows relief on the order of 7,500 feet, the highest point being Bonanza Peak at the extreme northwest corner. The valleys are all narrow, steep sided, and of high gradient.

The oldest rocks, in the vicinity of the known tungsten-bearing property, are a series of metamorphosed sediments consisting chiefly of quartzites, schists, and gneisses with a small amount of calcareous beds. The strike of these metamorphic rocks averages about N. 30° W. and the dip is about 60° to 70° SW. Certain elongate zones within the metamorphics have been more or less granitized, and associated with this granitization there is a mineralized zone from 40 to 75 feet wide and exposed for a length of 1,400 feet and a depth of 1,600 feet. This mineralized zone follows the strike and dip of the old sediments and carries varying amounts of chalcopyrite, pyrite, pyrrhotite, and sphalerite. The metamorphics, granitized zones and sulfide zones are cut by still younger granite and lamprophyre dikes and occasional barren quartz veins.

Tungsten has been recorded at only one property, the Holden (pl. 2), which was staked in 1896 and is now operated by the Howe Sound Company.

Holden

The Chelan Division of the Howe Sound Company controls property consisting of 13 patented and 78 unpatented claims. The mine is opened in the NW¼ sec. 18 (31-17 E.) above Railroad Creek. Development (Jan. 1943) comprises about 136,430 feet of drifts, crosscuts, and raises, and over 147,000 feet of core drilling. Improvements include a 2,200-ton mill and concentrating plant for the gold-bearing copper and zinc ore, together with roads, docks, tug and barges on Lake Chelan and all necessary transportation facilities. The camp provides very modern facilities for 450 men.

Along the footwall of the sulfide zones there has been a small development of garnet and epidote in what may have been the more calcareous members of the old sedimentary rocks. This garnet-epidote rock carries occasional minute crystals of scheelite but nowhere have they been found in large enough quantity to make ore. There has been no production of tungsten.

FERRY COUNTY

Two districts in Ferry County have produced tungsten, Covada and Keller, known from the official records as the Enterprise and San Poil respectively. Tungsten minerals have also been found in two other districts, Danville and Republic.

COVADA DISTRICT

The Covada district, known also as Meteor and, in official county records, Enterprise, occupies the northeastern part of the Colville Indian Reservation, (see fig. 2) having as its eastern boundary the Columbia between Harvey and Gerome, communities of western Stevens County. At its north edge the district extends westward to the San Poil divide, following Wilmont Creek southeastward to the Columbia. Topographically it includes part of the east slope of the San Poil divide with elevations ranging from 1,300 to 4,500 feet. Larger streams, Hall, Lynx, and Wilmont creeks and their tributaries, are sharply incised so that the district is characterized by the mountain spurs trending east and southeast from the divide toward Columbia River.

A relatively thick series of metasedimentary rocks, including white marble, light and dark argillite, and micaceous quartzite, has been intruded by both plutonic granitic rocks and somewhat more basic dike rocks. The sediments are thought to have been laid down in Paleozoic seas and the igneous intrusives are tentatively placed in the Mesozoic. During late Mesozoic and Tertiary time erosion produced a rough surface which was smoothed and somewhat reduced in relief by Pleistocene glaciation.

The tungsten-bearing veins lie within the rocks of the Covada series. Structurally they conform roughly to the dip and strike of the metasedimentary rocks. Without exception they are quartz veins probably filling fissures which antedate much of the faulting of the district. Mineralogically the veins are simple, carrying some tungsten with sulfides, in a gangue largely quartz but in places containing fluorite and orthoclase.

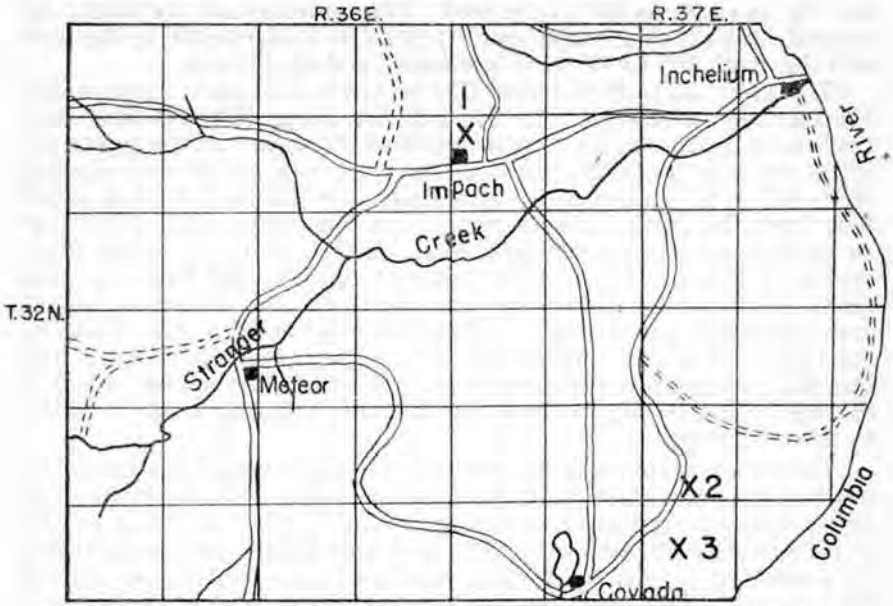


FIGURE 2—Tungsten occurrences in Covada area. 1—Gwin, 2—Silver Leaf, 3—Orion.

The presence of these minerals in the gangue suggests a pegmatitic character easily referable to the Colville granite, which crops out near most of the prospects in the district and presumably underlies all of the district at no great depth.

Only three properties, Gwin, Silver Leaf, and Orion, have had tungsten reported from them. (See fig. 2.) Of these the first two have produced what tungsten has been recorded for the Covada district.

Gwin

The workings of the Gwin mine are in the NW¼ sec. 11 (32-36 E.). The main adit is approximately 1,375 feet south and 1,170 feet west of the north ¼ cor. sec. 11, and the property extends into the SW¼ sec. 2. It is owned by Ed. Hodson of Colville, Washington. In 1941, at the time of this examination, the main adit was being retimbered. The property can be reached from Inchelium by going west 4 miles on the Twin Lakes road and then half a mile north.

Gwin Hill, on which the mine is located, is one of a series of rounded elongate hills which lie above the 1,800-foot level of the Nespelem silt plain. While the upper portion of the hill is bare, there is an adequate growth of conifers on the property for mine timbering and probably enough water in the underground workings for mining operations.

Argillites and quartzites of the Covada series compose Gwin Hill. The beds have a northerly strike, ranging from 10° to 35° W., and dip about 45° SW. The ore occurs in quartz veins up to 4 feet wide. These veins consistently parallel the strike of the sedimentary rocks.

but dip as much as 60° to the east. The underground workings cut several faults that are also roughly parallel to the strike of the beds and dip from 30° to 70° both northeast and southwest.

The main adit, on the east side of Gwin Hill near its base, has been driven westward into the hill for about 300 feet and then northwest and north for a total length of 750 feet. On the top of the hill there is an inclined shaft that was sunk on a quartz vein dipping from 45° to 60° to the east. This shaft cuts the main tunnel at 398 feet from the portal and continues to a reported depth of 100 feet as an inclined winze along the vein. Neither shaft nor winze could be entered at the time of this examination. At 460 feet from the portal of the adit a 40-foot stope to the southwest follows a faulted and brecciated quartz vein. About one-eighth of a mile south of the main adit a short opening has also been driven westward into the hill. Numerous prospect holes and open cuts appear all over the hill and the low, narrow, north-south-trending ridge that lies to the northeast.

Two veins, which may be portions of a single vein, have furnished most of the production from the Gwin property. The inclined shaft and winze are reported to follow a quartz vein carrying pyrite, tetrahedrite with silver (probably freibergite), and wolframite. This opening is reported to have produced some wolframite during the last war. The other quartz vein, located at the end of the main adit, is 14 inches wide, strikes N. 50° W., dips NE. 42°, and carries a small amount of pyrite, tetrahedrite (freibergite), and wolframite. The sulfides occur along fractures or zones in the quartz, while the wolframite is scattered through the quartz and appears to be a little earlier than the sulfides. The crystals of wolframite are irregular to euhedral in shape, generally large, measuring up to 2 inches in length. About 25 feet of the vein is exposed along the side of the adit, but all of the wolframite found at the time of this investigation was within a zone about 18 by 6 inches. It is definitely not distributed uniformly throughout the vein. From what can be seen, the vein as a whole would run low in tungsten.

On the south end of the low ridge northeast of Gwin Hill an opening shows both wolframite and scheelite. This is the only other tungsten occurrence found on the property. Here an open cut, 15 feet square, exposes fine-grained quartzite and argillite that strike north-south and dip 40° to the east. This opening, 800 feet west and 75 feet north of the south ¼ cor. sec. 2, follows the beds down dip for about 15 feet. Along the footwall and parallel with the beds is a quartz vein that varies from 1 to 10 inches in thickness. It carries crystals of wolframite up to three-fourths of an inch in length and crystals of scheelite up to one-half inch across. Many of the wolframite crystals show scheelite along cleavage cracks or as an outer coat, as though the wolframite had begun to alter to scheelite. The wolframite is unusually red and its high transparency suggests that it is close to the hübnerite end of the series. The vein has a number of small vugs lined with quartz crystals. Some shearing of the quartz has taken place parallel to the vein and the fractures are coated with manganese oxide. The

vein quartz also contains a few milky-white, euhedral crystals of orthoclase and some small crystals of pink fluorite.

The vein appears to carry roughly 2 to 3 percent of the tungsten minerals. The rocks next to the vein and especially those of the footwall carry a rather large amount of pyrite. There are several other small quartz veinlets parallel to the main vein, but they apparently do not carry tungsten minerals.

The Gwin mine has primarily been a silver producer. Mr. Hodson states that during the last war leasers made several shipments of wolframite ore from the inclined winze in the main tunnel, but he has no record of the tonnage.

Silver Leaf

The Silver Leaf mine is located in the SE¼SW¼ sec. 30 (32-37 E.) at the south tip of Rattlesnake Mountain. By road the property is 3 miles northeast of Covada and 7½ miles southwest of Inchelium. It is owned by Hal Hightower of Covada.

Rattlesnake Mountain is the southernmost of the island-like masses of old metamorphic rocks projecting above the 1,800-foot surface of the Nespelem silt plain. Like the others it is elongate north-south in harmony with the structure of the beds composing it. A good growth of conifers will provide mine timbers. The mine workings lie above the present water table so that provision for an adequate water supply must be made.

In the vicinity of the mine, Rattlesnake Mountain is made up of members of the Covada series which here are thin, interbedded quartzites, argillites, and marbles. The beds strike about N. 10° W. with practically vertical dips. Along the mineralized zone the beds are highly sheared and crenulated. This sheared zone, less resistant to erosion than adjacent beds, can be traced on the surface where it parallels the strike of the sedimentary rocks. On the southwest side of the mountain, extending up along its western slope from its base, a body of granodiorite has intruded the metamorphosed beds. Its contact, about 100 feet west of the mine workings, shows some development of garnet, epidote, and muscovite.

A set of prominent joints runs parallel to the strike of the beds, while another set, nearly vertical, strikes N. 75° E. Small quartz veins, less than one inch in width, parallel each of these sets of joints as well as running in other directions across the beds. In places, where brecciated, the sedimentary rocks have been recemented by these small quartz veins. The brecciated zones contain cavities up to 1½ inches in diameter, lined with delicate quartz crystals.

All of the mine workings are confined to the shear zone. Approximately 210 feet west of the south ¼ cor. sec. 30, at an elevation of about 1,800 feet above sea level, an adit has been driven in a northerly direction for 200 feet. A 40-foot shaft was also sunk on the shear zone, 150 feet to the north and 70 feet above the adit. At the present time the adit and the shaft are caved. About a rod east of the shaft a second adit has been driven northward about 50 feet along the shear zone. There is an open cut extending north-

ward from the old shaft for 30 feet and ending in a 20-foot adit. Approximately 20 feet farther to the north and 40 feet higher a 50-foot open cut extends in an east-west direction across the strike of the beds. Another 100 feet farther to the north and 90 feet higher there is a small open cut about 10 feet in diameter.

The mineralization is essentially restricted to the shear zone in the siliceous and calcareous beds, although some pyrite can be found in the less sheared rocks on either side. No well-defined vein is present, but the ore minerals are confined to the lenticular quartz veins paralleling the strike of the beds and making up a mineralized lode or zone roughly 50 feet wide.

The chief minerals present are pyrite, chalcopyrite, sphalerite, galena, stibnite, tetrahedrite, and scheelite. On the whole, the sulfide mineralization has been slight. The minerals are difficult to find even on the dumps. The only stibnite was in the open cut above the old shaft where a few small crystals in a 1-inch quartz vein were found. There is much secondary limonite as well as a small amount of malachite and azurite staining in places. The gangue material is chiefly quartz.

Most of the scheelite occurs in the 20-foot adit at the end of the open cut just north of the old shaft. On the face of the adit there is a zone of brecciated, argillaceous quartzite that has been recemented with vein quartz. In an area about 2 feet square scheelite constitutes about 10 percent of the surface. It is in the vein quartz and particularly concentrated around the edges of the quartzite fragments. Small patches of scheelite are in the roof of the adit over an area 10 by 5 feet. Some of the scheelite crystals are as much as half an inch across, but the majority are smaller. In the east wall of the open cut just north of the old shaft there are several half-inch quartz veins carrying a high percentage of scheelite, but they pinch and swell from mere seams to the half-inch thickness. The entire zone would not run high in scheelite. Besides these veins there are several isolated patches of scheelite up to 1 inch across. The dump in front of this open cut and the 20-foot adit shows much scheelite.

The open cut 40 feet above the 20-foot adit shows several small quartz veins, one-half inch wide and 6 to 8 inches long, that carry some scheelite. The open cut 100 feet farther to the north shows several small quartz veins containing some scheelite.

Three patches of scheelite about 1 inch square occur in the ledge midway between the two last-mentioned open cuts and 15 feet to the west. No other occurrences of scheelite were found in the other mine workings or outcrops in the immediate vicinity.

The scheelite is confined to the sheared and brecciated zone that parallels the strike of the beds. It is associated with quartz-breccia fillings and small quartz veins that parallel the strike of the beds. The occurrence is confined to a zone about 30 feet wide and 180 feet long, but the total amount in this area is small.

It appears probable that the sedimentary rocks were first metamorphosed and that subsequently, perhaps at the time of the granodiorite intrusion, the jointing parallel to the bedding was de-

veloped, together with local brecciation. Solutions, probably derived from the granodiorite, filled the fractures, producing quartz veins carrying sulfides and scheelite. The only mineral besides quartz that is closely associated with the scheelite is pyrite, and even that mineral is rare in the scheelite-bearing veins. Later stresses produced fractures cutting across the bedding and schistosity and striking about N. 75° E. Some of these fractures are filled with vein quartz, but they do not contain the other minerals.

On the whole the scheelite is "spotty". Some production might be obtained, but the percentage of scheelite over the entire mineralized zone is low.

From the volume on Mineral Resources for 1915[1] is taken the following:

> The Silver Leaf property produced a small amount of scheelite, as well as a shipment of silver ore.

Orion

The Orion prospect is located just west of the center of sec. 31 (32-37 E.), on the east side of the ridge between Covada and the Columbia. The dump can be seen from the road which is half a mile to the east. The property is owned by A. Messenger, Covada, Washington. At the time of inspection in 1941 no work was under way.

The ridge on which the workings are located comprises metamorphosed sedimentary rocks of the Covada series. These are mainly slaty beds, as exposed in the adit, those at the east being limy argillites while farther in the hill highly sheared graphitic strata with interbedded talcose slates were encountered.

The strike is northwesterly, the dip northeasterly from the portal westward for over 1,100 feet, where the structure changes to a northeast strike and northwest dip. In this zone the soft carbonaceous shales have become all but structureless black graphitic beds.

The adit crosses a number of quartz veins ranging in width from a fraction of an inch to 4 feet. Although all the veins dip eastward steeply, 65°—75°, their strike ranges from 45° west of north to 30° east of north. Some carry a little pyrite, but for the most part they are barren of metallic minerals. Veins in the highly sheared zone have largely been incorporated in the schist.

Two adits have been driven straight westward into the ridge for 500 feet and 1,200 feet respectively. The shorter of the two was caved in 1941.

The only tungsten minerals found in the workings were in a single one-half-inch vein of quartz encountered 690 feet in from the portal. Exposed in roof and both sides, the vein strikes N. 45° W. and dips 65° NE. It carries a very small amount of pyrite with the scheelite, which occurs as specks about the size of a pin head up to crystals several millimeters across. The total percentage of scheelite in that part of the vein exposed is estimated to be less than one percent. Several paper-thin quartz seams running from the main vein into the argillite show occasional specks of scheelite.

The Orion property has never been in commercial production.

[1] Mineral Resources U. S., 1915, pt. 1, p. 569, 1917.

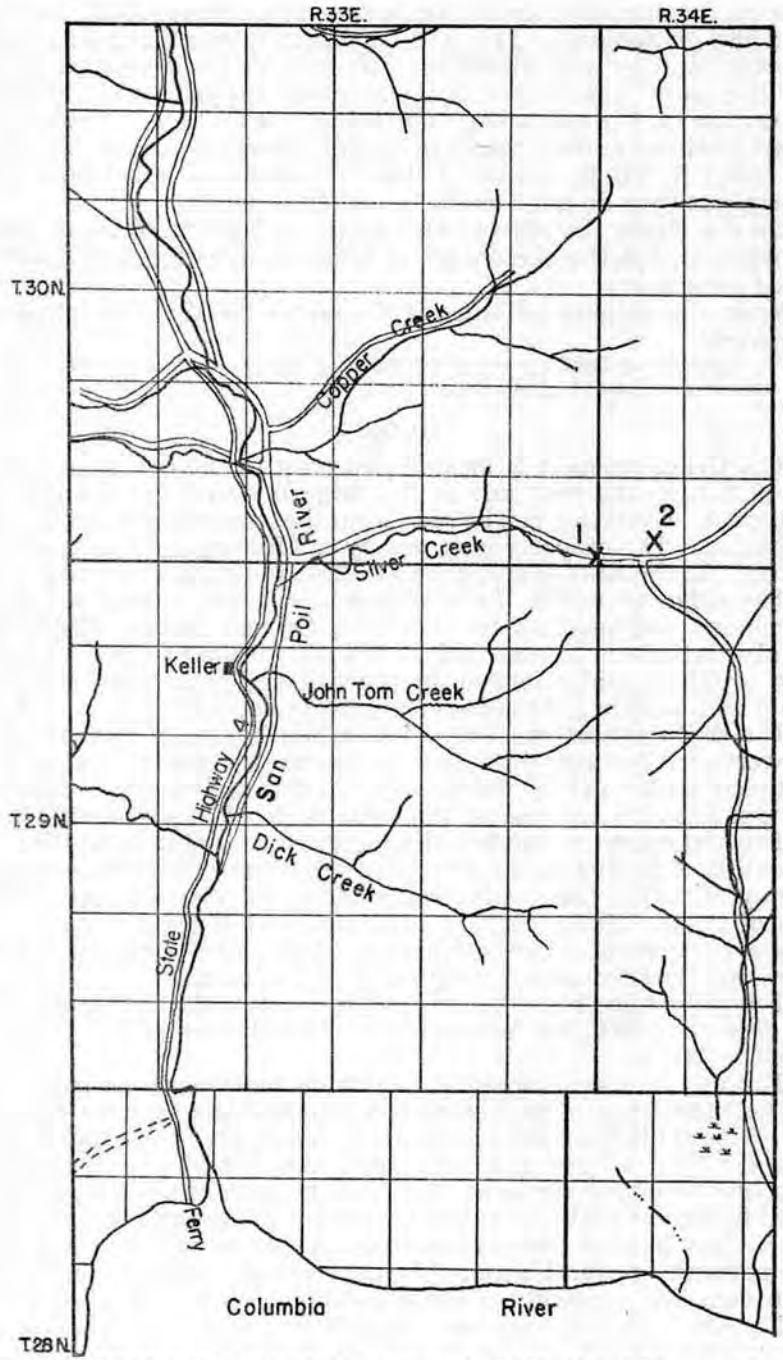


FIGURE 3—Tungsten occurrences in Keller area. 1—Pacific Mutual Silver and Lead, 2—Pit near Friedlander Meadow.

KELLER DISTRICT

The San Poil or Keller district, including most of the south third of Ferry County, overlaps on the northeast the Enterprise, or Covada district.

The Keller is a rugged mountainous district, which, outside the narrow flats of San Poil River, shows steep slopes and relief ranging up to 4,000 feet.

Of the many kinds of rock exposed in the Keller district only two groups, the Covada metamorphic and Colville granitic rocks, are of importance in considering the deposits carrying tungsten. There are many separate occurrences of the fine-grained sedimentary rocks of the Covada series. These include all three common types, sandstone, shale, and limestone, which, because of a high degree of metamorphism, are now changed to argillite, slate, marble, and several schist types. Intruding these old strata is the granite of the Colville batholith, which, as Pardee[1] points out, underlies at least half the district and probably underlies all Covada rocks at no great depth. The original cover or roof of the batholith was a great thickness of these Covada beds, which have been eroded from large areas of the district.

The only recorded occurrence of tungsten minerals is in the south central part of the district along the divide between Silver Creek and the South Fork of Ninemile Creek. Both wolframite and scheelite have been found in the old Addison mine (Pacific Mutual Silver and Lead mine), and on the dump from a small open pit about half a mile east of the Addison property. (See fig. 3.)

The reported occurrence of tungsten "near Keller, Ferry County, at the head of Copper Creek" recorded by Shedd[2] was investigated but could not be verified. The short adit could not be entered, but careful inspection of the dump failed to reveal the presence of any tungsten mineral.

Pacific Mutual Silver and Lead (Addison)

The Pacific Mutual Silver and Lead property comprises ten claims located in the SE¼ sec. 36 (30-33 E.) and the SW¼ sec. 31 (30-34 E.). The main shaft is located 1,320 feet east and 120 feet north of the SW. cor. sec. 31, on the northeast slope of the mountain about 2,640 feet above sea level. The property is northeast of Keller, 5 miles along the Silver Creek road. It is under the management of Mr. Clare Gray, Spokane, Washington.

The mine is in a hilly, nearly mountainous part of the divide between Silver and Ninemile creeks. The hills slope steeply to narrow valleys, giving about 2,500 feet of relief. Some of the larger valleys are flat-bottomed with considerable meadow area.

The hills are covered with a rather dense growth of conifers that can be used for mine timbering. There is considerable mine water

[1] Pardee, J. T., Geology and mineral resources of the Colville Indian Reservation: U. S. Geol. Survey Bull. 677, p. 106, 1918.

[2] Shedd, Solon, The mineral resources of Washington: Washington Div. Geology Bull. 30, p. 109, 1924.

present in the underground workings and several springs in the vicinity of the property. Water for mining operations should be adequate.

The mine workings, consisting of two adits, four shafts, and several open cuts, are along a N. 60° W. line on the northeast slope of the mountain. The main adit is about 640 feet in length with three short drifts to the southwest and at 250 feet from the portal a raise inclined about 70° NE. connecting with an old shaft. Forty-five feet above the main level and about 35 feet below the surface, drifts extend for 30 feet both northwest and southeast from the raise. Northwest of the main adit about 700 feet is an old shaft that could not be entered at the time of the examination (Sept. 1941) and about 1,650 feet farther northwest is another shaft 35 feet deep with a 30-foot drift extending N. 5° E. from its bottom. Across the road about 1,000 feet southeast of the main adit is an old 25-foot vertical shaft that is connected with a short adit by a short inclined shaft.

The occurrence of tungsten minerals is in a 4- to 6-foot quartz vein on which the raise from the main adit to the surface has been made. The 60-foot drift 45 feet above the main level is also on this vein. The footwall is a dark, schistose rock high in biotite, and the hanging wall is a medium-grained rock made up almost entirely of quartz and muscovite. The vein strikes N. 28° W. and dips 78° SW. Northwest of the raise and along the drift the vein carries galena, sphalerite, pyrite, chalcopyrite, chalcocite, malachite, azurite, and a few scattered grains of wolframite and scheelite. The sulfide minerals are also reported to carry gold and silver. Southeast of the raise along the drift the vein is very heavily mineralized with the above sulfide minerals and with a high content of wolframite and scheelite. Northwest of the raise the entire amount of tungsten would not run over one percent, whereas a sample taken across the vein near the southeast face of the drift is reported to have contained 8.3 percent tungsten. It is not known whether the 8.3 percent represented W or WO_3. The tungsten minerals occur chiefly in the roof and face of the drift. Neither the sulfides nor the tungsten minerals appear in the raise below the level of the drift, however the rocks here are highly stained with limonite and malachite.

The tungsten occurs chiefly as long, tabular wolframite crystals roughly lined up parallel with the vein. Some of the crystals are as much as 2½ inches long. The scheelite is apparently a product of alteration of the wolframite, appearing both on outer surfaces and along cleavage cracks. The vein itself shows a well-defined zoning in places, although the margins of zones are not sharp. One measured cross section from footwall to hanging wall shows 12 inches of quartz with a very high content of sulfides, then 16 inches of quartz with only a small amount of sulfides, followed by 10 inches of quartz with some sulfides and much wolframite and scheelite, 8 inches of quartz high in sulfides, and finally 2 inches of quartz only slightly mineralized.

This property has produced a small amount of lead, copper, zinc, silver, and gold, but there is no record of tungsten production.

Pit near Friedlander Meadow

A round pit 15 feet in diameter and 8 feet deep has been opened in the SW¼SE¼ sec. 31 (30-34 E.), on the southeast slope of a low hill about 250 feet northwest of the road. It is about half a mile east of the Pacific Mutual Silver and Lead mine. No information on ownership was acquired.

The geology here is similar to that at the Pacific Mutual Silver and Lead property to the west. A schist, strongly micaceous, is cut by a single pegmatitic dike and a quartz vein. The schistosity of the country rock trends N. 45° E., dipping 85° SE. On the northeast side of the open pit the 6-inch pegmatite is parallel to the schist cleavage in strike but dips 75° in the opposite direction. Traced southward the pegmatite flattens and appears to end where it meets a 12-inch vein of quartz, which cuts across the pit in a N. 35° W. direction, dipping 75° SW.

No tungsten minerals were found in place in the quartz vein, but several pieces of the vein containing thin blades of wolframite were found on the dump. Several of the wolframite crystals are as much as 1½ inches long and all appear to be altering to scheelite around the edges and along cleavage cracks. Some of the scheelite appears at short distances from wolframite crystals in joints cutting the quartz vein.

No tungsten ore is known to have been produced from this property.

DANVILLE DISTRICT

The Danville district is in northwestern Ferry County, extending south about 12 miles from the International Boundary and east about 20 miles from the Okanogan-Ferry county line. It includes the drainage of Kettle River, lower Curlew and Toroda creeks, Tonata Creek, and Lone Ranch Creek. Topographically the district is mountainous with narrow valleys. The maximum elevation is over 5,000 feet which is about 3,200 feet above Kettle River Valley.

The oldest rocks in the district are Paleozoic metamorphics composed of slates, quartzites, marbles, and greenstones occurring as a large mass in the northern part of the district and as small isolated masses in the western part. Large masses of granitic rocks of probable Mesozoic age intrude the metamorphic rocks and in the main occupy the southeast and southwest parts of the district. The northwest and south central parts of the district are covered by acidic lava flows of Miocene age.

There is only one known occurrence of tungsten in the district, the Morning Star. (See pl. 4.) Supplies of timber and water in the vicinity of this property are adequate for mining purposes.

Morning Star

The Morning Star mine, owned by the Morning Star Mining Company of Spokane, is about 3 miles south of Danville in the SW¼ sec. 16 (40-34 E.). It is on the east side of Kettle River at an elevation of about 2,300 feet.

The development work consists of a long adit which, with drifts, raises, and stopes, totals several thousand feet of underground workings. Due to recent caving of this adit it was not possible to examine much of the workings in 1945.

The Morning Star is primarily a gold property with the gold occurring free as well as in pyrite. The ore minerals are in a quartz vein cutting serpentine. It is reliably reported that a few small crystals of scheelite have been found in the quartz vein.

REPUBLIC DISTRICT

The Republic mining district is located in Ferry County, and is named for Republic, the principal town of the district. In the office of the county clerk of Stevens County the boundaries of the district are recorded as follows:

> Beginning at the dividing line of Stevens and Okanogan counties at a point where the said county line leaves the dividing line between the north half and the south half of the Colville Indian Reservation, thence north on said county line 21 miles, thence due east to the summit of the highest range of mountains dividing the watersheds of Kettle River and Columbia River on the east side and Curlew Creek and the Sanpoil River on the west side, following the summit south to the dividing line of the north half and the south half of the Colville Indian Reservation, thence west to place of beginning.

Topographically the Republic district is mountainous, broken only by relatively narrow steep-sided valleys. Elevations range from about 2,200 feet to over 5,600 feet above sea level.

The oldest rocks in the area are metamorphic sedimentary rocks of Paleozoic age. These occur as relatively small isolated masses, remnants of the roof rocks of the Colville batholith. Most of the western part of the district is underlain by this intrusive granite, while the central and eastern portions are covered by Tertiary rocks, mostly of volcanic origin but including some continental sedimentary beds.

Only one occurrence of tungsten has been reported to date. This is from the Kelly property on Bodie Mountain. (See pl. 5.)

Kelly

The Kelly property is in the east half of sec. 6 (38-32 E.) on Bodie Mountain in the northwest corner of the district at an elevation of about 5,000 feet. It can be reached by half a mile of trail from the road up Trout Creek.

Development work (September 1943) consists of a westward-trending adit, a shaft inclined to the south, and numerous open cuts.

The ore body is in a contact metamorphic zone along the west side of a small roof pendant of metamorphosed sedimentary rocks, mainly quartzites, surrounded by intrusive diorite. The contact metamorphic zone is a mixture of garnet, epidote, calcite, and magnetite, with minor amounts of chalcopyrite and scheelite. The scheelite ranges in size from minute disseminated crystals up to coarse crystal aggregates several inches across. No large body of high-grade scheelite ore was seen, yet commercial ore bodies may possibly be found along the contact zone. A considerable amount of low-grade milling ore is present.

KING COUNTY

The only reported occurrence of tungsten in King County is at the Devils Canyon property. (See pl. 6.) The following information on this occurrence was furnished by the State Division of Mines and Mining.

Devils Canyon

The Devils Canyon property is in the S½ sec. 27 (25-10 E.) on the northwest side of the divide between Cougar and Lennox creeks. It is in Devils Canyon, a deep gulch trending northwest to Cougar Creek. The property can be reached from North Bend by 13 miles of road and 12 miles of trail up the North Fork of Snoqualmie River.

Development work consists of at least one adit. There is an adequate supply of timber and water for mining purposes in the vicinity.

The oldest rocks in this area are Paleozoic metasedimentary rocks. These have been intruded by relatively large masses of Tertiary granitic rocks of possible Miocene age. The youngest rocks are Miocene volcanics.

Variable amounts of powellite, molybdenite, pyrite, and siderite are found on the Devils Canyon property in irregularly spaced quartz veins ranging from a fraction of an inch to 6 inches in thickness and occurring in a shear zone striking N. 60° to 70° W. and dipping 80° to 85° NE. in granodiorite. This mineralized shear zone can be traced for at least 2,000 feet and has a depth of at least 1,000 feet. No tungsten ore has been produced from this property.

A piece of float quartz carrying considerable chalcopyrite, pyrite, scheelite, powellite, and a small amount of pyrrhotite and sphalerite was found below the Devils Canyon property. This piece is unlike the ore in place on the property, but may have come from a vein in this general vicinity.

OKANOGAN COUNTY

Tungsten has been reported from widely separated points in Okanogan County, which stretches for two full degrees of longitude along the 49th parallel and has Columbia River for its south boundary. The occurrences are in six of the sixteen recognized mining districts of the county. They are Myers Creek, Oroville, Nighthawk, Chewack, Conconully, and Squaw Creek.

MYERS CREEK DISTRICT

The Myers Creek district, in the northeast corner of Okanogan County, occupies Tps. 39 and 40 N. from Okanogan River east to the Okanogan-Ferry county line. The eastern part of the district, which contains the known tungsten occurrences, is in the Myers Creek drainage area with elevations up to 2,200 feet above Myers Creek and 5,500 feet above sea level.

The predominant bedrock is a thick series of Paleozoic (Umpleby)[1] quartzites, schists, greenstones, and limestones that have been

[1] Umpleby, J. B., Geology and ore deposits of the Myers Creek mining district: Washington Geol. Survey Bull. 5, pt. 1, p. 17, 1911.

intruded by small bodies of Mesozoic (Umpleby) granite and syenite. The largest intrusive body is a mass of syenite covering about 3 square miles in the northeast corner of the district. Smaller bodies of syenite occur 2½ miles southeast of Chesaw. In addition, there is one body of granite, about one square mile in area, 1½ miles northwest of Chesaw. Contact metamorphism, with the formation of scheelite, has occurred at some of the contacts between the intrusive granitics and the Paleozoic metamorphic rocks. Three such scheelite-bearing contact zones are known. (See pl. 7.) One is on the north end of Buckhorn Mountain in the vicinity of the Magnetic and Roosevelt mines, another is on the south end of Buckhorn Mountain at the Crystal Butte iron deposit, and the third is near Strawberry Lake northwest of Chesaw. Numerous quartz veins cut the Paleozoic metamorphic series, but only one such vein, near Strawberry Lake, is known to carry scheelite.

Supplies of timber in the vicinities of the tungsten occurrences are adequate for mining purposes, but water is scarce.

Magnetic

The Magnetic mine, owned by A. E. Wilson and John Citkovich of Colville, consists of eight unpatented claims in secs. 13 and 24 (40-30 E.) on the north slope of Buckhorn Mountain at an elevation of about 5,000 feet. The property is accessible by good truck roads from both Curlew and Chesaw.

Development work consists of three open pits from which considerable magnetite ore has been removed, as well as numerous short adits, open cuts, and prospect shafts.

The mine is situated along a northwest-trending contact metamorphic zone between a large mass of quartz-bearing hornblende syenite on the northeast and the thick series of quartzites, schists, limestones, and greenstones making up the bulk of Buckhorn Mountain on the southwest. The contact metamorphic zone is over 500 feet wide and can be traced for a distance of nearly a mile along the contact. The contact metamorphic rock is composed essentially of garnet, epidote, magnetite, pyrrhotite, and chalcopyrite. Occasional small crystals of scheelite ranging from mere specks up to an eighth of an inch across have been found in the garnet-epidote rock.

No commercial scheelite ore is known to occur on the property, but the geologic conditions are favorable for scheelite and future development may disclose bodies of commercial tungsten ore.

More information on this deposit has been published in the Division of Geology Report of Investigations No. 8, The Buckhorn Iron Deposits.

Roosevelt

The Roosevelt mine, owned by Mrs. Elise Maclean Dewar, Mrs. Joseph McCarthy, and Mr. Roger O. Oscarson of Spokane, consists of ten unpatented claims and two fractions on the northeast slope of Buckhorn Mountain in secs. 24 and 25 (40-30 E.). It is about a mile southeast of the Magnetic mine at an elevation of about 4,600 feet and is accessible by good truck roads from Curlew and Chesaw.

The main development work consists of an 825-foot lower adit with about 800 feet of drifts and stopes. Two hundred feet above the lower adit are several short adits and open cuts all caved.

The mine is situated on the southeast extension of the same syenite-metasedimentary rock contact on which the Magnetic mine has been opened. The Roosevelt contact metamorphic zone is considerably smaller and separate from the Magnetic zone, although mineralization in both zones is the same. The scheelite observed in the Roosevelt workings occurs as occasional minute crystals in garnet-epidote rock and was nowhere abundant enough to constitute tungsten ore. However, it is not impossible that future development may disclose commercial tungsten ore along the contact.

More information on this property has been published in the Division of Geology Report of Investigations No. 8, The Buckhorn Iron Deposits.

Crystal Butte

A quarter of a mile east of the old Crystal Butte mine there is, in the SW¼SE¼ and the SE¼SW¼ sec. 35 (40-30 E.), a small contact metamorphic zone on land owned by Mr. Speadon of Seattle. It is about 5 miles by road southeast of Chesaw on the south slope of Buckhorn Mountain at an elevation of about 4,300 feet. It is connected by road with the Roosevelt and Magnetic properties.

Development work consists of five prospect shafts, a 350-foot adit, two trenches totaling 420 feet in length, and three small open cuts. All of these old workings are caved, but the adit can still be entered.

The only bedrock exposed on the property is quartzite and argillite striking about N. 25° E. and dipping about 25° SE. About a quarter of a mile northwest of the workings is a small stock of intrusive syenite similar to that at the Roosevelt and Magnetic mines. The quartzite and argillite beds, over an area 900 feet long and 300 feet wide, have been incompletely and irregularly replaced by pyrite, pyrrhotite, magnetite, chalcopyrite, and a very small amount of scheelite. It is believed that an extension of the small syenite stock underlies this area at shallow depth and has been responsible for the mineralization. The scheelite occurs as minute crystals sparsely scattered through the mineralized zone and was nowhere found to be abundant enough to constitute tungsten ore.

A description of this property has been published in the Division of Geology Report of Investigations No. 14, Some Magnetite Deposits of Stevens and Okanogan Counties, Washington.

Strawberry Lake

The Strawberry Lake deposit, owned by W. Buckley and T. Buckley of Chesaw, is a quarter of a mile west of Strawberry Lake about 3 miles by road northwest of Chesaw. It is in the SE¼ sec. 7 (40-30 E.) at an elevation of about 4,000 feet above sea level.

Development work consists of five shallow prospect shafts, all more or less caved, two short adits, and several open cuts.

The bedrock is a dark gray to greenish quartzite with occasional lenses of siliceous limestone. No bedding was observed in any

of the exposures and the structure of these rocks was not determined. Granite, intrusive into the quartzite-limestone rock, is exposed about a quarter of a mile north and east of the workings. Two narrow quartz veins are known to cut the quartzite.

The prospect shafts have been made in a small contact metamorphosed zone where the quartzite and limestone beds have been partially replaced by magnetite, pyrite, garnet, and scheelite. It is believed that an extension of the granite mass that lies to the north and east of the deposit underlies the metamorphosed zone and is responsible for the mineralization. The replaced zone is roughly 165 feet long and 75 feet wide with a central core of nearly solid magnetite about 70 feet long and 50 feet wide. Pyrite is the chief ore mineral around the edges of the magnetite core and grades outward into quartzite containing only a few disseminated crystals of pyrite. The magnetite-pyrite rock contains numerous small crystals of scheelite up to an eighth of an inch across. It was estimated that the scheelite content of the exposed rock is only a small fraction of one percent.

About 350 feet northeast and southeast of the magnetite-pyrite mass are small lenses of siliceous limestone that contains occasional crystals of scheelite up to a quarter of an inch across. The scheelite is most abundant along minute fractures cutting the limestone.

The two short adits are about 250 feet southwest of the magnetite-pyrite mass. Each adit is about 40 feet long and has been driven westward along 6- to 8-inch quartz veins that strike N. 80° W. and dip about vertically. The more northerly of these two quartz veins carries a few very small crystals of scheelite.

No commercial tungsten ore was observed in this deposit, but geologic conditions are extremely favorable for the formation of scheelite and future development work may disclose commercial tungsten ore.

This deposit has been described in detail in the Division of Geology Report of Investigations No. 14, Some Magnetite Deposits of Stevens and Okanogan Counties, Washington.

OROVILLE DISTRICT

The Oroville district is in the north central part of Okanogan County just south of the International Boundary and east of the Nighthawk district. As here defined it includes T. 40 N., R. 26 E. and the west half of T. 40 N., R. 27 E.

The district is characterized by the predominant rolling upland, which nevertheless shows steep slopes commonly, particularly along the Similkameen.

Wood and water for mining and milling purposes are relatively scarce within the district as a whole and this is especially true on the known tungsten-bearing properties.

The oldest rocks are a series of interbedded slates, schists, quartzites, marbles, and greenstones thought to be of Carboniferous age.[1]

[1] Umpleby, J. B., Geology and ore deposits of the Oroville-Nighthawk district: Washington Geol. Survey Bull. 5, p. 68, 1911. All three of the stratigraphic units described in this report, but not mapped, appear prominently in the Oroville mining district.

In general these rocks strike a few degrees west of north and dip from 30° to 35° SW. They have been intruded by small bodies of hornblende granite, and both the granite and metamorphic sedimentary rocks are cut by still later granite dikes. Narrow quartz veins, carrying ore minerals, traverse the older rocks. The veins vary from a fraction of an inch to 1 foot in width and the majority of them strike from N. 45° W. to N. 65° W. and dip from 30° to 45° SW. A few strike from due west to N. 45° W. and dip from 40° to 80° NE. There are also a small number of north-south veins that dip about 35° W. In several places in the old metamorphic rocks are zones in which well-defined fracture cleavage strikes from N. to N. 80° W. and dips from 30° to 35° W. and SW. The maximum exposed width of these zones is 5 feet. Vein quartz has been deposited in the fractures as narrow lenses, in places thickened by overlap.

Four properties in the Oroville district show tungsten (pl. 8), the Moncosilgo, O. K. Copper, Golden Chariot, and the 49th Parallel. No production has been recorded from any of them.

Moncosilgo

This property is at the south end of the main ridge between Osoyoos Lake and the Similkameen, about 1½ miles north of Oroville. It is owned by C. S. Adam, W. J. Ripley, and J. Stuible of Oroville and consists of two 40-acre tracts, the NE¼SE¼ sec. 20 and the NW¼SW¼ sec. 21 (40-27 E.) less 7 acres along the south edge. The workings, about 600 feet above the lake level, are reached by truck road connecting with the county road west of Lake Osoyoos, about 1⅓ miles north of Oroville.

An adit has been driven 60 feet N. 70° W. into the hill, and a 10-foot drift opens northeastward about 50 feet in. This is along the irregular contact of the gneissoid diorite first encountered and the granite in which the adit ends. Several open cuts have also been made on the property.

The ore body appears to consist of a network of intersecting mineralized fractures in diorite. The largest fractures, often slickensided, are as much as 3 inches wide and strike northeastward, dipping both northwest and southeast at various angles. They are filled with crushed and altered diorite, limonite, cuprite, bornite, chalcopyrite, molybdenite, pyrite, and calcite. The rock between the major fractures is crisscrossed by minute, tight fractures that are frequently lined with native copper, cuprite, chalcopyrite, molybdenite, pyrite, and occasional small crystals of scheelite. Frequently the diorite on either side of these fractures has been partially replaced by the ore minerals.

At the time of the examination (Jan. 1943) no commercial body of tungsten ore had been exposed.

O. K. Copper

This property, commonly known as the O. K., consists of three full claims and two fractions near the center of sec. 6 (40-27 E.). It is owned by Al Hagelberge of Oroville, Washington. The claims are reached by a truck road from the U. S. Customs depot about

1 mile to the northeast. They are north of the Golden Chariot property and south of the 49th Parallel property, at an elevation of 1,500 feet on the northeast lower slope of Kruger Mountain.

The workings consist of two adits, two inclined shafts, and numerous open cuts. The main adit, with 120 feet of drifts, has been driven for 520 feet southeasterly into Kruger Mountain. A caved 60-foot inclined shaft and a 20-foot inclined shaft, 600 feet and 760 feet respectively southeast of the main adit, have been sunk on the ore. An adit about a quarter of a mile southwesterly from the main adit has been driven westward into the mountain for 75 feet, but has failed to cut ore.

The two inclined shafts have been sunk in a zone of fracture cleavage more than 5 feet wide in quartzite and argillite of the old metamorphic series. The zone of fracture cleavage strikes a few degrees west of north and dips about 32° SW. As many as a dozen veinlets or lenses of quartz, 1 to 8 inches wide, make up the ore zone in places. These carry much marginal chalcopyrite and pyrite, apparently contemporaneous with the quartz, and some molybdenite that appears to have been deposited somewhat later than the quartz. Relations are obscured by post-mineral movement.

The main adit crosscuts a 2- to 6-inch quartz vein striking about N. 45° W. and dipping from 30° to 40° SW. This narrow quartz vein carries considerable chalcopyrite and pyrite, a lesser amount of molybdenite, and occasional small crystals of scheelite. The scheelite is most abundant at the face of the adit, where the vein has been broken up and widens out into a zone of fracture cleavage with numerous quartz stringers up to 4 inches in width. This fracture zone is possibly a continuation of the one exposed in the two inclined shafts.

No commercial bodies of scheelite ore have been found on this property.

Golden Chariot

Four patented claims comprise this property lying in secs. 6 and 7 (40-27 E.) just south of the O. K. Copper. It is owned by a stock company and under the management of W. H. Thomas, of Oroville, Washington. A mile of truck road connects the property with the county road to the east.

The property has been opened up mainly by an incline shaft down the 30° dip of the ore zone for a reported distance of 350 feet. This exploration is amplified by considerable drifting and stoping at the 150-, 200-, and 300-foot levels. In addition there are several open cuts.

The ore zone, striking about north and dipping about 35° W., averages 5 feet in thickness and consists of a series of overlapping S-shaped lenses of mineralized quartz filling fracture cleavages in argillite beds. The quartz lenses vary from a fraction of an inch to a foot in thickness and carry considerable chalcopyrite, pyrite and some scheelite and molybdenite. Individual quartz lenses may contain up to one percent scheelite with crystals up to one inch across, but the exposed zone of fracture cleavage as a whole will

not carry more than a small fraction of one percent scheelite. The narrow argillite bands between the quartz lenses are slightly impregnated with the sulfides, but apparently do not carry scheelite.

Nine carloads of hand-sorted copper ore have been shipped from this property, but no attempt was made to save the tungsten values.

49th Parallel

This property is in the NE¼ sec. 6 (40-27 E.) and consists of five claims, which lie between the O. K. group and the International Boundary. It is owned by Kent Hagelberge of Oroville. Nearer Okanogan River than the O. K. claims, this group lies in an area of less relief, the average elevation being about 1,200 feet. Very little timber or water is available for mining on the property, although the water table is probably less than 50 feet below the surface. The property is reached by about a mile of truck road westward from one-half mile south of the U. S. customs depot.

An incline has been put down about 300 feet northwest of the cabins on the O. K. claims. This trends 5° west of south following a fracture zone in greenstone down dip. In addition there is a 145-foot adit, a 100-foot adit, and two 20-foot adits. Four other shafts of undetermined extent have also been sunk but were flooded in 1943.

The fracture zone followed by the incline is at least 5 feet wide and includes numerous veinlets and lenses of quartz up to 1 inch thick. These, and the zone itself, strike N. 80° W., dipping SW. at 35°. The quartz carries much pyrite and chalcopyrite and some bornite. The greenstone walls show sulfide impregnations. The long adit, about 200 feet west of the incline, also in greenstone, was driven on small quartz veins which also carry abundant pyrite and chalcopyrite and occasional small crystals of scheelite. In places there were 3 or 4 small grains to the square inch. Scheelite was found by ultra-violet light in but one place on the property. Some of the quartz veins on this property are at least 6 inches wide and in places range up to 12 inches. While no ore body can be said to be established, the mineralized quartz veins trend approximately N. 70° W., dipping southward at low angle in the southern part of the property, but dipping northward at high angle at the north end.

Some copper ore was shipped during the last war, but there is no record of tungsten.

NIGHTHAWK DISTRICT

This small mining area, lying just west of the Oroville district, includes only Rs. 24 and 25 E., both in T. 40 N. It has frequently been considered as a unit with the Oroville area.

Topographically the district is dominated by the canyon-like walls of the Similkameen where it meanders across a sandy flat in stiff awkward fashion. On the east wall is Ellemeham Mountain rising over 3,600 feet above the valley floor, while on the west the walls rise even more steeply to the top of Mount Chopaka at over 7,800 feet, over a mile and a quarter above the floor. Fortunately for mining development, even the highest points are easily reached

from the back slopes, but roads are confined to the lower levels. Nighthawk is the only community in the district. It should be noted that below Nighthawk the Similkameen shows a rapid descent to Oroville and could furnish considerable water power for local mining operations. Timber and water abound in the district but none appears on the tungsten properties.

The oldest rocks in the vicinity of the tungsten properties are a series of metamorphosed Paleozoic sediments consisting of interbedded quartzite, marble, argillite, and slate. The beds strike from N. 30° E. to N. 70° E. and dip from 80° NW. to 70° SE. These old metamorphic rocks have been intruded by diorite and in the more siliceous members contact zones (up to 50 feet exposed width) consisting chiefly of garnet and epidote have been formed.

The metamorphosed sedimentary rock and the granite are cut by quartz veins that strike about north and dip from 30° to 50° westward. Lamprophyre dikes cut all of the older rocks and more or less parallel the quartz veins or cut across them at low angles.

From both the disposition of outcropping veins and the topography of the area southwest of Nighthawk it seems probable that the southern projection of Little Chopaka is separated from the main hill by a north-trending fault along the west side of sec. 23 (40-25 E.). Minor faulting is abundantly indicated. Two mining properties, the Four Metals and the adjacent Kaaba-Texas (pl. 8), carry tungsten minerals, but neither has produced tungsten, even as a by-product.

Four Metals

The Four Metals property consists of eleven claims in secs. 22 and 23 (40-25 E.) on the southern projection of Little Chopaka, the 2,000-foot hill west of Nighthawk. These are owned by James Stack of Oroville. A fair road approaches the claims from the south, rising from river level about 500 feet in a mile.

Development work includes two shafts, 110 and 150 feet deep, three adits, 340, 235, and 140 feet long, as well as several open cuts.

The workings follow quartz veins which range from mere stringers to bands over 6 feet wide. These all trend north to northeast and dip about 35° westward. Scheelite, detected with ultra-violet light, appeared only in the Shamrock adit, where it comes in scattered small crystals one-sixteenth to one inch across. Small patches of wall or roof show abundant scheelite, with some crystals as much as one inch across. The limited development seen in 1943 suggests that scheelite is more abundant northward and down the dip of the veins.

Shipment of 20 or more tons of high grade and concentrates is reported for the period of the last war. In 1939 some 600 tons were milled. No tungsten has been reported shipped.

Kaaba-Texas

The Kaaba-Texas property lies in secs. 14 and 23 (40-25 E.) on the southeast side of Little Chopaka, adjacent to the Four Metals on the west. It is owned by a Seattle-Spokane group with L. B. Carroll of Nighthawk as superintendent. The claims are practically

along the county road on the west side of the Similkameen about a mile south of Nighthawk.

The vein is opened by an incline shaft some 300 feet long with about 1,100 feet of drifts on four levels, more than half being on the third.

The workings follow a quartz vein of unusual regularity in the diorite country rock. Wherever opened the north-trending vein dips about 45° to the west and ranges from about 6 to more than 9 feet in width, averaging about 8 feet. Several lamprophyre dikes appear on the three lower levels, mainly parallel to the vein, along hanging or foot walls, but in places within the vein or even cutting across it at high angle. Mineralization is rather uniform in pyrite, sphalerite, galena, chalcopyrite, and, on the fourth level, scheelite and molybdenite. There is a marked tendency toward banding of ore minerals along the footwall and toward bunching along the hanging wall.

Some 1,800 tons of ore was reported shipped to an experimental mill at Nighthawk, but tungsten was not recorded.

CHEWACK DISTRICT

Within the Chewack district, which occupies most of Tps. 35-40 N. in Rs. 22 and 23 E., tungsten is known only in the vicinity of Wolframite Mountain.[1] (See fig. 4.)

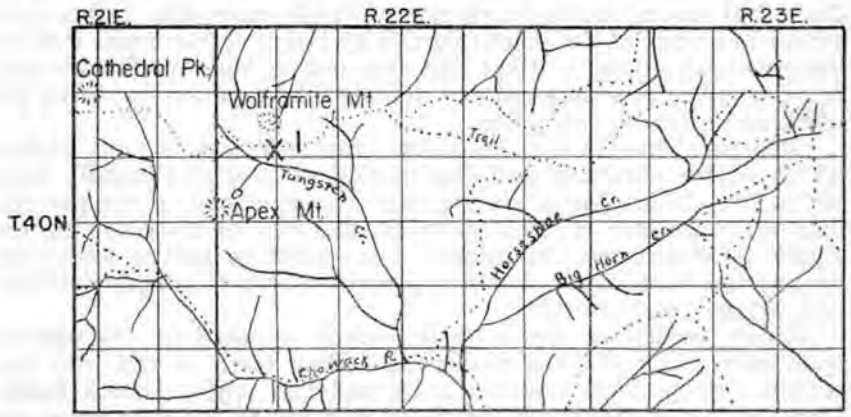


FIGURE 4—Tungsten occurrences in Chewack area. 1—Wolframite Mountain.

The district, set off by arbitrary and rectilinear boundaries, lies just west of the Nighthawk, Loomis, and Conconully districts. It includes the entire east side of the Chewack drainage area and is characterized by the very general occurrence of the granitic rocks of Mesozoic and Tertiary age and the corresponding absence of other rock formations. While some metamorphic sedimentary rocks corresponding to those in the Oroville-Nighthawk districts probably are present in the Chewack, they are not known on the one property which has produced tungsten.

[1] Until recent years Wolframite Mountain appeared on most maps with the designation Wolfnite, or Wulfnite, Mountain.

Wolframite Mountain

Wolframite Mountain is located in northwestern Okanogan County about 1½ miles south of the International Boundary. Tungsten-bearing veins crop out principally on the eastern and southern slopes of the peak, and to a lesser extent on the eastern slope of Apex Mountain, which lies 1½ miles west of south from Wolframite. This area is 30 miles by road and 13 by trail from Winthrop via the Chewack River and its tributaries. It is also 25 miles by trail northwest from Loomis. It is owned by John Hatfield of Wenatchee.

Wolframite and Apex mountains are respectively 8,100 and 8,300 feet above sea level, and lie along the extreme west margin of the Okanogan Highlands. Tungsten Creek, a west tributary of the Chewack, flows southeastward between the mountains in a broad glacially modified valley whose bottom is 1,500 to 2,000 feet lower in elevation. The north side of Wolframite drains into the Ashnola River in Canada.

Water may be obtained from either Tungsten Creek or from springs and is adequate throughout the year. Water for mining higher up on the slopes of the mountains, however, is scarce. Timber for mining is not plentiful on the mine claims, although abundant at no great distance.

A coarse-grained biotite granite is the predominant rock type. It alone contains the tungsten veins. This mass has been named the Cathedral batholith by Daly.[1] A later and dikelike phase of the Cathedral occurs on the north side of Wolframite; this is therefore a mile southeast of the point mapped by Daly. Other rocks include some vesicular basaltic dikes that crop out on both Wolframite and Apex mountains, a dark-colored dioritic dike exposed in one of the adits, and a few aplitic dikes.

Structural features of the coarse granite include a joint system which strikes northeast and dips northwest at angles usually from 10° to 15°. These joints are especially conspicuous on the precipitous northeast face of Apex Mountain and may be traced across the valley to Wolframite Mountain. They seem to flatten somewhat toward the southeast. Another prominent set is steeply inclined and strikes nearly north.

Faults, mostly of small displacement, exposed in the various open cuts and adits, are numerous. They seem to fall into two groups: steep angle normal faults and low angle normal faults. Those of low angle, if not restricted entirely to the vein zone, are particularly abundant in it, and are marked by grooved or fluted surfaces without slickensides. These faults usually dip westward, and usually the hanging wall has dropped relative to the foot; sometimes they occur in imbricate fashion, oblique to the vein walls beyond which they seem never to extend.

The ore of Wolframite Mountain area appears in a zone of veins. This zone dips, as indicated by the position of the veins themselves, 10° to 15° northwestward. The strike and dip of the veins coincides

[1] Daly, R. A., Geology of the North American cordillera at the forty-ninth parallel: Canada Geol. Survey Mem. 38, pp. 459-464, map 86A, 1912. See also Smith, G. O., and Calkins, F. C., A geological reconnaissance across the Cascade Range near the forty-ninth parallel: U. S. Geol. Survey Bull. 235, pp. 47, 65, 1904.

generally with that of the low dipping joints already mentioned. The veins may be considered to fall into four groups of outcrops, (1) those along the northeast slope of Wolframite near 7,300 feet in elevation, (2) those on the southeast slope at 6,800 to 7,200 feet, (3) those near the valley floor, three-fourths to a mile west of groups 1 and 2, at 6,500 to 6,600 feet, and (4) those along the ridge leading east from Apex Mountain at 7,400 feet and 1¼ miles south of groups 2 and 3. (See pl. 9.)

The veins range in width from fractions of an inch up to 2 feet but commonly they are between 5 and 10 inches. No individual vein has been opened up for more than 250 to 300 feet in any direction. The veins are all of quartz carrying wolframite predominantly, but showing some scheelite, pyrite, sphalerite, and a tin-white mineral containing lead and bismuth which may be galenobismutite. A yellowish alteration product, probably tungstite, was noted in a few places. The wolframite is apparently near the hübnerite end of the series with a low iron-to-manganese ratio. All outcrops reveal more or less wolframite, but its greatest concentration is apparently in the veins of group 3 near the valley floor, followed, in order, by groups 2, 4, and 1. At its maximum the wolframite is estimated to constitute 4 or 5 percent of the volume of the vein, or over 9 percent WO_3. The most common gangue mineral besides quartz is sericite; it occurs as a fringe along the hanging and foot walls or along fractures in the vein itself. Numerous quartz crystals up to 2 inches long, some of them water clear, occur in vugs; comb structures as well as cryptocrystalline or chalcedonic varieties of quartz are less common.

The wall rock shows hydrothermal alteration on both foot and hanging walls, being most intense between adjacent parallel veins, where considerable silicification has occurred. In general the textural identity of the wall rock is not obliterated, but kaolinization of orthoclase crystals is generally complete as far as 12 inches from the vein wall and less marked from 1 to 2 feet.

Of the four groups of outcrops, group 3, in the S½ sec. 7 (40-22 E.) near the floor of Tungsten Valley, has been most extensively developed. Here, five adits and three open cuts are located along 1,500 feet of the vein zone. Two veins have been opened by open cut and short adit on either side of Tungsten Creek near the 6,500-foot contour. These are only 2 to 3 inches thick and show a little wolframite and considerable pyrite with scattered minute blades of the lead-bismuth mineral that resembles galenobismutite. The vein in the adit north of the stream strikes N. 65° E. and dips 25° NW., and that in the open cut south of the stream strikes N. 57° E. and dips 18° NW.

The next opening to the northeast is an adit, located close to the north center line of sec. 7 and driven N. 40° E. for 265 feet. Two side drifts have been driven southeast at 85 and 140 feet and two inclined drifts or flat raises at 175 and 215 feet from the portal. The lengths of these are respectively 18, 14, 40, and 25 feet. One other drift, at 170 feet, driven west of north for 30 feet, completes the development in this adit; it and a raise on the opposite side of the

adit are respectively 18 and 10 feet wide, and suggest that a small amount of ore was removed. The raise is caved in one corner, probably being stopped close to the bottom of the overlying glacial deposits.

The vein is first seen at about 70 feet from the portal where it is cut by one or more dikes that have an over-all width of at least 24 feet. The dikes trend northwestward and dip steeply south. Much wolframite occurs in the vein where it lies close to the floor of the first drift southeast. At 115 feet from the portal in the main adit the vein is faulted up 3 feet above the floor and shows a width of 6 to 7 inches with considerable wolframite; it strikes north and dips 15° west. In the second side drift southeast there is sparse mineralization of wolframite and pyrite. But in the main adit the vein is dislocated several feet in places by northwestward-trending faults, so that the vein is near the floor in one place and at the back in another. The width remains at 6 to 8 inches along the adit up to the northwestward drift along which the vein decreases to 2 inches at the face. A few feet beyond the intersection, there is an abrupt widening to 1 foot, after which the vein decreases to 2 or 3 inches until faulted out close to the face of the adit. In general wolframite occurs as occasional blades from 1 to 2 inches long in both the main vein and splits therefrom.

Two northwestward-trending faults move the vein up on the northeast side some 5 to 10 feet where they cross the first two side drifts and the main adit. At one other place the vein is dropped down 2 feet on the northeast side of a 3-foot dike in the main adit between the two principal faults just mentioned. Several minor dislocations occur along the vein, all of them by northwestward-trending faults, between the northwest drift and the face of the main adit.

A third adit, located 230 feet N. 17° E. from the one just described, is 40 feet long. It follows N. 40° E. along the strike of a 6- to 8-inch vein which dips 10° to 15° NW. Sparse pyrite and wolframite show in the face.

A fourth adit is located 55 feet N. 60° E. and 8 feet above adit number 3. This is the principal adit of the Wolframite Mountain area, as it produced most of the ore shipped. The adit follows a vein about N. 45° E. for 360 feet, then swings N. 15° E. for 90 feet, N. 15° W. for 20 feet, and finally N. 65° W. for 85 feet to the face. Five drifts have been driven southeastward at 130, 160, 200, 255, and 315 feet from the portal. These are respectively 30, 30, 40, 85, and 110 feet in length, the last one being driven partly on an incline to reach the surface. A raise at 340 feet off the main adit is 28 feet long on a 35° incline, 30 feet on a 15° incline, and 30 feet nearly level to a cave that came down an incline from the surface. At 58 feet from the main adit a 10-foot winze off the south side of this raise connects with a sub-drift that trends south to connect with the fifth drift and incline from the main adit. One raise at 430 feet and another at the end of the main adit, both short and not on a vein, complete the development.

An 8-inch vein with three narrow splits below is exposed in the main adit at 130 feet; it carries some wolframite here but the mineral is particularly conspicuous 10 to 15 feet farther along in the adit where blades 1 to 3 inches long are inclined to the plane of the vein. At 200 feet the vein retains a 6- to 7-inch width, although a hanging wall split 1 to 2 inches wide is visible for 20 feet; wolframite is still abundant. Between 240 and 280 feet the vein widens to 1 foot in one place then starts to narrow, finally splitting in two parts that terminate beyond the fifth side drift; at one place there is a relatively high tenor in wolframite with 22 clusters of crystals along 10 feet of surface. Where the vein splits, a third and apparently separate stringer appears along the adit for several feet. At some 330 feet from the portal four veins each 1 to 2½ inches wide and 6 to 8 inches apart are visible, and the remainder of the adit shows no vein of greater width. Another vein, or a faulted segment of the one which is exposed south of the splits on the main adit, appears at the head of the 35° incline in the raise which leaves the main adit at 340 feet from the portal; its width is only 5 to 6 inches, but the wolframite reaches a maximum estimated at 4 to 5 percent of the volume of the vein. Before reaching the winze the vein narrows to 2½ inches where it closely parallels another of equal width; one or the other of these veins continues for several feet beyond the winze to the caved part of the raise. The stope on the northeast side of the third side drift shows, next to the adit, three veins that are 6, 1½, and 1 inches wide with 6 to 8 inches of hydrothermally altered wall rock between. The southeast side of the stope shows the vein widening to 10 inches close to the surface. The vein in this stope shows considerable wolframite, particularly next to the adit, together with scheelite. A little pyrite occurs at the southeast end.

The veins are dislocated a few inches or feet in several places by faults that trend northeastward and dip steeply northwestward. The southeast or footwall side in most places is uplifted relative to the hanging wall of these faults. Some low angle faults occur within or close to the veins. These strike northeast, dip at low angles to the northwest, and show grooved surfaces that pitch usually west or southwest. Joints strike northeast to north of east and dip from 10° to 15° northwest. The strike of the veins in most places corresponds to that of the low dipping joint set.

Two open cuts on the veins of group 3 are located 500 feet N. 62° E. of the principal adit just described. Both veins carry considerable wolframite although some scheelite occurs in the lower. These veins range in thickness from 4 to 15 inches, strike N. 80° E. to due east, and dip 10° to 16° northward.

The only other opening of group 3 is an adit that lies 230 feet northeast of the open cuts and has been driven N. 40° E. for 40 feet, then N. 80° E. for 10 feet to the face. A vein is exposed in only the last 10 feet; it is 4 inches wide, splits into two parts back from the face, and shows two vertical appendages on the footwall. This vein shows no wolframite.

The veins of group 2, located in the S½ sec. 8 (40-22 E.), have been opened by four adits and several open cuts about 1,800 to 2,000 feet north of east from group 3 and 350 to 375 feet higher on the slope of Wolframite. The western opening on this group is a combined open cut and adit. The 12-inch vein is exposed for 35 feet along the sides of the open cut and back of the adit and it is bordered on the hanging wall by five veins less than an inch wide, and on the footwall by a 2- to 3-inch stringer that diverges from the footwall of the vein near the face of the adit. Very little wolframite and pyrite occur in these veins.

To the east and 60 feet above the one just described, another adit opens a vein trending N. 10° E. for 155 feet, then swings to N. 35° E. for 45 feet to the face. Two side drifts, one at 65 feet, driven N. 63° W. for 52 feet, and another at 105 feet, driven S. 70° E. for 20 feet, complete the development. At the junction of the first side drift the vein widens abruptly to 2 feet and shows some wolframite; but in the drift the vein maintains an 8- to 10-inch width for several feet then widens to 16 inches after which it splits, and at the face three veins appear, 6, 1½, and 1 inches wide. An occasional blade of wolframite with considerable pyrite occurs in the second side drift. Fractures in this part of the vein are coated with manganese oxide. About 30 feet beyond the second side drift the vein is faulted and apparently dropped down to the floor of the adit. At the face a second fault was encountered which cuts the vein out entirely. A few wolframite blades were seen but in general the tenor throughout probably does not exceed 0.5 percent.

The vein varies in strike and dip from essential flatness to low northwest and southeast dips. Two prominent faults cut the vein. The first of these crosses both the first side drift at 20 feet from the intersection and the main adit at 120 feet from the portal; it strikes N. 30° E. and dips 80° NW. At least two movements, both nearly horizontal, are indicated. Consequently the vein is moved up 2 feet on the east where it is cut by the fault in the first side drift, and dropped down on the west in the main adit. Another fault, that parallels the last 25 feet of the adit, moves the vein out of sight on the northwest side.

Other adits and open cuts in group 2 veins are located 200 to 400 feet north of east from the second adit. These are at various levels within a range of 10 to 20 feet, and as a group by themselves, rise 50 to 75 feet higher along the slope. The veins exposed in these openings all show more or less wolframite, sometimes in bunches composed of large blades several inches long, but usually as single crystals in the quartz. The tenor is roughly estimated at 1 percent of the volume of the vein in wolframite. No vein of the group has a greater width than 15 inches, nor an exposed length greater than 30 feet. Narrow parallel veins on either the foot or hanging walls, or splits from the larger veins, are visible in one or two open cuts.

These veins strike nearly east and dip northward at low angles. They are dislocated in places by steeply dipping northward-trending faults. Very often the walls of the veins are fault surfaces.

The occurrences of group 1 are natural exposures on the sides of a precipice. A 6- to 10-inch flat vein is exposed intermittently for 30 to 40 feet; it shows numerous vugs and comb structures and sparse wolframite. Numerous closely spaced parallel faults occur in the vein, much like fracture cleavage in folded sediments. The surfaces of these faults are coated with sericite.

Group 4 veins on the east slope of Apex Mountain have been opened up by one small cut which shows a vein up to 10 inches in thickness. Considerable wolframite with scheelite shows in parts of the vein, also with some pyrite and minute amounts of the mineral resembling galenobismutite. The total length of vein exposed is 20 feet, and at one end there are two 1½- to 2-inch footwall splits.

At the upper part of the outcrop the vein strikes N. 40° E. and dips 48° NW., but on the lower side the dip decreases considerably. Prominent joints in the granite strike N. 50° to 60° E. and dip 15° to 20° NW.

The veins exposed in the Wolframite Mountain area were discovered in 1898 by the staff of the International Boundary Commission, although locations were not made until 1908. Most of the development was done during 1915 and 1916. Prior to 1920, at which time the mine was closed down, 6 cars of hand-picked ore were packed out and shipped. The sawmill and concentrating plant were destroyed by forest fire in 1930. In 1936 30 tons were shipped to New Jersey but reportedly at a loss to the operators.

CONCONULLY DISTRICT

This well-known mining district lies along the border between the Cascade Mountains and the Okanogan Highland. Although established in the eighties, the exact limits are in doubt. It lies within Tps. 34 to 37 N., between Okanogan River and the main divide setting off the Methow drainage area. By some the district is extended from the mouth of Salmon Creek northward to the Sinlahekin, thus including the Ruby and Salmon River districts of the earlier reports. For the purposes of this report it is restricted to Tps. 35 to 37 in Rs. 24 to 26 in the vicinity of the town of Conconully.

Topographically the district comprises two units; on the west, a mountainous area where relatively smooth slopes lead to summit levels between 5,000 and 8,000 feet; on the east, an area of lower relief, maximum elevations less than 5,000 feet, and correspondingly gentler slopes. The two surfaces are fairly well separated by Toats Coulee.

The geologic formations in the district are few and these are closely related to the topography. Only two formations need be noted for this study, although the detailed areal map shows the assortment of both igneous and sedimentary rocks commonly seen in the Okanogan country. A series of more or less metamorphosed sedimentary rocks of Carboniferous (?) age has been intruded by a granitic mass of wide extent and varied petrologic character. This

plutonic is probably to be correlated with Daly's late Cretaceous or Tertiary Similkameen along the 49th parallel just north.

Only four properties have so far shown tungsten minerals (pl. 10), the Starr, the Silver King, the Lady of the Lake, and the Gubser. None has yet produced tungsten ore.

Starr

The Starr property is located at the southeast extremity of the north-trending ridge known as Aeneas Mountain, the 5,200-foot summit of which is called Lemanasky Mountain. The portal of the main adit is in the SE¼ sec. 8 (37-26 E.) about 1,500 feet west and 690 feet north of the southeast corner. The property is owned by Andrew Starr, Tonasket. The southeast slope of Aeneas Mountain is gentle and the property is easily accessible over a road of easy grade from the junction with a county road some 500 feet lower, in the northeast quarter of sec. 17 (37-26 E.). Sufficient timber and water are at hand for mining operations.

At the time of examination (1941) the main adit had been driven westward into the mountain for about 1,100 feet with several short drifts on either side. One of these, going north, leads to a winze and stope of unknown extent. About a quarter of a mile west of the main adit, just over the crest of a small ridge, two short adits have been driven eastward, one about 50 feet above the other. Each has short drifts to the south. Near here several open cuts have been made.

The main adit and connecting drifts penetrate a mineralized zone in the country rock, a granite with rather high quartz content. This zone, 80 by 400 feet in plan, contains pyrite and molybdenite concentrated along fractures and more or less disseminated through the granite. It probably averages less than one percent molybdenite.

About 700 feet in from the portal, the main adit reveals a 60-foot zone bearing scheelite. Neither the north nor south drifts at this point show a width greater than that in the main adit. The scheelite occurs with lenticular or irregular concentrations of quartz that may be connected, but there is no suggestion of a vein system. Associated with the quartz and scheelite are pyrite and molybdenite. The amount of scheelite shown along the zone would not constitute more than a small fraction of one percent of the surface. Six of the scheelite crystals are from one-half to one inch in diameter, but the majority of the spots are less than one-fourth of an inch in diameter and many were just large enough to be seen. About 30 spots from one-fourth to one-sixteenth of an inch were counted along this 60-foot zone. The scheelite does not extend into either the left- or the right-hand drifts. Scheelite also occurs near the faces of the two short drifts to the south in the two short adits west of the main adit. In each case there was one crystal of scheelite about one-fourth of an inch in diameter occurring in the same manner as in the main adit.

There has been no production of tungsten from this property.

Silver King

The Silver King property, consisting of 13 claims, is in the SW¼ sec. 31 (36-25 E.), about one mile north of Conconully. It is just east of the Salmon Creek road and the main workings are about 100 feet above the creek. The property is controlled by J. D. Lindstom of Wenatchee.

At the time of the examination (April 1942) the main development consisted of a 240-foot adit driven about N. 15° E. and a 100-foot inclined shaft at the portal of the adit. At the 50-foot level a 130-foot drift extends eastward along the vein. About 600 feet south of the shaft is a crosscut adit several hundred feet long, and about 600 feet east of the mill is another similar adit. There are also numerous open cuts on the property.

The main ore body is exposed in the 240-foot adit and the inclined shaft and drifts. It consists of a quartz vein that narrows to 4 inches at the face of the 130-foot drift. The vein strikes N. 15° E., dips 60° NW., and parallels an older, 1- to 4-foot, basic dike. The country rock cut by the quartz vein is granite. The quartz carries considerable pyrite, galena, and sphalerite, and a small amount of scheelite. The scheelite is found near the face of the 130-foot drift and near the bottom of the inclined shaft. Although small crystals of scheelite are scattered through the quartz in these areas the main concentration is along the footwall of the vein.

The crosscut adit 600 feet south of the shaft cuts a 3-foot quartz vein 85 feet from the face. The vein carries a small amount of pyrite and galena and occasional minute crystals of scheelite. This vein strikes S. 20° W. and dips 45° NW.

An unknown amount of lead-silver ore has been produced, but no tungsten ore has been shipped from the property.

Lady of the Lake

The Lady of the Lake property, consisting of one claim, is in the NE¼ sec. 6 (35-25 E.), on the north bank of Conconully Lake about half a mile northeast of Conconully, and is easily accessible by road from that town. The property is controlled by J. D. Lindstom of Wenatchee.

The main development consists of an adit about 150 feet long, with about 50 feet of drifts, driven approximately N. 15° E. into the hill. The portal is about 60 feet above the level of Conconully Lake. Above the portal are several open cuts on the mineralized zone and a caved, short adit. An adit of unknown length is reported to be on the mineralized zone below the level of the lake.

The ore body is a mineralized zone striking N. 15° E., dipping about 35° NW., and cutting a complex of argillites, granite, and both acidic and basic dikes. The mineralized zone is generally from 3 to 5 feet wide, but in places has a width of about 20 feet. However, the wider portions contain considerable unmineralized country rock. This zone is principally vein quartz with a small amount of pyrite, galena, chalcopyrite, sphalerite, molybdenite, scheelite, and calcite. The quartz is highly sheared and fractured and the best ore is confined to these zones of shearing and fracturing. The scheelite is scattered through the quartz as crystals rang-

ing from mere specks to over a quarter of an inch across. As exposed, the mineralized zone on the whole will not average more than a small fraction of one percent tungsten, but small areas up to several feet across may run as much as a quarter of one percent.

No tungsten ore has been shipped from this property, although some of the ore is being concentrated at the Silver King mill.

Gubser

Tungsten has been found in the long Gubser crosscut adit in the SW¼ sec. 31 (36-25 E.), about half a mile north of Conconully on the west bank of Salmon Creek.

The adit, about 50 feet above Salmon Creek, has been driven westward into the mountain for 900 feet. At 390 feet from the portal there are short drifts, about 50 feet long, both to the north and the south.

At 390 feet from the portal of the adit is a quartz vein striking N. 5° E. and dipping 85° NW. The vein consists of 1 to 2 feet of quartz on the footwall separated from 1 to 2 feet of quartz on the hanging wall by a basic dike from 1 to 2 feet wide. The quartz carries some pyrite, galena, sphalerite, and scheelite. Although small crystals of scheelite occur scattered sparsely throughout the quartz they are most abundant along the footwall.

The structure, mineralization, and relationship of this vein to the basic dike is similar to that of the Silver King vein and it is possible that they are one and the same.

No tungsten ore has been produced from this property.

SQUAW CREEK DISTRICT

The Squaw Creek district is in the southwestern corner of Okanogan County. The district includes the drainage area of the lower Methow from its junction with the Columbia to the vicinity of Benson Creek, the western limit being the Sawtooth Ridge divide while the eastern is arbitrarily placed to include R. 23 E. between Tps. 29 and 33 N.

The district is characterized by mountainous topography with increasingly higher and steeper mountains from east to west. East of the Methow River the peaks rise to a maximum elevation of about 2,500 feet above the river, while to the west the maximum elevation above the river is about 7,000 feet.

The oldest rocks are a series of metasediments composed chiefly of interbedded limestones, quartzites, argillites, and mica schists of probable Carboniferous age. These metasedimentary rocks occur as small masses completely surrounded by younger granitic rocks of Mesozoic (?) age. The granitic rocks underlie more than 90 percent of the district, the sedimentaries being isolated like roof pendants. Scheelite-bearing quartz veins, ranging from less than a foot to more than 15 feet in thickness, cut both the granitics and the metasedimentaries. The majority of these quartz veins strike in a general easterly direction and dip steeply either to the north or the south, but a few of them strike northward and dip to the east or west. About 45 percent of the known scheelite-bearing quartz veins are

associated with basic dikes. In general the dikes parallel the veins, occurring either within the veins or along one of the walls. In places the veins can be seen to cut across the dikes, indicating that they are younger than the dikes. The old fissures occupied by the dikes appear to have been influential in controlling the locations of the veins and probably acted as channels for the movement of the vein-forming solutions. In some places, where the granitics intrude limestones, scheelite-bearing contact metamorphic deposits have been formed.

Eleven properties in the Squaw Creek district show tungsten (pl. 11), the Holden-Campbell Mining Company, Highland Mining and Milling Company, Methow Mining and Milling Company, Chelan, Golden Eagle, Washington, New Deal, Dutch John, Sherwood, Lodge, and Minnie. No tungsten ore has been shipped from any of these properties.

Holden-Campbell

The Holden-Campbell Mining Company, represented by S. J. Holden and A. C. Campbell of Chelan, controls 29 mine claims on the north side of Squaw Creek about 11 miles northwest of Pateros. The claims are mainly in secs. 10 and 11 (32-22 E.), and a few of them are along the southern edge of secs. 2, 3, and 4 and in the northern half of sec. 14. They cover the west side of Hunter Mountain and extend over the mountain to the west into the McFarland drainage area. The property is easily accessible from the Methow highway by 4 miles of road up Squaw and Grub Stake creeks.

The ore bodies on the Holden-Campbell property are quartz veins that cut the gneissoid diorite country rock, striking both eastward and northward and dipping at steep angles. Although there are numerous quartz veins on the property only those that are known to carry tungsten are here described.

Most of the development work on this group of claims has been done on the largest and most persistent vein, the Hunter, on the west side of Hunter Mountain in the NW¼ sec. 11 and consists of three adits and several open cuts. The upper adit is now caved. The middle adit has been driven eastward for 480 feet along the vein and then 180 feet farther along a fault zone. A 50-foot winze has been sunk 150 feet from the portal. Approximately 180 feet below the middle adit another adit has been driven about 120 feet eastward on the vein.

The Hunter vein strikes N. 80° E. and dips from 85° SE. to 85° NW., but the northwest dip is the most common. It consists of from 2 to 10 feet of quartz (3 feet average) between two good walls of diorite and parallels an earlier basic dike averaging about one foot in thickness. The quartz carries considerable pyrite, some chalcopyrite and scheelite, and a very small amount of molybdenite. The sulfides are particularly abundant along the footwall where they occur as bands up to several inches thick paralleling the wall. Although scheelite crystals are scattered throughout the quartz they are most abundant along the footwall where they are arranged

roughly in streaks paralleling the sides of the vein. The crystals range in size from minute specks to one inch across, but the majority are less than a quarter of an inch across. Some small areas of the vein will probably carry several percent of scheelite, but the entire vein as exposed will probably not run over a quarter of one percent scheelite. The vein is cut by reverse faults that nearly parallel it in strike, but dip at lower angles. In the main adit at 480 feet from the portal the vein is cut by such a fault, the vein on the footwall side of the fault being offset about 25 feet to the southeast. Similar faulting has also taken place at the face of the lower adit.

The Okanogan vein on the west side of Grub Stake Valley in the NE¼ sec. 10 has been developed by one adit and several open cuts. The adit is about half a mile N. 80° W. of the main Hunter adit. It has been driven westward for 80 feet to where it encounters the Okanogan vein and then follows the vein westward for 70 feet to where the vein splits into two segments, and then follows the right and left segments for 20 feet and 30 feet respectively. A winze, now flooded, reported to be 45 feet deep has been sunk on the vein 130 feet from the portal.

The vein strikes about N. 75° W. and dips 75° NE. On the surface it has a thickness of 8 feet which narrows to 3 feet where the vein is first encountered in the adit. The vein splits, at 110 feet from the portal, into two segments separated by a 1-foot basic dike and a narrow "horse" of diorite. The footwall segment of the vein averages 3 feet in thickness, strikes N. 90° W. and dips 75° N. The hanging wall segment averages 1 foot in thickness, strikes N. 70° W. and dips 75° NE. The vein has two good walls that show considerable movement and the vein itself has been fractured and sheared parallel to its walls. The quartz carries considerable pyrite and scheelite and in places is slightly copper stained, but no primary copper minerals were found. The scheelite is scattered throughout the vein material in crystals ranging from minute specks to half an inch across, but the greatest part of it occurs as fracture fillings in the quartz, producing a banded or ribbon-like ore. Individual ribbons of scheelite seldom exceed a quarter of an inch in thickness and several inches in length, but they are frequently close together, two or three ribbons to an inch of quartz, and at such places they constitute high-grade ore. The individual crystals of scheelite may be contemporaneous with the quartz. The banded scheelite is definitely somewhat later than the quartz. The vein matter will probably average between a quarter and a half of one percent scheelite.

Other tungsten-bearing veins are noted briefly in the following paragraphs.

The Doris Barbara, which strikes N. 65° E. and dips 65° NW., consists of 2 to 5 feet of quartz-carrying pyrite, chalcopyrite and scheelite. The scheelite occurs as numerous small crystals, seldom as large as a quarter of an inch across. A 75-foot adit has been driven on this vein about 600 feet north of the Okanogan adit.

The Bay Horse vein is exposed on the surface for a total distance of about 200 feet. It strikes N. 65° E. and dips 70° NW. and

consists of 2½ to 3 feet of quartz with a small amount of pyrite, chalcopyrite, and scheelite. The scheelite is not as abundant as in the Hunter vein. This vein is cut by several trenches about 1,000 feet northwest of the main Hunter adit.

The Ace of Diamonds vein is exposed for about 20 feet on the surface. It strikes N. 55° E. and dips 90°. It carries a small amount of pyrite and chalcopyrite and about as much scheelite as does the Hunter vein. This is opened by a trench about 900 feet S. 30° W. of the Okanogan adit.

The Esther vein strikes N. 35° E. and is vertical. It consists of 1 to 2 feet of quartz with some pyrite, chalcopyrite, and scheelite. The percentage of scheelite appears to be somewhat less than that of the Hunter vein. About 1,200 feet S. 55° W. of the Okanogan adit this vein is opened by a trench.

Another vein, 1,500 feet N. 55° E. of the main Hunter adit, strikes N. 65° W. and dips 60° NE. It consists of 2½ feet of quartz with a small amount of pyrite, chalcopyrite, and scheelite, but apparently less scheelite than the Hunter vein. This is opened by a 10-foot adit.

Considerable gold ore has been produced from this property, but there has been no production of tungsten.

Highland

The Highland Mining and Milling Company of Tacoma, represented by Mark Slabodnik, controls seven claims on the top and east slope of Hunter Mountain in the eastern part of sec. 11 and the western part of sec. 12 (30-22 E.). The property is bounded on the west by the Holden-Campbell holdings. It is accessible by about 2 miles of steep truck road from the Squaw Creek road.

There are several old adits and shafts on gold-bearing veins, but the only tungsten-bearing vein that has been developed is the Sailor Boy, or Lookout. It is exposed over a distance of 3,000 feet showing an average thickness of about 6 feet. The strike is S. 70° E. and the dip is 70° NE. It is opened by a 40-foot shaft and a 15-foot shaft 3,000 feet apart on the vein, and a long crosscut adit with drifts on the vein. The adit is north of the shafts and 200 feet below them, and was caved at the time of the examination. These workings are in the NE¼ sec. 11. The quartz carries a small amount of scheelite, the crystals of which range from minute specks up to one inch across. The scheelite content of the exposed parts of the vein appears to be only a small fraction of one percent. Other ore minerals present in the vein are pyrite and a small amount of chalcopyrite. The country rock cut by the vein is gneissoid diorite.

Considerable gold ore has been shipped from the property, but there has been no production of tungsten.

Methow

The Methow Mining and Milling Company of Seattle, represented by Richard Stevens, controls at least four claims on the east side of Hunter Mountain between the Highland claims and the Methow River and at least three claims east of the river. The claims are in the eastern half of secs. 12 and 13 (30-22 E.), and the

western half of secs. 7 and 18 (30-23 E.). The Methow highway crosses the eastern end of the property and is connected with the western end of the property by a truck road.

The New London claim has been developed by a large open cut and two underground levels on the northeast slope of Hunter Mountain in the NW¼ sec. 12 (30-22 E.). The main adit level is 350 feet long with stopes both above and below. A 75-foot winze connects this level with a lower level where a drift, with some stoping, has been driven for 100 feet along the ore body.

The New London vein is narrow, usually being measured in inches rather than feet, and is composed of quartz containing much pyrite, considerable free gold, and some chalcopyrite and scheelite. It lies along the footwall of a narrow basic dike that strikes about N. 60° E. and dips 55° NW. This narrow inclined dike is cut by a vertical basic dike that also strikes about N. 60° E. and is from 3 to 4 feet wide. The southward or upper portion of the inclined dike has been faulted several feet upward along the vertical dike relative to the northward or lower portion. The New London ore body is in that part of the vertical dike that lies between the faulted portions of the inclined dike and has the same mineral composition as the narrow vein. The ore body strikes about N. 60° E., is practically vertical, and pitches about 10° NE. It is known to be cut by several reverse faults that strike about N. 75° W. and dip about 55° SW. Each of these faults displaces the upper part of the ore body as much as 10 feet to the northeast. The scheelite crystals in the ore body are scattered through the quartz and range in size from mere specks to half an inch across. The scheelite content of the ore is probably less than a quarter of one percent.

It appears that the New London vein was formed by mineralizing solutions migrating upward through a narrow channel along the footwall of the inclined dike and depositing the vein minerals in this channel. That part of the vertical dike between the faulted portions of the inclined dike was no doubt broken up by the faulting and acted as a favorable host rock for the deposition of the vein minerals forming the ore body.

A shaft has been sunk on the Homestake vein on the crest of the large spur half way down the east side of Hunter Mountain. It is 50 feet deep and at the bottom a 30-foot drift follows the vein northward. The vein strikes N. 35° E., dips 55° NW., and is at least 15 feet wide. At the north end of the drift it is cut by a 4-foot basic dike that strikes N. 85° W. and dips 65° NE. The quartz carries a large amount of pyrite and a small amount of scheelite. Some of the scheelite crystals are as much as half an inch across.

East of the Homestake shaft and just west of the ranch buildings an adit, caved in 1942, has been driven westward for a reported distance of 850 feet on a nearly vertical vein striking N. 60° E. parallel to a narrow basic dike. The vein consists of 3 feet of quartz with some pyrite and small amounts of scheelite.

The Mineralite vein in the SE¼ sec. 13 (30-22 E.), has been developed by several small open cuts west of and about 100 feet above the Methow highway. The vein strikes about N. 90° E. and

is vertical. It ranges in width from 2 to 4 feet and is composed of quartz with a small amount of pyrite and chalcopyrite and occasional crystals of scheelite up to a quarter of an inch across.

In the NE¼ sec. 18 (30-23 E.), the Roosevelt vein is developed by two adits driven eastward into the hill on the east side of the Methow River. The lower adit is about 1,700 feet east of the river and about 200 feet above it. This adit is open for 700 feet from the portal, but is reported to continue beyond this point. The upper level adit is about 200 feet higher and is 140 feet long. This vein strikes N. 85° E. and dips from 85° NW. to vertical. It ranges from 6 inches to 8 feet in width and is composed of quartz paralleling a 1-foot basic dike. The quartz carries much pyrite, some chalcopyrite, and about a quarter of one percent scheelite. The scheelite occurs much the same as it does in the Hunter vein. Most of the scheelite crystals are less than half an inch across, but there are occasional solid masses up to 6 inches long and 3 inches wide.

The Tungstic vein crops out about 1,400 feet north of the upper Roosevelt adit, but no work has been done on it. It strikes N. 90° E. and is practically vertical. As exposed it is about 1½ feet wide and carries a very small amount of pyrite and scheelite.

The Milwaukee vein has been developed by a 125-foot adit in the SE¼ sec. 7 (30-23 E.), about 100 feet above the Methow River. It has been driven eastward into the hill on the vein, which strikes N. 60° W., and dips 75° NE. It consists of 3 inches to 1 foot of quartz that carries a very small amount of pyrite, chalcopyrite, and scheelite. The scheelite is confined to the footwall portion of the vein.

Considerable gold has been produced from the Methow property, but no shipments of scheelite have been made.

Chelan

The Chelan group of at least seven claims, controlled by Roy Pennington of Chelan, is in the NE¼ sec. 17 (30-22 E.), near the head of Squaw Creek on the north side of the valley and about a quarter of a mile from the creek. It is accessible by road up Squaw Creek.

The workings, mainly open cuts on non-tungsten-bearing veins, include an old caved adit on Number 7 vein and a 40-foot adit on Number 4 vein.

The diorite country rock is cut by several narrow quartz veins, only two of which are known to carry tungsten.

The Number 7 vein strikes N. 80° W. and dips 85° SW. It is from 1 to 2 feet wide and parallels a 1-foot basic dike. The quartz is heavily iron stained and is reported to carry gold, but the only mineral found was scheelite. The scheelite crystals range in size from minute specks up to a quarter of an inch across and are not numerous.

The Number 4 vein consists of 6 inches of quartz along a shear zone striking N. 85° W. and dipping 90°. The quartz carries a small amount of free gold, and three small crystals of scheelite were found along the gouge seam on the hanging wall.

No tungsten ore has been produced from this property.

Golden Eagle

The Golden Eagle vein, ownership unknown, is exposed by an old shaft at least 70 feet deep on the south slope of Hunter Mountain in the NW¼ sec. 13 (30-22 E.). The vein strikes S. 80° W., dips 90°, and consists of 2 feet of quartz containing a small amount of pyrite and scheelite. Scheelite crystals up to a quarter of an inch are rather common, but it is doubtful that the vein contains as much as a quarter of one percent scheelite. No tungsten ore is known to have been produced from this vein.

Washington

The Washington property, owner unknown, is in the NW¼ sec. 18 (30-23 E.) on the east side of Methow River about an eighth of a mile south of the Roosevelt property.

Development work consists of an upper shaft, now caved, and a lower adit. The adit has been driven N. 60° E. for about 60 feet to the vein and then continues S. 70° E. for several hundred feet along the vein. Due to its caved condition the adit is open for only about 200 feet from the portal.

The vein strikes N. 70° W. and dips 80° NE. It ranges in width from 1 to 3 feet and consists of quartz with considerable pyrite, chalcopyrite, and scheelite. Most of the scheelite occurs as small crystals less than an eighth of an inch across, but occasional crystals up to a quarter of an inch across can be seen. It is estimated that the scheelite content of the vein is not over a quarter of one percent.

There has been no production of tungsten ore from this property.

New Deal

The New Deal property has in former years been known as the Antimony Queen, Dixie Queen, Ready, and Silver Seal. The property is 4.3 miles up the Gold Creek road from the Methow highway and is in the SW¼ sec. 11 (31-21 E.), on the south side of Gold Creek. The lower workings are about 30 feet above Gold Creek. The property is controlled by A. Gibson and Vernon LaMotte of Twisp.

The main workings on the New Deal property consist of two adits, one about 30 feet above Gold Creek and the other about 250 feet higher and directly up the hill. In the upper adit about 150 feet from the portal there is a winze that is reported to connect with the lower adit through a stope. There are several open cuts and a short caved adit between the two main adits and a large open cut 500 feet above and about 1,000 feet south of the lower adit.

The only known occurrence of tungsten minerals on the property is in the upper adit. Quartz veins exposed along the walls of the adit 30 to 60 feet from the portal carry small amounts of pyrite, stibnite, and scheelite. On the south wall the vein is 1½ feet wide and on the north wall it has split into three veins from 2 to 4 inches wide. The quartz veins, striking N. 75° W. and dipping 60° NE., cut limy slate beds that strike N. 25° W. and dip 60° SW. The observed scheelite consisted of numerous minute crystals, twelve crystals about a quarter of an inch across, and four crystals about one inch across.

Another quartz vein is exposed in the adit 90 to 125 feet from the portal. It ranges from half an inch to 3 inches in width, strikes N. 90° W., and dips 30° N. In a distance of 35 feet the vein shows four seams of scheelite about a sixteenth of an inch wide and from 2 to 5 inches long, eight crystals between a quarter and a half inch across and numerous crystals just large enough to be seen. The vein also carries a small amount of stibnite.

The U. S. Bureau of Mines Mineral Yearbooks from 1907 to 1941 show a production of about 1,050 tons of antimony ore from this property, but there has been no production of tungsten.

Dutch John, Sherwood, Lodge

The Dutch John, Sherwood, and Lodge properties are treated here as one geologic unit. They are on the southwestward-trending ridge in sec. 2 (31-22 E.), about 4½ miles southeast of Carlton and about 1 mile south of Texas Creek. H. E. Seneff of Kirkland controls the Dutch John property of 80 acres in the W½SW¼ sec. 2. S. J. Sherwood of Twisp and W. L. Lodge of Soap Lake control the two 80's to the northeast.

There is a sparse growth of timber on the properties, but practically no water for mining operations.

The major part of the development work consists of numerous open cuts. The underground workings consist of two short adits and a 12-foot shaft located on top of the ridge 420 feet S. 20° E. from the Dutch John cabin. One of the adits is at the northeast corner of the Dutch John cabin and has been driven southeastward for 85 feet. The other adit about 50 feet farther northeast has been driven southeastward for 35 feet and is now caved. (See pl. 12.)

The top of the ridge and the upper part of the northwest slope is made up of a series of thin-bedded mica schists, argillites, limestones, and quartzites. To the northwest of the ridge is a large intrusive body of diorite. Although the exact contact between the diorite and the metasedimentary rocks is not exposed the approximate contact (within 50 feet) can be traced for about 1,500 feet at the north end of the ridge. At the southern end of the ridge in the vicinity of the Dutch John cabin the nearest exposure of diorite is several hundred feet to the west. Narrow aplite and pegmatite dikes probably related to the diorite have been injected into and between the metasedimentary beds and in places produce a lit-par-lit effect.

The detailed structure is complex, but in general the metasedimentary beds appear to lie near the nose on the northwest limb of an anticline pitching to the northeast. For about 300 feet south of the cabin the beds strike about N. 85° E. and dip from 15° to 35° NW., with the dips progressively increasing from southeast to northwest. On top of the ridge south of the cabin the beds strike about N. 50° W. and dip from 15° to 20° NE. This general strike and dip continues along the ridge top to its northeast end. About 3,000 feet N. 60° E. of the cabin the beds strike about N. 60° E. and dip 30° SE. Minor discrepancies in the major structure are not uncommon, but occur most frequently near the contact between the metasedimentary beds and the diorite. The thinly laminated beds

are slightly crenulated and there has been the development of numerous small drag folds whose structure indicates they are on the northwest limb near the nose of a major anticline pitching northeast.

Several of the limestone beds have been altered to garnet (grossularite) with smaller amounts of epidote, calcite, molybdenite, scheelite, magnetite, pyrite, and chalcopyrite. There are at least ten of these garnetiferous beds exposed over an area 3,000 feet long and 1,000 feet wide. They vary from 1 to 9 feet in thickness and average about 3 feet. Just south of the cabin a garnet bed averaging about 4 feet in thickness covers an area of about 800 square yards on the surface. A 2- to 4-foot garnet bed is exposed for a distance of 100 feet, 300 feet S. 20° W. from the cabin. A 3- to 9-foot garnet bed 340 feet S. 20° E. from the cabin is exposed for a total distance of 850 feet. Several smaller garnet beds are exposed in this same general area. About 2,000 feet due east of the cabin are several small exposures of 1- to 5-foot garnet beds. About 3,000 feet N. 60° E. of the cabin are several 2- to 3-foot garnet beds exposed over an area of 280 square yards.

The garnet beds have probably resulted from alteration and replacement of certain lime beds by solutions and gases given off from the diorite mass at the time of its intrusion. Chemical composition and permiability probably determined which of the calcareous beds were replaced. The molybdenite and chalcopyrite do not occur in sufficient quantities to constitute ore of molybenum and copper, but there are small areas several feet in diameter that would make good molybdenum ore. Much of the magnetite occurs as bladed crystals, up to 1 inch across, showing well-developed parting. Frequently several magnetite crystals are arranged in radial pattern. The scheelite occurs scattered through the garnet rocks, and there is considerable variation in the scheelite content of various beds as well as in different parts of the same bed. The scheelite crystals range from minute specks to as much as a quarter of an inch across. The average scheelite content of the garnet beds is estimated to be less than a quarter of one percent. Considerable powellite, resulting from the oxidation of the molybdenite and scheelite, has formed in the garnet beds.

No tungsten ore has been produced from these properties.

Minnie

The Minnie property, owned by William LaMotte of Twisp and now under lease to M. McCain and L. R. Shaver, is in the SW¼ sec. 14 and the NW¼ sec. 23 (32-22 E.), on a fork of Leecher Creek, an intermittent stream.

The workings on the Minnie vein consist of a 60-foot adit with a small amount of underhand stoping. Several open cuts have been made on small, nearby veins.

The Minnie vein, which strikes N. 15° E. and dips 63° SE., parallels the strike and dip of the enclosing metasedimentary rocks that are predominantly biotite schists with narrow crystalline limestone bands. Approximately 1,000 feet northwest of the adit is the contact between the metasediments and a large granitic mass. The

vein averages 3 feet in thickness and as exposed in the adit is a very porous white quartz heavily iron stained in places. The porosity is probably due to leaching of an originally large amount of sulfides. Even at the face of the adit, about 40 feet underground, the vein is porous, which indicates a rather deep zone of oxidation and leaching for this area. Scheelite was the only ore mineral observed, although the vein is reported to carry values in gold, silver, and copper. The scheelite occurs as small crystals, usually less than an eighth of an inch across, scattered sparsely through the quartz in amounts too low to make good mining ore. The small quartz veins near the Minnie vein were not found to carry scheelite.

A small amount of ore has been shipped from the Minnie vein, but the tungsten values were not determined.

PEND OREILLE COUNTY

Tungsten minerals have been found in only one place in Pend Oreille County. The occurrence is just southeast of Sullivan Lake in the Metaline district.

METALINE DISTRICT

The northern part of Pend Oreille County from the 49th parallel south to T. 36 N. makes up the Metaline district.

The district is characterized by northeastward-trending mountain ridges, rising to a maximum height of about 7,300 feet above sea level. The Clark Fork flows northward in the major valley of the district.

Wood and water for mining and milling purposes are relatively abundant in the district as a whole, but timber is scarce in the vicinity of the tungsten occurrence.

The oldest rocks are pre-Cambrian[1] phyllites, quartzites, limestones, conglomerates, greenstones, and schists. These metamorphosed pre-Cambrian rocks, according to Park and Cannon,[2] are overlain unconformably by Cambrian quartzites, phyllites, and limestones which in turn are overlain by Ordovician slate and Devonian dolomite and limestone. Both pre-Cambrian and Paleozoic rocks have been intruded by small bodies of Kaniksu granite and are intensely folded and faulted with the major structures trending northeastward. The Kaniksu granite, possibly of Cretaceous age according to Park and Cannon,[3] probably has the same relationship to Pend Oreille County tungsten veins as the Loon Lake granite has to Stevens County tungsten veins. The older sedimentary rocks and the granite form the mountains of the district. Tertiary and Quaternary sediments cover the major valley bottoms and form terraces along their sides.

Numerous quartz veins carrying ore minerals of lead, zinc, copper, silver, and gold cut the pre-Cambrian and Paleozoic rocks

[1] Park, C. F. Jr., and Cannon, R. S. Jr., Geology and ore deposits of the Metaline quadrangle, Washington: U. S. Geol. Survey Prof. Paper 202, pp. 6-11, 1943.
[2] Idem, p. 11.
[3] Idem, p. 26.

and are very likely genetically related to the granite. In some areas certain members of the sedimentary rocks have been sufficiently replaced by the ore minerals to form ore bodies.

The known tungsten of the district is in the Little Noisy (pl. 13) in the form of scheelite occurring in a 1- to 4-foot quartz vein that parallels the major regional structure in strike and dip. Associated with the scheelite are the ore minerals sphalerite, galena, pyrite chalcopyrite, molybdenite, and pyrrhotite.

Little Noisy

The Little Noisy property, consisting of six unpatented claims, is in the center of sec. 17 (38-44 E.) on the north side of Noisy Creek about one mile east of the south end of Sullivan Lake.

The property is controlled by E. A. Boswick of Ione and a group of Bremerton men headed by A. Krantz.

Noisy Creek flows in a narrow steep-sided valley, in a mountainous region rising to 6,000 feet above sea level. The Little Noisy property is at an elevation of about 3,500 feet above sea level. Water for mining and milling operations is adequate, but due to recent logging operations and fires good timber for mining purposes is scarce.

The oldest rock formation in the vicinity of the property is the Maitlen phyllite, of Cambrian① age, including many thin beds of platy quartzite and limestone. Small bodies of the Kaniksu granite intrude the Maitlen phyllite. One such body of granite is exposed about one-fifth of a mile west of the Little Noisy workings. Granite is also exposed for about 15 feet in the southeast wall of the lower adit and is reported to have been cut by the caved middle adit. Quartz veins carrying ore minerals cut the sedimentary rocks and are reported to cut the granite.

The Maitlen phyllite formation has been folded, and in places the beds are intensely crenulated. In general the beds strike about N. 70° E. and dip from 75° SE. to 80° NW. The quartz veins tend to parallel the phyllite in strike and dip.

The lower adit, 230 feet long, is about 3,000 feet up Noisy Creek from the end of the mine road. It has been driven northeastward at creek level and penetrates 200 feet of talus before encountering bedrock. The middle adit, about 150 feet upstream from the lower adit, is now caved at the portal. Of the reported 950 feet of workings reached from this portal very little has been driven on the vein. The upper adit is about 420 feet N. 25° E. of the middle adit and 180 feet higher. It has been driven northwestward for a distance of 80 feet through metasedimentary rock and encounters the vein at its face. A shaft about 60 feet north of the upper adit has been sunk for 30 feet on the vein, and about 50 feet northeast of the shaft is an open cut on the vein.

The Little Noisy quartz vein lies near the phyllite-granite contact and is confined mainly to the phyllite where it more or less

① Park, C. F. Jr., and Cannon, R. S. Jr., Geology and ore deposits of the Metaline quadrangle, Washington: U. S. Geol. Survey Prof. Paper 202, 1943.

parallels the strike and dip of the beds. It is reported to cut the granite in the caved middle adit, and it is probable that the vein is genetically related to the granite.

The vein carries considerable pyrite and in places enough sphalerite and galena to constitute ore of zinc and lead. Chalcopyrite, pyrrhotite, and molybdenite occur in the vein, but are not common. Wherever exposed the vein carries a small amount of scheelite.

The scheelite-bearing quartz vein ranges from 1 foot to 4 feet in thickness and averages about 2 feet. The greatest single exposure of the vein is about 15 feet long, but the vein has a total length of at least 460 feet between exposures and a difference in elevation of about 250 feet between the highest and the lowest exposures. The scheelite crystals are most abundant in those parts of the vein that are nearly barren of the sulfide minerals and are particularly abundant along the footwall side of the vein where they are arranged more or less parallel to the wall. The scheelite ranges in size from minute specks to crystals one inch across, but they average not more than a quarter of an inch across. The vein as a whole will not average more than a small fraction of one percent scheelite, although there are several areas a foot or more in length that will probably carry from one-half percent to one percent scheelite.

The phyllite wall rock has in places been partially replaced by ore minerals, especially pyrite, for a distance of several feet from the vein. However, the replacement does not appear to be complete enough to have made ore.

No tungsten ore has been produced from this property.

SNOHOMISH COUNTY

Tungsten is known to occur in the Sultan district of south central Snohomish County. It has been reliably reported that a small amount of scheelite was found in diamond drill cores from recent exploratory work on the Glacier Peak property in the Glacier Peak district of eastern Snohomish County.

SULTAN DISTRICT

The Sultan district is bounded on the north by the divide between Sultan River and the South Fork of Stilaguamish River, on the east and southeast by the divide between Sultan River and the North Fork of Skykomish River, on the south by King County, and on the west by R. 6 E.

Paleozoic slates, quartzites, and marbles occur along the northern edge of the district and have been intruded by small bodies of Mesozoic (?) granitic rocks. Marine sedimentary rocks cover the eastern half of the district, and andesitic lavas of Miocene age cover the southwestern part. Glacial sediments cover the western part of the district. The mineral deposits are mainly in the granitic intrusives and along their borders in the old metamorphic rocks.

The tungsten so far reported from the district is in the Sultan Basin (pl. 14) where small amounts of scheelite and powellite occur in a few veins confined chiefly to the intrusive rock. The moun-

tains inclosing the basin are rugged, being cut by narrow steep-sided valleys. Maximum elevations are about 6,200 feet above sea level. The basin is accessible by roads up Olney Creek and Sultan River, and the mines are reached by trails from these roads. Timber and water are abundant in the basin.

The important tungsten occurrences are on the Mint (old Iowa), and the Kromona properties.

The following information on the tungsten occurrences in the Sultan district was furnished by the State Division of Mines and Mining.

Mint (Iowa)

The old Iowa property, now known as the Mint, consists of several claims owned by the Sultan Basin Mining Company. The claims are in the NW¼ sec. 27 (29-10 E.) at elevations from 2,600 to 2,900 feet.

Development consists of three groups of underground and surface workings: the Jerry Chapman, the Iowa, and the Calumet.

The mineral deposit consists of quartz veins cutting quartz diorite and carrying chalcopyrite, pyrite, molybdenite, sphalerite, scheelite, powellite, calcite, and chlorite. The veins exposed by the Jerry Chapman and the Iowa workings contain a small amount of scheelite and powellite. Tungsten minerals are not exposed in the veins of the Calumet workings. No tungsten ore has been produced from this property.

Kromona

The Kromona property, owned by Kromona Mines Corporation of Seattle, is in the SW¼ sec. 13 (28-9 E.) at elevations from 3,000 to 4,000 feet. The mineral deposit is in a shear zone striking N. 65° E. and dipping 75° NW. in quartz diorite. The zone is from 10 to 15 feet wide and consists of shattered diorite and gouge crisscrossed by narrow quartz veins carrying chalcopyrite, pyrite, pyrrhotite, molybdenite, and calcite with minor amounts of scheelite, powellite, marcasite, bornite, and malachite.

About 1,500 feet east of the main workings a similar shear zone is exposed in a natural cave locally known as the "Bear Cave". The cave roof contains several branching fractures from 1 to 7 inches thick that contain quartz, chalcopyrite, bornite, molybdenite, scheelite, and powellite. No tungsten ore has been produced from this property.

SPOKANE COUNTY

Tungsten, in the form of scheelite and wolframite, has long been known to occur on Silver Hill south of Spokane. This occurrence was not examined by the Division of Geology for this report. A detailed report[1] covering the deposits was published in 1942 by the U. S. Geological Survey. For details the reader is referred to that report.

[1] Page, Lincoln R., Tin and tungsten deposits at Silver Hill, Spokane County, Washington: U. S. Geol. Survey Bull. 931-H, 1942.

Silver Hill

The Silver Hill tungsten deposits, owned by the Spokane Tin Co., are in secs. 23 and 24 (24-43 E.) at an elevation of about 2,900 feet above sea level. (See pl. 15.) They are accessible from Spokane by 11 miles of good road and by the Great Northern Railway.

Development work consists of several shafts and adits and many hundred feet of trenches and open cuts. The workings are roughly connected by truck roads.

A summary of the Silver Hill geology and mode of tungsten occurrences as presented by Page[1] is as follows:

> Cassiterite, the only tin mineral present, is found in pre-Mesozoic sillimanite-andalusite pegmatite and feldspar-quartz pegmatite. Scheelite, rimmed with wolframite, occurs in quartz pegmatite and quartz veins, and in the schists adjoining them. These pegmatite and quartz veins cut sillimanite-biotite schist, graphite-andalusite schist, and quartzite. Small dikes and sills of Mesozoic (?) granitic rocks, including diorite, monzonite, granodiorite, and granite, accompanied by biotite-tourmaline pegmatites, aplites, and quartz veins, intrude both the schists and the early quartz veins and pegmatites. The pre-Mesozoic rocks were strongly folded, metamorphosed, and faulted before the intrusion of the granitic rocks. Basaltic lavas fill the Latah Valley to the west and reach the lower slopes of Silver Hill. They are in part covered by Pleistocene glacial debris, which extends to an elevation of about 2,550 feet. . . .
>
> Eight small lenticular tungsten-bearing quartz veins have been prospected by the Bureau of Mines. In places these veins contain sufficient scheelite and wolframite to be of commercial grade. . . .
>
> Scheelite, $CaWO_4$, is the most abundant tungsten mineral in the quartz pegmatite and veins. It occurs as yellow to brownish-gray, medium to coarsely granulated crystals and masses of irregular shape, which average more than an inch in diameter, though masses more than 12 inches across were observed. These grains and masses have an irregular distribution in both the quartz pegmatite and the quartz veins. In the schists they occur apparently on the trend of veinlike masses of quartz within the pegmatite bodies and parallel to the walls of the veins.
>
> Most of the scheelite is partly or completely enclosed by a rim of the black, iron-manganese tungstate, wolframite. This mineral occurs sparingly along fractures and quartz veinlets that cut the scheelite, and there it is intimately mixed with biotite, muscovite and quartz.
>
> A specimen of wolframite from the Scheelite adit was analysed in the chemical laboratories of the Geological Survey by Mr. W. T. Schaller. The gangue-free material contained 76.38 percent of WO_3, 20.74 percent of FeO (total iron reported as FeO), 1.72 percent of MnO, 0.47 percent of CaO, and 0.85 percent of MgO.
>
> No tungsten minerals were noted in other types of pegmatite except within 2 or 3 inches of their contact with quartz pegmatite. Both scheelite and wolframite occur in the schists, where they are accompanied by tourmaline, aluminum silicates, feldspar, quartz, and micas. The grains are more irregular and appear more strongly intergrown in the schists than in the veins.

Page recognized eight main tungsten-bearing veins of large enough size to be of possible commercial value, and a large number of tungsten-bearing veins that are probably too small to be considered as sources of tungsten ore. The eight main veins have average exposed lengths, thicknesses, and depths of about 160 feet, 3 feet, and 40 feet respectively. Page estimated that these veins contain approximately 0.5 percent WO_3, but states that small portions of individual veins are of much higher grade. He also points out that

[1] Op. cit., pp. 177, 191-192.

the veins probably do not maintain their exposed dimensions more than a few feet below the surface and that it is possible that none will extend much more than 50 feet below the surface.

No tungsten ore has been shipped from the Silver Hill deposits.

STEVENS COUNTY

Tungsten has been reported from six mining districts of Stevens County distributed from the Canadian line to Spokane River at the south. The six districts are: Northport, Orient, Summit, Chewelah, Cedar Canyon, and Springdale. In spite of rather thorough prospecting it seems not unlikely that other and equally good deposits of tungsten minerals are yet to be found.

NORTHPORT DISTRICT

The Northport district is situated in the extreme northeastern part of Stevens County, between the Metaline district on the east and the Orient district on the west. As originally recorded the western limit was set at Kettle River, but the line is more commonly placed at the 118th meridian. The district thus comprises some 265 square miles in Tps. 39 and 40 N. of Rs. 38 to 42 E. It is approximately bisected by Columbia River following a southwesterly course from Boundary.

In general the district is characterized by mountainous topography, with peaks rising over 4,500 feet above sea level separated by steep valleys, which give a total relief of more than 2,300 feet. The best-known tungsten properties are in the vicinity of Red Top Mountain, a north-trending ridge some two and one-half miles long and about a mile wide. Adjacent to the mountain on the west is the flat-bottomed valley of Cedar Creek, while on the north and east are tributaries of that stream. Deep Creek, flowing southward, forms the south boundary.

The entire area is covered by a heavy growth of conifers adequate for mining operations. Numerous springs on Red Top Mountain and abundant mine water would give enough water for ordinary operations.

The mountain is formed of two units of the Stevens series, the Red Top marble and the Cedar Creek argillite. Granite is exposed along the east shore of Cedar Lake about a mile west of Red Top mine and about 1½ miles north of the mine. The northern granite appears as a dike-like mass cutting across the north end of the mountain in a general easterly direction. Several schistose lamprophyre dikes are exposed by the underground workings. They range from 1 to 11 feet in thickness, having in all cases a northeasterly strike and southeasterly dip.

Tungsten appears in three properties of the district, the Red Top and the Lucile (Boundary Silver Lead) on Red Top Mountain and the Magma about 13 miles to the south. (See pl. 16.)

Red Top

The Red Top mine is located on the southern end of Red Top Mountain in the NE¼SE¼ sec. 25 (40-41 E.) at an elevation of 3,100 feet above sea level. This is about 6 miles by road from Leadpoint. The property is connected by 1½ miles of good truck road with the Northport-Leadpoint road about 4 miles from Leadpoint. Title is held by a Minneapolis group and is under the direction of J. Richard Brown of Spokane.

The main opening is a 2,700-foot adit approximately parallel with the northeasterly strike of the sedimentary beds, which dip 80° NW. Some 1,500 feet of drifts, raises, and winzes have been opened off the adit.

At 120 feet from the portal there are a drift to the northwest, a raise to the surface, and a winze, filled with water at the time of examination (1941). Here the country rock is white marble with dark bands, striking N. 40° E. and dipping 80° NW. A zone of sheared rock trends N. 87° E., dipping 80° SE., across the bedding of the marble. It is crisscrossed by narrow quartz veins and carries much scheelite with some galena and pyrite, which has produced a limonitic phase locally. Both the winze and raise are on this sheared zone, and along the raise, some 50 feet above the adit, a mass about 50 feet long, 30 feet wide, and 6 feet thick has been stoped out. The hanging wall of the stope is in this sheared material. At the winze the zone is vertical and strongly limonitic. It crosses the adit and then, striking about N. 45° E., runs parallel to both the adit and the contact between marble and argillite, which here forms the southeast wall of the adit.

The chief ore bodies are in the numerous quartz veins and bordering disseminations of pyrite, chalcopyrite, galena, and sphalerite. The galena is reported to be argentiferous.

Scheelite occurs at five places in the mine. (See fig. 5.) The largest and apparently most important occurrence is in the sheared, highly limonitic zone 120 feet from the portal of the main adit at the location of the drift, the winze, and the raise to the surface. Here the scheelite occurs in lenticular masses up to 8 inches across, closely associated with the quartz veins that crisscross the zone. Associated minerals are pyrite, galena, and sphalerite. This zone is exposed in the main adit, at the entrance to the drift, and in the raise. There are approximately 1,500 square feet of it exposed in the stope. The winze appears to have been sunk on this zone. To the northeast the zone thins to a mere limonitic seam along the main adit where it appears to parallel the contact between the marble and argillite, but even this narrow seam carries a few spots of scheelite. It is estimated that the entire limonitic zone will carry from 2 to 4 percent of scheelite. As shown in the stope and raise, the limonitic zone extends to the surface and carries scheelite all of the way.

A second occurrence of scheelite is 190 feet in from the portal, at the junction of the main adit with a drift and a stope. Here is a poorly defined 3-foot mineralized zone that strikes N. 70° W. and

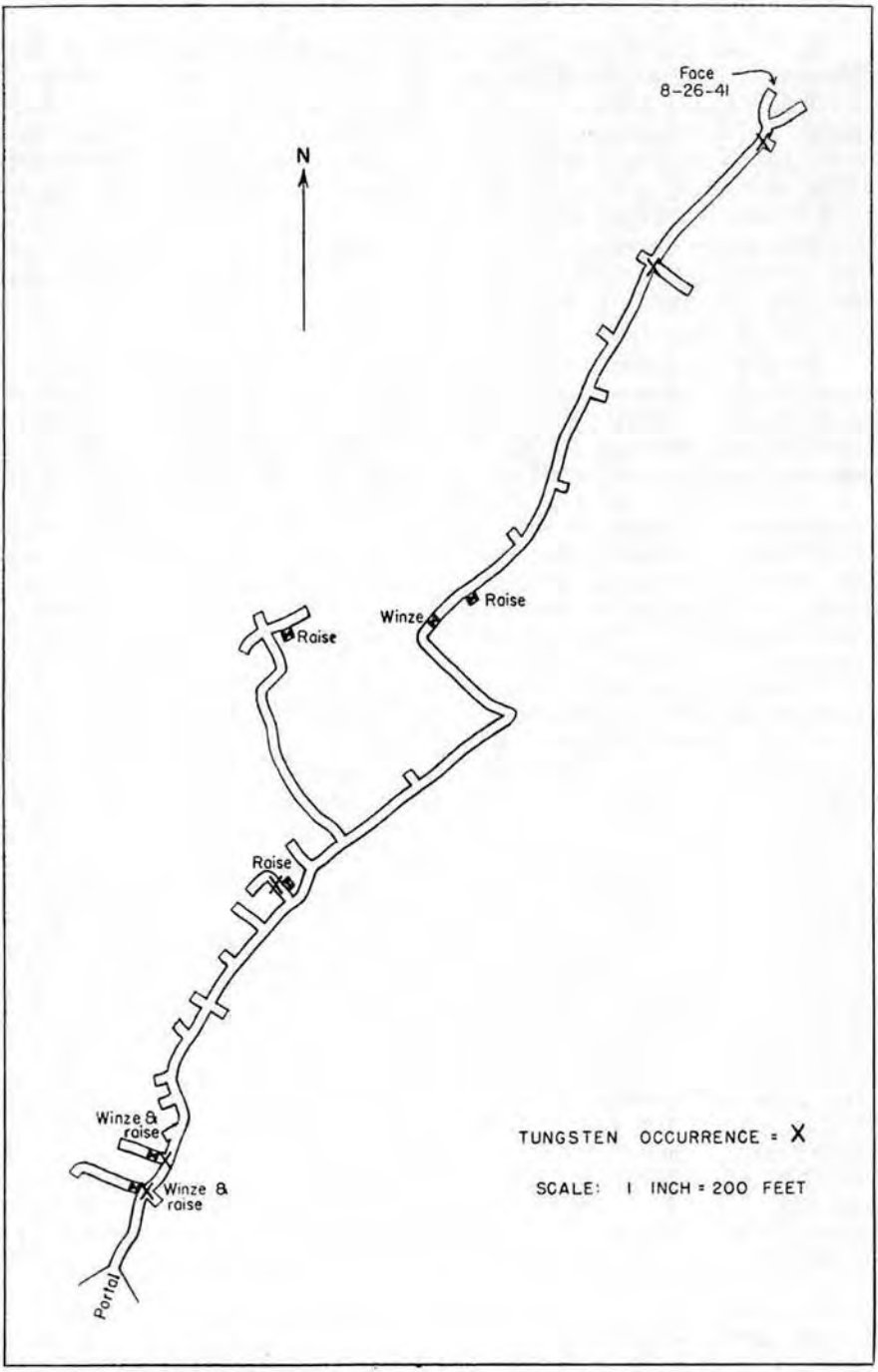


FIGURE 5—Detail of tungsten occurrence in Red Top adit.

dips 53° SW. The zone is made up of quartz, pyrite, chalcopyrite, galena, sphalerite, and scheelite more or less disseminated in the marble. The scheelite, in bunches up to 1½ inches in diameter, occurs closely associated with the quartz. This part of the zone is estimated to contain not over one percent scheelite.

A third occurrence of scheelite is in the left wall of the main adit 750 feet from the portal. Here are four quartz and calcite veins not over one-fourth of an inch wide. They are several inches apart and there is some disseminated pyrite in the marble between them. Associated with these veins are elongated spots of scheelite up to one-half inch in length. The entire zone would carry only a fraction of one percent of scheelite.

A fourth occurrence of scheelite is in the 70-foot drift 2,350 feet in from the portal of the main adit. The drift is in the marble, which here strikes N. 15° W. and dips 28° SW. In the face of the drift there is a quartz vein up to one inch thick striking N. 60° W. and dipping 25° SW. that shows up intermittently on both sides of the drift for its entire length. The quartz vein contains a little pyrite and galena and about 20 percent scheelite. Some of the scheelite spots are one-half inch wide and one inch long. Opposite the entrance to the drift, the quartz vein occurs in the wall of the main adit. Here it is 8 inches wide and carries a small amount of pyrite, galena, and scheelite.

A fifth occurrence of scheelite is in a 15-foot drift to the southeast at 2,600 feet from the portal of the main adit. Here the tunnel is on the marble-argillite contact. The argillite strikes N. 30° E. and dips 67° NW. In the left wall of the drift there is a one-eighth-inch quartz vein that strikes N. 60° W. and dips 70° SW. It carries a little pyrite, galena, and scheelite. On the adit wall opposite the mouth of the drift there are a few spots of scheelite in the marble. No quartz is present, but there is an iron stain along that area of the wall. The entire amount of scheelite is very small.

At the time of the examination (1941) the main adit was being driven farther to the northeast. It was later reported that the shaft 120 feet from the portal was dewatered as an exploratory project in an attempt to extend the main scheelite-bearing zone.

No tungsten ore has been shipped from the Red Top mine, but possibilities of production are good. Some shipments of lead, silver, and zinc ore have been made.

Lucile

The Lucile mine, known also as Owen's or Boundary Silver and Lead mine, is located in the NE¼NW¼ sec. 25 (40-42 E.), on the east side of Red Top Mountain about 3,825 feet above sea level. By road it is 1 mile northeast of the Red Top mine and some 7 miles from Leadpoint. It is owned by the E. C. Owen estate, Spokane.

An adit has been driven northwestward into the mountain for a distance of 212 feet. At 105 feet from the portal there are a 21-foot drift trending S. 76° E., a raise to the surface at an angle of 56°, an irregular winze inclined to the southwest at 42°, and a 6-foot winze to the west. At 135 feet from the portal there is a 30-foot drift to the southwest. At 10 feet from the mouth of the drift

there are a 40-foot winze inclined 50° to the south and a 37-foot winze inclined 40° to the northwest. At 190 feet from the portal of the main adit there are a 22-foot drift to the southwest and a 13-foot winze inclined 40° to the northwest.

For the first 60 feet the adit is in argillaceous quartzite; then it penetrates a light bluish-colored marble for 130 feet where it enters the overlying argillite. The general strike of the beds is northerly, ranging from N. 8° W. to N. 16° E. Dips are westerly, ranging from 23° SW. to 50° NW., and increasing inward from the portal to the face. There has been some movement along the contact of marble and argillite at 190 feet with the development of slickensides in the argillite. At the contact the argillite strikes N. 10° E., dipping 50° NW. Mineralization is marked along this contact.

Ore bodies as well as enclosing sedimentary rocks are cut by a network of basic dikes, lamprophyric originally and now altered to biotite schist. At least seven dikes may be distinguished, 5 to 36 inches thick, which strike N. 50° to 80° E. and dip from 55° to 65° SE.

The ore bodies are irregular mineralized zones in the marble and appear to be associated with quartz veins. The chief ore minerals are pyrite, galena, tetrahedrite, sphalerite, and scheelite. There is also some development of secondary lead carbonate. Both galena and tetrahedrite are reported to carry good values in silver. Scheelite appears in appreciable amounts in the quartz veins and stringers.

The chief occurrence of scheelite is in a mineralized zone exposed for 30 feet along the contact of the marble with the overlying argillite near the face of the adit. This zone, from 1½ to 2 feet wide, strikes N. 7° E. and dips 41° to the west. Crisscrossing it are quartz veins ranging from less than an inch up to 5 inches in width. They carry pyrite, galena, sphalerite, tetrahedrite, and scheelite, the sulfides also appearing as disseminations in the marble. This same mineralized zone was followed down the winze inclined toward the west at this point. The scheelite crystals, ranging in size from specks to 1 inch in diameter, occur in the quartz veins. The entire scheelite content of the mineralized zone probably does not exceed 2 percent.

Scheelite also occurs in the face and along the sides of the inclined winze 105 feet from the adit portal. The crystals, as much as half an inch long, are in narrow quartz veins that can be traced for several feet. Occasional scheelite crystals up to a quarter of an inch across appear in the marble adjacent to the quartz veins. A narrow quartz vein in the face of the other winze at this place carries some scheelite. Scheelite also occurs in a narrow quartz vein in the winze 135 feet from the adit portal. All of these narrow quartz veins strike from 40° to 70° west of north, dipping southwest at 40° to 60°.

This property has produced some lead, silver, and zinc, but no tungsten ore. A small production of scheelite might readily be obtained from the mineralized zone at the contact of marble and argillite near the face of the adit.

Magma

The Magma property is in the SW¼ sec. 28 (38-41 E.) on the east side of the South Fork of Deep Creek Valley at an elevation of about 3,200 feet above sea level. It is accessible by poor truck road. Development work consists of an adit driven eastward for about 485 feet and several open cuts about one-eighth of a mile N. 25° W. from the adit portal.

The predominant rock formation on the property is limestone probably belonging to Weaver's undifferentiated limestone series of Cambrian (?) to Carboniferous (?) age. The strike of the limestone beds is very irregular, ranging from N. 55° W. to N. 35° E., and the dip is steep, ranging from 75° to 90° westward. Aplite dikes and sills cut the limestone. Intrusive granite is exposed a few hundred feet northeast of the open cuts.

No tungsten minerals were found in the adit, but the open cuts show a zone, several feet wide, containing much garnet and epidote, some molybdenite, and occasional crystals of scheelite up to half an inch in diameter. The structure of this mineralized zone appears to parallel the structure of the limestone. The scheelite crystals do not appear to be sufficiently abundant to constitute tungsten ore, but it is possible that higher concentrations of scheelite will be found elsewhere along the garnet-epidote zone.

ORIENT DISTRICT

The part of the Orient district that is in Stevens County is bounded on the north by the International Boundary, on the east by the Northport district and Columbia River, on the south by T. 36 N., and on the west by Kettle River. Maximum elevations are about 5,000 feet above sea level, giving a total relief of about 3,500 feet.

The rocks of the district, as mapped by Weaver,[1] include the pre-Cambrian Orient gneiss; the Northport limestone, the Mission argillite, and undifferentiated limestone and argillite all belonging to the Paleozoic Stevens series; the Rossland volcanics and the Sheep Creek conglomerate of Carboniferous to Tertiary age; the Loon Lake granite and serpentine of Mesozoic age; and granite, diorite, diabase, and the Jumbo volcanics of Tertiary age.

The Big Iron deposit contains the only known occurrence of tungsten in the district. (See pl. 17.)

Big Iron

The Big Iron deposit, owned by W. Lon Johnson and associates of Colville, consists of nine claims in the SW¼SW¼ sec. 24 (40-37 E.). It is about 14 miles by road northeast of Orient on the east side of Sulphide Mountain at an elevation of about 3,750 feet.

The main development work is a large open pit about 200 feet long and 100 feet wide with an average depth of about 25 feet. Other workings include two short shafts, several caved shafts, five long trenches, and several open cuts. Improvements consist of two large cabins in excellent condition, several dilapidated cabins

[1] Weaver, C. E., Geology and mineral resources of Stevens County: Washington Geol. Survey Bull. 20, 1916.

and sheds, and one large ore bunker in serviceable condition. There are ample supplies of timber and water on the property for both domestic and mining purposes.

The Big Iron deposit is within an elongate zone of hydrothermal replacement trending N. 55° W. through interbedded quartzites and limestones that strike east and west and are nearly vertical. The metasedimentary rocks are cut by greenstone dikes and sills, diabase dikes, and monzonite- and granite-porphyry dikes. It is believed that the granitic dikes are apophyses from an underlying granitic mass that furnished the mineralizing solutions that formed the ore minerals in the replaced zone. As exposed by the workings, the zone of replacement is about 480 feet long, 130 feet wide, and has a maximum depth of about 45 feet. Within this zone the quartzite and limestone beds have been partially replaced by pyrite, pyrrhotite, and magnetite with minor amounts of chalcopyrite and scheelite. The scheelite ranges in size from mere specks up to crystal clusters 3 inches across. It is scattered through the mineralized zone, but is most common in the south and west sides of the pit. The scheelite as exposed is not abundant enough to make tungsten ore but it is possible that future work along the replaced zone may expose bodies of commercial tungsten ore.

About 35,000 tons of magnetite ore have been produced from this property, but there has been no production of tungsten.

This property is described in detail in the Division of Geology Report of Investigations No. 14, Some Magnetite Deposits of Stevens and Okanogan Counties, Washington.

SUMMIT DISTRICT

The Summit district lies in west central Stevens County along Columbia River, having as its eastern boundary the great quartzite ridges known as Huckleberry Mountains. It includes most of Tps. 32 to 34 N. of Rs. 37 and 38 E.

Maximum elevations are nearly 6,000 feet above sea level, giving total relief of about 4,500 feet above the level of the lake formed by the Grand Coulee dam. Drainage is all westward to the Columbia through Harvey and Stranger creeks and a number of lesser, mainly intermittent, short streams.

As mapped by Weaver[1] the rocks of the district include the Mission argillite, the Colville quartzite, the Chewelah argillite, and some undifferentiated limestone, all belonging to the Stevens series of Paleozoic age. These have been intruded by a small stock of the Loon Lake granite, which is locally nearly as basic as diorite in this area. In general the sedimentary beds dip away from the intrusive, but faulting has produced a reversal in many places, giving rise to rather complicated structures.

Three properties, the Daisy, Columbia Tungsten, and Washington Metals have shown the occurrence of tungsten. (See fig. 6.)

[1] Weaver, C. E., Geology and mineral resources of Stevens County: Washington Geol. Survey Bull. 20, 1916.

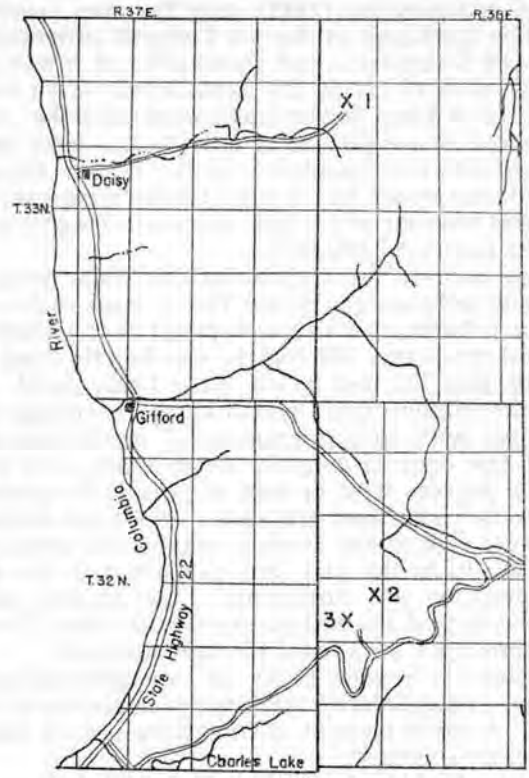


Figure 6—Tungsten occurrences in Summit area. 1—Daisy, 2—Washington Metals, 3—Columbia Tungsten.

Daisy

The Daisy is on the western slope of Huckleberry Mountains, at an elevation of about 3,400 feet above sea level, along the northern edge of sec. 7 (33-38 E.). The property, which includes the old Daisy and Tempest mines, is connected by about 5 miles of good truck road with the Columbia River highway (State No. 22) at Daisy, about 16 miles south of Kettle Falls.

An abundant growth of conifers and numerous springs on the property provide adequate timber and water for mining operations.

The property is owned by Carl Lawson and Mabel Claar of Daisy, A. A. Roath and E. Ross of Colville, P. C. English of Waterville, and C. Ross of Kettle Falls. At present it is under 15-year lease to the Silverado Mining Co., formed by E. C. Tousley, F. M. Mitchell, and S. Coolin of Spokane.

The development work consists of seven adits, several drifts and raises, and one shaft. On the old Daisy property there are four adits having a total length, including drifts, of about 4,000 feet. The four adits, covering a vertical distance of 300 feet, are connected by raises, and a 60-foot shaft connects the upper level with the surface.

At the time of examination (1942) only the two lower adits could be entered. The workings on the old Tempest property, one-fourth mile south of the Daisy adits and about 300 feet lower in elevation, comprise three adits at about the same level. Two are about 200 feet apart and have been driven northward into the mountain and the third is about one-eighth of a mile to the west and has been driven eastward into the mountain. At the time of the examination the middle adit was caved, but it is said to be connected with a long drift off the westernmost adit. The aggregate lengths of these adits and their drifts is about 2,600 feet.

The country rock in the vicinity of the Daisy mine consists of both igneous and sedimentary rocks. The igneous rock is a stock-like body of diorite, 600 feet of which is exposed in the westernmost adit on the Tempest property, 330 feet in the fourth level adit on the Daisy property, and 150 feet in the third Daisy level. The diorite has intruded the Mission beds, which comprise mainly dark, thinly bedded argillites with minor amounts of quartzites and marbles. The strike of the beds is roughly north-south, but may vary as much as thirty degrees west or east of north. In general the beds dip from 60° to 90° both west and east. There is a tendency for the beds on the west side of the stock to dip to the west and those on the east side to dip to the east, but variations in the directions of dips due to faulting are numerous. The major joints roughly parallel the bedding of the sedimentary rocks and the contacts between the sedimentary rocks and the igneous rock.

The ore minerals consist chifly of arsenopyrite, pyrite, tetrahedrite, galena, and sphalerite with minor amounts of chalcopyrite and scheelite. A small amount of malachite occurs where the ores have been slightly oxidized.

The ore minerals occur in fissure veins composed predominantly of quartz with a small amount of calcite. The main ore-bearing veins are in fracture zones either paralleling the bedding or the contacts between the sedimentary rocks and the diorite, and vary from a few inches to as much as 10 feet in thickness. In the diorite the veins follow the major joint systems which tend to parallel those in the sedimentary rocks. There are numerous narrow veins, from a fraction of an inch to 1 foot in width, both parallel to and cutting the general structure, and carrying small amounts of the ore minerals. Frequently in small areas there is a considerable dissemination of sulfides in the country rock bordering the veins, whether sedimentary or igneous.

An outstanding characteristic of the ore minerals, especially the scheelite, is that they frequently occur within the veins as lenses and stringers paralleling the veins and as linings of small fractures within the veins, suggesting that the ore minerals were deposited slightly later than the quartz.

On the number three level of the Daisy, scheelite occurs in three small quartz veins in the diorite on the west side of the main vein 370 feet from the portal. These veins range from 6 to 10 inches in width and in general parallel the strike of the main vein. The scheelite occurs as spots from the size of pin points to one-fourth

of an inch across and probably constitutes less than one percent of the vein matter. On the number four level of the Daisy, scheelite occurs in the second main vein cut by the adit at 870 feet from the portal and in three small quartz veins just west of the main vein. The scheelite occurs as occasional spots up to one-fourth of an inch across and as linings of minute cracks, up to 5 inches long, in the quartz. In general the total amount of scheelite would probably be less than one percent of the vein matter, but one half-inch veinlet shows at least one percent scheelite for a distance of several feet.

The westernmost Tempest adit and its drifts show scheelite in three major veins cut by the workings and in at least four minor quartz veins roughly paralleling the major veins. The scheelite has the same mode of occurrence as in the upper workings, but appears to be somewhat more abundant and in slightly larger spots. One crystal 1 inch across was noted.

The easternmost Tempest adit follows a vertical quartz vein N. 5° W. for its entire length of about 550 feet. This vein is from 6 inches to 2 feet wide and carries much sulfide and shows spots of scheelite quite regularly along its length. The scheelite occurs as spots from mere points to one-half of an inch across and as minute linings of fractures. The entire scheelite content of the vein is probably less than half of one percent, but occasional areas several feet across will run higher. One small quartz vein at right angles to the main vein shows several small spots of scheelite.

It appears that those veins cutting the diorite more frequently carry scheelite than those cutting the sedimentary rocks. It also appears that as depth is increased there is a tendency for the scheelite spots to increase slightly in size and for a greater number of the veins to carry the tungsten mineral.

No tungsten has been produced from the Daisy property.

Columbia Tungsten

The Columbia Tungsten Corporation holds 15 claims in sec. 19 (32-38 E.). The veins being prospected lie a quarter of a mile north of the Addy-Bissell road that joins State Highway 22 at a point 2 miles north of Cedonia. The distance from Cedonia is 7 miles, and from Addy, 18 miles.

The claims are situated immediately west of the divide between Columbia River and Mill Creek, the latter being a tributary of Colville River. The elevation is about 3,500 feet above sea level. (See fig. 7.) Much of the area is forested, particularly the northerly slopes. Water is obtainable from streams but not within a few hundred yards of the claims.

The country rock is a porphyritic granite whose surficial area is about 2½ square miles; it is intrusive into gray, arkosic quartzites and argillites of the Stevens series. A few hundred feet from the west contact the granite is cut by quartz veins that trend north-northeast and dip from 50° to 90°, mainly southeast. At the base of the vein zone which crosses an adit near its portal, two stringers are shown, 1 inch and 4 inches thick. A few feet above the adit an

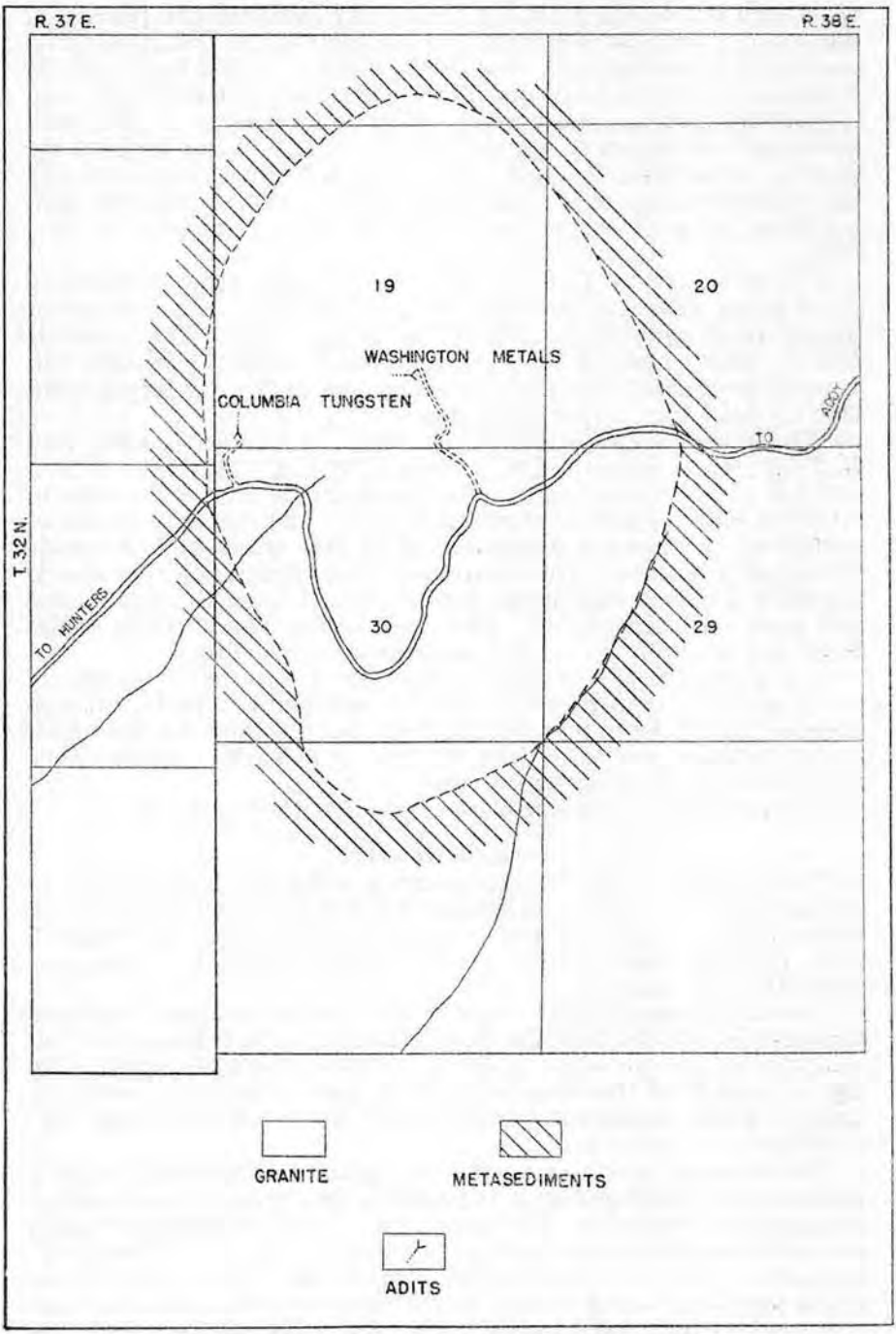


FIGURE 7—Geology of Columbia Tungsten and Washington Metals area.

open cut shows these veins merging into a single vein about a foot thick which, a little farther northeastward, splits into five narrow and diverging stringers. These range in strike from north to northeast, but each is irregular in its course. In 50 to 75 feet these veins appear to wedge out after attaining a maximum thickness of 7 to 12 inches. At 135 to 150 feet above the adit and open cut, veins again appear, some of them being parallel to joints in the granite that trend N. 53° E. and dip 90°. In places these veins are 8 inches thick.

These veins are all more or less mineralized with wolframite and tourmaline, and in places contain a little molybdenite and apparently scheelite.

Development consists of an old winding adit driven in a direction averaging about N. 10° W. for 150 feet. At 80 feet from the portal a side crosscut was driven southeastward for 30 feet intersecting a 3½-inch barren quartz vein at 12 feet from the junction. This vein appeared to be cut out on both the floor and roof. No vein is exposed in the main adit except close to the portal, the remainder being driven along a fault in the granite.

When this property was examined in July 1940, an open cut 18 feet above the adit was to be the starting point for a drift. A 25-ton ore bin was nearing completion, and a 25-ton mill was contemplated. No production has been reported.

Washington Metals

The Washington Metals Corporation has mined tungsten veins in sec. 19 (32-38 E.). This property is about half a mile east and a little north of the Columbia Tungsten but on the east side of the Columbia River-Mill Creek divide, at an elevation of 4,200 feet. (See fig. 7.) It is accessible by a short road that turns north from the Addy-Bissell road immediately west of the summit.

The prevailing rock is a medium- to coarse-grained porphyritic granite, intrusive into metasediments of the Stevens series. This intrusive is the same that encloses the veins of the Columbia Tungsten property.

A gray vitreous quartz vein ranging from 2 inches up to 12 inches in width, striking a little south of west, and dipping 60° to 70° NW., has been opened by an adit for 500 feet. Much of the vein has been stoped to the surface, judging from work both underground and up the slope west from the portal. However, 120 feet of the vein between the portal and the first raise has not been stoped. Half of this contains considerable wolframite in aggregates that may attain 2 percent of the vein by volume. Another vein in this part of the adit is generally 2 to 3 inches wide, in places 6 inches, and contains considerable orthoclase in crystals up to half an inch across. This vein contains some wolframite and occasional aggregates of tourmaline. Some vein samples picked up in the ore bin show vugs lined with dark-green tourmaline penetrating scattered minute crystals of brownish scheelite. Adjacent to these vugs are a few blades of ferberitic wolframite. On the top of the hill 170 feet ver-

tically above the portal and approximately above the face of the adit, a vein, which presumably is the same one followed underground, splits into two veins each 2 to 3 inches wide and 1½ feet apart. These are well mineralized with wolframite and tourmaline, strike S. 60° W. and dip vertically. One split soon disappears and the other is exposed for 100 feet farther southwestward in the direction of the Columbia Tungsten property.

About 85 feet east and 50 feet below the main adit is another adit driven S. 85° W. for 90 feet and S. 78° W. for 43 feet to the face. This opening shows only narrow, discontinuous, barren, glassy quartz veins in places. One, 20 feet back from the face, is 1 to 1½ inches wide, strikes N. 45° E., and dips 48° SE. Although no mineralization was seen in this adit, some blocks on the dump show a little molybdenite, wolframite, and scheelite.

The total length of drifts and crosscuts on this property is 768 feet. A block of ground 300 feet by 100 feet in the main adit is largely stoped. Some ore is to be expected below the main level and in a small block along the first hundred feet of the main level.

Ore from this mine presumably was concentrated in a small mill located a considerable distance eastward on the Addy road. Some production was reported in 1931 by the U. S. Bureau of Mines from "a mine 18 miles southwest of Addy". This undoubtedly refers to the Washington Metals property.

CHEWELAH DISTRICT

The Chewelah district is located in the central part of Stevens County on the east and west sides of Colville Valley and includes Tps. 31 N. to 33 N., in Rs. 39, 40, 41, and 42 E. The town of Chewelah is near the center of the district.

The district is marked by flat-bottomed valleys and low, rounded mountains, which rise about 3,000 feet above the elevation of the Colville Valley.

There is an adequate supply of timber and water in the district for mining and milling purposes.

The rocks exposed in the district are mainly argillites, limestones, and quartzites of the Stevens group which are probably mainly of Paleozoic age. These rocks have a prevailing strike of north or northeast and a prevailing dip to the west or northwest. The sedimentary rocks were intruded by small masses and dikes of Mesozoic granite known as the Loon Lake granite, which varies considerably in composition, and in the vicinity of the tungsten deposits it should probably be called a diorite. The above formations are cut by basic dikes. Quartz veins, bearing ore minerals, cut both the sedimentary rocks and the granites, but are mainly found cutting the sedimentary series.

One property, the Juno-Echo, in the Chewelah district has shown the presence of tungsten. (See pl. 18.)

Juno-Echo

This property consists of six patented claims in sec. 7 (32-41 E.), about 2 miles east of Chewelah, held by the Western Molybdenum Corporation of Spokane. Development consists of a main working shaft 292 feet deep with about 850 feet of drifts and raises, three inaccessible shafts of unknown depth, two adits 165 and 50 feet long, and numerous open cuts. Improvements consist of several miles of truck roads, one cabin, three large buildings, and a hoist.

Scheelite, the only tungsten mineral, occurs mainly in quartz veins at or close to the contact between limestone and the intrusive diorite. A single vein may wander back and forth across the contact. This zone of veins has been traced on the surface for at least 2,500 feet. The veins are more or less lenticular in shape and pinch and swell both along the strike and down the dip. The predominant strike of these quartz veins is from N. 35° to 45° E. and the predominant dip is about 80° SE. The veins vary in thickness from a fraction of an inch to 2 feet and in places the ore body is made up of several parallel quartz veins up to 6 inches in thickness. The ore minerals are chalcopyrite, pyrite, scheelite, and molybdenite. The scheelite crystals range from minute specks up to 1 inch in diameter scattered throughout the vein material and often along narrow ribbon-like fractures cutting the veins parallel to their walls. Some scheelite also occurs as disseminations in the diorite and limestone along the contact and in fault gouge in these rocks, but usually does not constitute ore in these places. The highest tungsten values are associated with the quartz veins, and the percentage of scheelite in the veins varies considerably, but probably averages about one percent.

No tungsten has been produced.

CEDAR CANYON DISTRICT

The Cedar Canyon district in southwestern Stevens County is bounded on the north by the Summit district, on the east by the Chewelah and Springdale districts, on the south by the Spokane Indian Reservation, and on the west by Columbia River. The highest elevations, approaching a maximum of 5,000 feet, are along the crest of the Huckleberry Mountains on the east edge of the district. From the Huckleberry range the general surface slopes westward to the Columbia. Drainage is westward through Cedar and Hunters creeks and a number of lesser, mainly intermittent, streams.

As mapped by Weaver[1] the rocks of the district include the Mission argillite, the Colville quartzite, the Chewelah argillite, the Addy quartzite, the Deer Trail argillite, the Stensgar dolomite, and undifferentiated limestone and argillite, all belonging to the Stevens series of Paleozoic age. These rocks have been intruded by stocks of the Loon Lake granite. The Gerome andesite of Tertiary age covers areas of considerable size in the southwest part of the district.

[1] Weaver, C. E., Geology and mineral resources of Stevens County: Washington Geol. Survey Bull. 20, 1916.

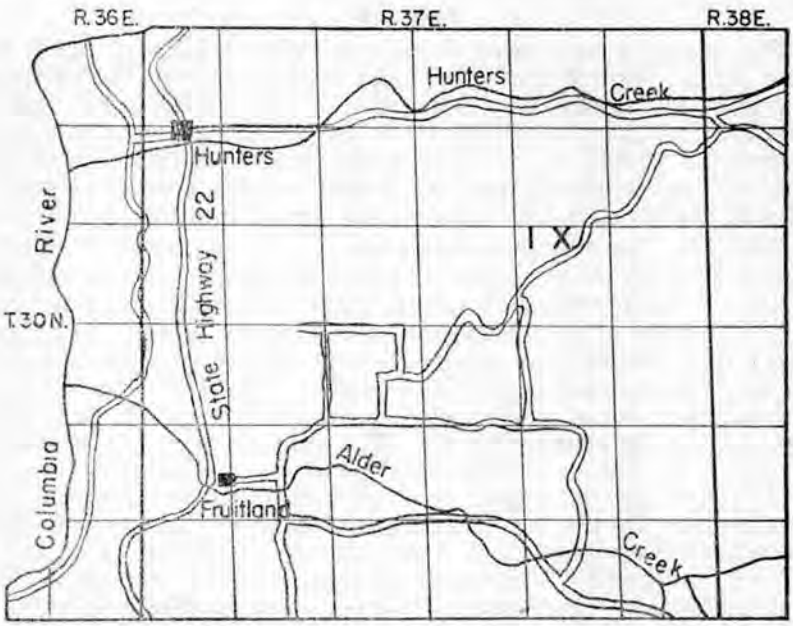


FIGURE 8—Tungsten occurrence in Cedar Canyon area. 1—Read.

The Read iron deposit contains the only known occurrence of tungsten in the district. (See fig. 8.)

Read

The Read property, owned by J. W. Glasgow of Hunters and Henry Becker of Fruitland, consists of two claims, the Granite and the Magnetic, trending east-west through the north half of sec. 14 (30-37 E.). It is on the divide between Hunter Creek and Alder Creek at an elevation of about 2,700 feet above sea level. The old Fruitland-Springdale road crosses the east end of the property, thus making it accessible to trucks.

Development work consists of five shallow prospect shafts, two short adits, and several open cuts. The two adits and three of the shafts are caved. These workings are aligned in a N. 85° E. direction for a distance of about 3,000 feet, and are connected by an old road.

There are few trees on the property, but timber for mining purposes is available on the hill just east of the property. The only surface supply of water is a small spring.

The Read deposit is of the contact metamorphic type lying between undifferentiated limestone of the Stevens series on the north and Loon Lake granite on the south. The contact metamorphic zone, which is from a few inches to possibly 40 feet wide, trends about N. 85° E. and dips steeply to the northwest. The limestone has been incompletely and irregularly replaced by magnetite, chalcopyrite, scheelite, wollastonite, tremolite, garnet, ludwigite, and

fluorite. The scheelite occurs as minute crystals sparsely disseminated through the mineralized zone and was nowhere found to be abundant enough to constitute tungsten ore. However, it is possible that future development will expose commercial bodies of scheelite ore along this contact.

This deposit is described in detail in the Division of Geology Report of Investigations No. 14, Some Magnetite Deposits of Stevens and Okanogan Counties, Washington.

SPRINGDALE DISTRICT

For the purposes of this report it is convenient to use the designation Springdale district for a rather extensive area between the Huckleberry Mountains on the west and the east line of Stevens County in Townships 29 and 30 North.

Topographically the area shows about 2,000 feet of relief between the central flat of Colville and Chamokane valleys and the highest hills at either margin. The uplands comprise more or less isolated hills with smooth slopes locally steep. Even the Huckleberry Mountains lose their prominent lineal ridge character in this latitude and fade out southward as a series of separate, relatively low hills. Runoff is slight, Colville River taking the waters of Sheep and Deer creeks northward, while the south drainage is through Dragoon, Chamokane, and Little Chamokane creeks.

Geologically, the Huckleberry Mountains on the west constitute a strongly folded mass of metasedimentary rocks of the Stevens series of Weaver. At the eastern margin the Loon Lake granite makes up the highest hills with marginal masses of the Stevens series beds. In the wide medial portion are smaller masses of both granite and metamorphics isolated by glacial and later deposits. Just west of Springdale a band of Tertiary flows of basalt crosses the district from north to south, covering most of the older rock.

Tungsten appears in veins in either the metasedimentary rocks or the granite but usually not far from the contact of the two. The tungstates wolframite and scheelite both are known, but the former is by far the more abundant. The close geographic association of tungsten with Loon Lake granite suggests its derivation from the original magma.

Two small areas in the Springdale district have shown tungsten, Blue Grouse Mountain (pl. 19) at the extreme east and Germania (fig. 9) at the extreme west.

Blue Grouse Mountain Area

The tungsten occurrences are located in secs. 15 and 16 (30-42 E.). The area is accessible by roads that lead north from Deer Park to the old Tungsten King property in sec. 16, or from Loon Lake on the west.

Blue Grouse Mountain is one of several rounded isolated low mountains at the south end of the main divide between Clark Fork and Colville River. Its elevation is 3,961 feet, and from top to bottom is an irregular growth of yellow pine; the more open areas are brushy. Water at an elevation of 3,200 feet is obtainable on the

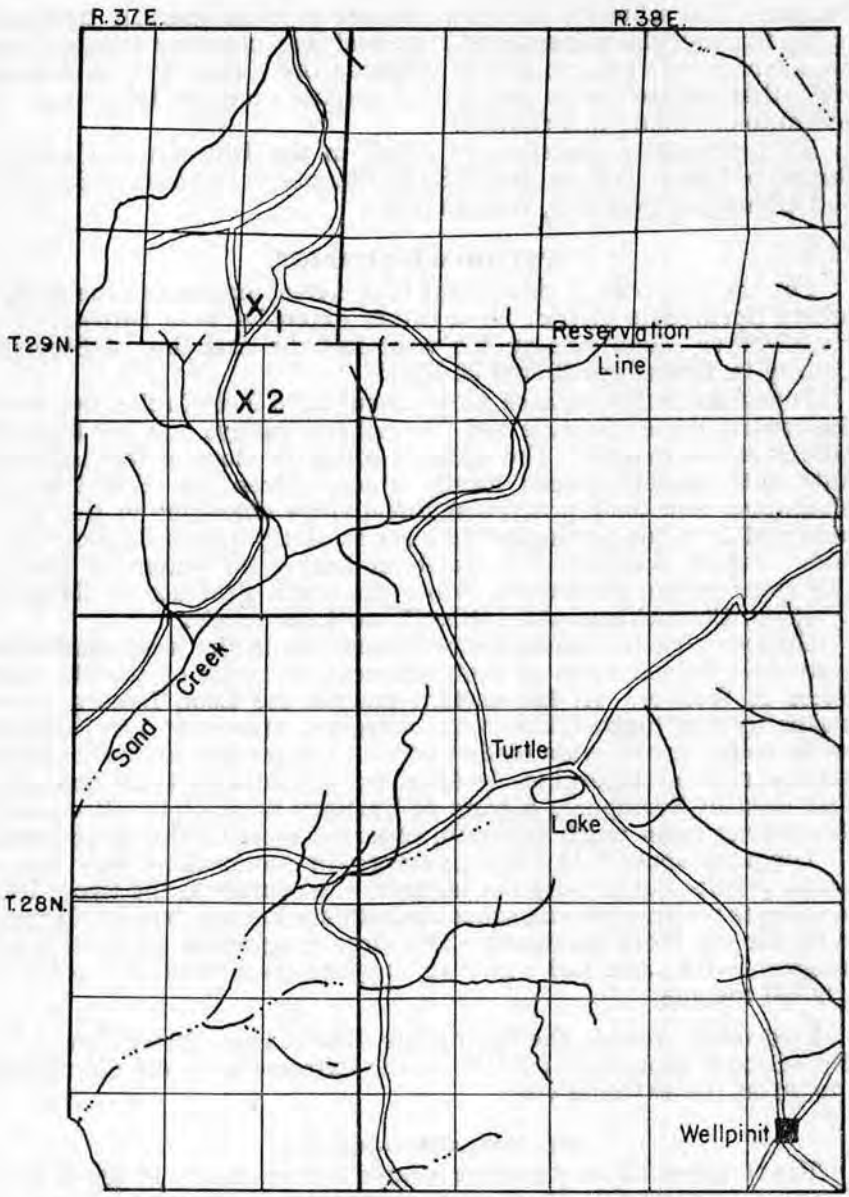


FIGURE 9—Tungsten occurrences in Springdale area, west half. 1—Germania, 2—Germania Consolidated.

west slope of the mountain, half a mile to a mile west of the main mining properties.

Most of Blue Grouse Mountain is composed of gray platy sandy argillite of the Deer Lake argillite formation of Weaver. The strike

is northwest and dips are generally 40° to 50° SW. These metasedimentary rocks are intruded by the Loon Lake granite, the contact of which trends eastward and crosses the north end of the mountain about 100 feet below the summit. (See pl. 20.)

Tungsten occurs (1) predominantly in veins that usually parallel the argillite bedding and (2) much less commonly as disseminations in the granite localized along the contact with the argillite. The veins range in width from several inches up to 4 feet but generally are less than 2 feet. They have been opened in adits and open cuts and show a length where not covered of little more than 50 feet (Bancroft reports 100+ feet).

Hübnerite is the sole ore mineral; it occurs as single blades and in aggregates. The blades may be an inch or more wide, 2 to 3 inches long, and an eighth to a fourth of an inch thick; the aggregates are sometimes several inches across, disposed in the vein without respect to foot or hanging walls. Disseminated hübnerite in the granite is in small crystals, never more than an eighth to a fourth of an inch long, much less wide, and a fiftieth to a hundredth of an inch thick. These have no uniform orientation, and make up about 10 to 15 percent of the rock. In one occurrence a half-inch band showed a concentration of these small crystals, each enclosed by the quartz-feldspar-muscovite groundmass of the granite.

Other minerals include pyrite, cosalite, and molybdenite which occur in the veins only. A few limonite pseudomorphs after pyrite occur in the veins but these are most abundant on either side in the argillite wall rocks; here they occur as cubes from 1 to 2 inches across occasionally but more commonly from a fourth to a half inch.

Manganese oxide is conspicuous along joints as platy masses, and as rounded bulbous projections adjacent to the joint planes. The mineral seems to coat other minerals rather than form thick masses which it appears to do when seen in two dimensions. A notable feature of the granite is the occurrence of plumose masses of muscovite in places along the contact with the argillite. This mineral over an area several feet square may make up more than three-fourths of the rock mass.

Two adits on the west slope of the mountain have been driven in argillite. One shows a vein 2 feet thick, well mineralized with large crystals of hübnerite. Only about 20 feet of the vein is exposed; at the end of the adit it is cut out by a fault trending northeast and dipping 60° NW. A number of open cuts on top of the mountain show little vein material, being caved from the sides. Blocks on the dump showed heavy mineralization in hübnerite and much limonite after pyrite in the wall rock.

The old Tungsten King property located at the head of a ravine on the southeast side of Blue Grouse Mountain was caved, but ore on the dump showed the vein to be at least 8 inches wide, carrying much hübnerite, some pyrite, molybdenite, and occasionally cosalite, limonite, hematite, and sericite. One pseudomorph of hematite after pyrite was 2 inches across, and fine granular pyrite masses occur up to 3 inches across.

A little above the Tungsten King adit is an open cut showing two bedding veins of quartz. The lower vein feathers out to a quarter of an inch in 20 feet along the bedding of the enclosing argillite. Hübnerite occurs here as scattered crystals concentrated chiefly on the hanging wall. The upper vein, 18 inches thick, is about as well mineralized and shows for 8 feet along the dip, but feathers out up the dip. Much pyrite occurs in the wall rock adjacent to the vein. These veins appear to be splits from a single 4½- to 5-foot vein that was left as a rounded knob at the opening of the combined open cut and adit. Hübnerite in the thick part is very sparse.

Some open cuts located several hundred yards northeast of the old Tungsten King adit show quartz veins lying more or less parallel to the bedding but there is very little tungsten in them.

The openings in the disseminated ore lie on the north side of Blue Grouse Mountain. They include a U-shaped open cut some 20 feet deep and 10 feet wide from which some tungsten was said to have been taken, and an inclined shaft which shows the best example of the disseminated hübnerite along the granite-argillite contact.

Some other open cuts and short adits are located on the west slope of Blue Grouse Mountain about half a mile from the summit. These are called the 'west-end' workings. The adit trends N. 8° E. for 96 feet to the face but shows only granite. Considerable limonite and manganese oxide forms coatings along joints up to an inch in thickness. About 250 feet along the stream above the lower adit is another open cut and adit from which a little disseminated hübnerite was mined, according to the operators.

A quartz vein on the Frank Gaber farm, in the SE¼NE¼ sec. 18 (30-42 E.), is reported to carry wolframite. This location is almost 2 miles west of the deposit on the north side of Blue Grouse Mountain, and although the Gaber farm vein in itself has not yet shown commercial ore it appears to be a good prospect and serves to extend the Blue Grouse Mountain tungsten area farther west.

The vein on the Gaber farm is exposed in the bottom of a trench about 8 feet deep, 5 feet wide, and 60 feet long. The trench work was done in 1941 by Willis J. Tubbs of Spokane in partnership with Frank Gaber, the owner of the property. The vein does not crop out but where exposed in the trench it is 12 inches wide and strikes N. 85° E. and dips 70° NW. in country rock of coarse-grained granite. The vein is highly oxidized, the original abundant pyrite being nearly completely altered to limonite pseudomorphs. No wolframite was seen in the vein, but in its general appearance and its mineralization it is very similar to that of some of the tungsten-bearing veins on Blue Grouse Mountain, and wolframite might confidently be expected.

Some 1,200 pounds of this vein material, milled by W. H. West, reportedly yielded 5 pounds of wolframite concentrate.

Germania area

The Germania mine, now controlled by a St. Paul company, is in the south end of the Huckleberry Mountains near the center of the SW¼ sec. 13 (29-37 E.). The property is most easily reached by road from Springdale on the east or from Reardan on the south via Wellpinit. Other roads lead southeast from Fruitland and eastward from an abandoned part of State Highway 22 near the old Detillion bridge site on Spokane River.

The low mountainous terrane of the Germania camp is the subdued southern end of the Huckleberry Mountains where they approach Spokane River. The main topographic features consist of northeastward-trending spurs with many lateral ridges flanked by broad ravines. Near the head of one of these ravines the Germania camp is located at an elevation of about 3,500 feet, 500 to 600 feet below the summits of the principal ridges. The ravine drains into Sand Creek, which flows southeastward into the Spokane.

Water at the mine is obtained from springs or shallow wells and also from ground water stored on the third level, lowest of the mine workings. The forested slopes and ridges provide sufficient timber for mining purposes.

The Germania tungsten veins (pl. 21) are enclosed in a medium-grained to porphyritic granitoid stock that is elongated northeastward parallel to the regional strike of the metasedimentary rocks which it intrudes.[1] This mass occupies 8 to 10 square miles exclusive of a narrow connection on the west with a larger batholithic mass of the Loon Lake granite. The metasedimentary rocks that almost encircle the stock consist predominantly of slates and argillites with minor beds of quartzite and dolomite on the west. That only a small amount of the stock has been removed by erosion is indicated not only by its topographic position but by a small roof pendant of argillite adjacent to the vein zone.

No part of the granitic mass is gneissoid; its chief structural feature is a set of longitudinal joints that dip steeply. The metasedimentary rocks strike N. 20° to 30° E. and dip vertically or steeply southeast, the latter being most likely an overturn to the northwest. The vein that has furnished the major portion of the tungsten produced strikes about N. 20° E., essentially parallel to the regional trend of the metasedimentary rocks and to the elongation of the stock itself. Several other veins mainly east of the one that has been mined are essentially parallel to it, suggesting a set of longitudinal fractures along which mineralization has occurred.

The principal vein at the Germania ranges in width from a few inches to a little more than 3 feet. At the south end of the main level it narrows to 2 or 3 inches. Some 500 feet above this point, on the summit of the ridge, the width is 4 to 5 inches. The more heavily mineralized parts of the vein have been mined out and only remnants of the wider portions remain, some of which show aggregates of black wolframite several inches across. Wolframite is the

[1] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 113-114, 1914. Weaver, Charles E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, pp. 59-61, 87-89, 1920.

principal mineral, being much more abundant than pyrite, scheelite, and galenobismutite, on and above the main level. The third level from the top, some 500 feet below the summit of the main ridge where the vein is exposed, shows wolframite decreasing markedly and being superseded by molybdenite. The most notable gangue mineral observed in the gray to white quartz is a dark-green chlorite that occurs in clots up to 2 or more inches across, entirely by itself and not associated with other minerals. The vein has generally sharp boundaries with the enclosing granite. The granite on either wall shows a lack of intense hydrothermal alteration. The workings on the summit of the ridge to the southwest show the sharp walls of the vein bordered in places by a fringe of sericite with cleavage surfaces normal thereto.

Other veins that lie mainly to the east of the main Germania lead, although mineralized in places, are narrow for the most part and have been opened by several open cuts and short adits. None of these has produced ore.

With the exception of two short adits driven southwestward on the upper part of the vein, most of the mining has been done on three levels that are 200, 375, and 500 feet below the highest point of the vein outcrop. These levels are respectively 800, 2,000, and 1,250 feet in length, the longest being used as a main haulage way. Ore from the third or lowest level was hoisted to the one above. Some 800 feet of vein length on the lowest level, 1,700 feet on the main level, and about 800 feet above the first level has been stoped. When the property was examined (1941) mining was confined to leaner parts that were left in pursuit of the richer part of the vein, and to the narrow south end. The cleaning-up operations within the mine were supplemented by recovery of wolframite resulting from disintegration of the vein on the surface. Much of this work was being done with a bulldozer and scrapers.

As recorded by the U. S. Bureau of Mines Mineral Yearbook, the Germania mine has produced about 1,250 tons of high-grade tungsten concentrates from 1904 to 1941.

The Germania Consolidated Mining Company, Inc. of Spokane controls 400 acres in secs. 23, 24, and 26 (29-37 E.). The holdings are south and southwest of the Germania property along the strike of the tungsten-bearing veins, and include the old Keeth and Industrial properties. The mine is accessible by the same roads that service the Germania.

The main topographic feature is the long ridge trending southwest from the Germania property. Tungsten-bearing veins are exposed on the east side of the north end of this ridge as well as on the top and west slope of the south end. Timber is abundant and water can be obtained throughout the year.

Except for a small roof pendant of quartzite and slate that covers about half a mile of the ridge top the bedrock is a part of the same granite stock that underlies the Germania ground. Both the granite and the roof pendant are cut by a series of parallel quartz veins that strike about N. 25° E. and dip from 70° to 80° SE. There appear to be at least three distinct veins and it is possible that there are

actually several more. Future development work accompanied by careful mapping will be necessary to establish their relationships.

The veins range from a fraction of an inch to about a foot in thickness and probably average 4 or 5 inches. They are composed of bluish-gray glassy quartz that in places shows development of individual quartz crystals several inches long. The quartz contains considerable pyrite and occasional crystals of wolframite, scheelite, and molybdenite. Parts of the veins contain sufficient wolframite to constitute ore. In the wider portions of the veins the wolframite occurs as aggregates of large crystals several inches across, while in the narrower portions the wolframite generally occurs as minute individual crystals. Although scheelite occurs in amounts subordinate to wolframite it is in places abundant enough to appreciably raise the tungsten content of the veins. Scheelite crystals ranging from minute specks to half an inch across were observed. Wolframite crystals are often bordered and cut by minute scheelite seams and some scheelite crystals have the tabular shape of wolframite which suggests an alteration of wolframite to scheelite. Molybdenite crystals less than a quarter of an inch across are common throughout the veins, and in some parts of the veins molybdenite crystals up to half an inch across are very abundant along the footwalls. The only gangue mineral observed besides quartz is a dark green chlorite which usually forms isolated crystal bunches in the veins.

The major part of the development work has been done just west of the ridge crest at the south end of the property. It consists of a 375-foot shaft with several hundred feet of drifts, a 650-foot adit with about 1,000 feet of drifts and raises along which considerable stoping has been done, several short adits, and numerous open cuts and trenches. On the east slope of the ridge at the north end of the property three short adits with a small amount of drifting have been driven westward into the ridge and considerable trenching has been done. The locations of the several workings are shown on plate 21.

It is reported that this property, while under former and present ownership, has produced about $100,000 worth of wolframite. No attempt has been made to recover the scheelite and molybdenite. A few thousand dollars' worth of wolframite was recovered from small-scale placer operations near the apex of the main vein at the south end of the property.

YAKIMA COUNTY

Tungsten has been reported from but one mining district in Yakima County, the Bumping Lake, and no tungsten production has been recorded.

BUMPING LAKE DISTRICT

Organized on August 25, 1913, according to an early map, the district known as Bumping Lake was set up with relatively well-defined limits. The boundary line is the crest line of American Ridge on the northwest; it then follows the Cascade crest south-

ward to Tumac Mountain, thence goes eastward through McNeill Peak to Bethel Ridge, north of the Tieton drainage basin, thence due north to the divide between Rattlesnake Creek and Naches River. It then follows this divide northwestward, across Bumping River to American Ridge. The region thus set off, about 175 square miles within Tps. 14-16 N. of Rs. 12-14 E., includes the upper part of the drainage basins of both Bumping River and Rattlesnake Creek. Topographically rough, the district shows over 4,600 feet of relief between the flats of Goose Prairie and the top of Mount Aix. Miners Ridge, on which the known tungsten properties are located, is a steep-sided spur of the Cascade Ridge extending northward between Bumping River and its main tributary, Deep Creek. The crest line is unusually even, although three knobs bring the top elevation slightly above the crest line to give a total relief of 2,500 feet above the adjacent valleys.

The geologic formations making up Miners Ridge are almost all igneous although some sedimentary beds are to be found across Bumping Lake at the north end. These appear to be older than any of the igneous rocks and have been tentatively placed in the Mesozoic. Surrounding Miners Ridge is a thick series of volcanic beds, the Keechelus, into which has been intruded a granitic mass similar to the Snoqualmie granodiorite. Dikes of acidic types, felsite, quartz porphyry, and aplite, cut the granitic mass and, in places, the older rocks. The extreme north slope of Miners Ridge is covered by a remnant of a still later igneous mass, which probably flowed out of some vent nearer the crest of the Cascades and may be as young as the Tieton andesite of Quaternary age.

Mineralization in the Miners Ridge region is in the granodiorite which makes up most of the Ridge, the volcanic rocks showing only a small amount of pyrite.

Exploration in the central part of Miners Ridge has revealed both molybdenum and tungsten (pl. 22) but they have not been reported elsewhere in this vicinity.

On Miners Ridge, in the Bumping Lake district, the Copper Mining Company holds a large group of claims. No accurate base map giving the township and section grid has been prepared for this area, hence the section locations given in the several reports on this property are subject to correction. A sketch map of the Copper City area (pl. 23) showing streams, roads, camps, and openings on the veins has been drawn from blue prints furnished through the courtesy of Mr. R. P. Root, president of the company.

The main camp and mill, at about 4,000 feet elevation, are on Deep Creek at the end of the road about 9 miles above Bumping Lake. The principal workings, the Lower, Middle, and Upper Bird adits lie north of the main camp with which they are connected by 2½ miles of truck road. All other workings, mainly open cuts, are reached by trail from this road.

Within the area covered by most of the workings the country rock is the granodiorite. This is cut by dikes of aplite and felsite porphyry. There are two varieties of the latter. One is a distinctively gray dense type with phenocrysts of both glassy plagioclase

and orthoclase feldspar as well as some quartz. This is in the northeast-southwest dikes dipping northeast parallel to ore veins, and apparently antedating them. The other porphyry dikes show feldspar and biotite phenocrysts in a less dense matrix, trend north-south, and appear to be later than the ores.

The Lower Bird adit, at an elevation of 5,200 feet, is driven for about 450 feet in a general N. 65° W. direction; the first 108 feet is crosscut through gray porphyry, granodiorite, and quartz porphyry. A shear zone in granodiorite, at or near its contact with a quartz porphyry dike, is then drifted on for 260 feet to where the mineralization becomes obscure. A 60-foot crosscut through a dike of quartz porphyry exposes a zone of mineralization parallel to the first. This last zone, which has been drifted on for 85 feet, may be a separate lead or, possibly, the faulted extension of the main zone.

The mineralized material is hydrothermally altered rock between well-defined walls that are 5 or 6 feet apart and show both slickensides and gouge. Within the shear zone are one or more parallel lenses of vein material that may be as much as 2 feet thick in places and absent in others. These carry chalcopyrite, arsenopyrite, molybdenite, and scheelite in a gangue of quartz and calcite. The scheelite appears to be confined to the eastern half of the 260-foot drift and there occurs sparsely disseminated as small crystals and as occasional irregular masses as much as 3 inches across.

The Middle Bird adit is 100 feet in elevation above the Lower Bird portal and has been driven for 80 feet in a northwesterly direction in the shear zone; similarly, the Upper Bird adit is 30 feet still higher and has been driven for about 160 feet. The mineralization in these adits is very similar to that in the Lower Bird adit—irregular veinlets and impregnations of quartz, containing here chiefly pyrite, in a fault zone that trends N. 80° W. and dips 50° to 70° NE.

A series of about a dozen open cuts, pits, and shallow shafts extends westward for about 1,200 feet from the Bird adits to the crest of Miners Ridge. These delineate what is known locally as the Clara vein. The "vein" is probably a series of parallel and diverging quartz veins, stringers, and irregular impregnations in a fracture zone that is marked in places by sheeting, in others by hydrothermal alteration, particularly bleaching and silicification. The width of the zone is decidedly variable. In places it is bounded by well-defined fault surfaces; elsewhere it grades into the granodiorite on one or both sides. The strike of the zone is northwestward and the dip averages 50° northeast.

The quartz is partly cryptocrystalline or chertlike and partly coarsely crystalline with comb structure fairly common. Some arsenopyrite occurs, but in the main the former presence of sulfide minerals is only indicated by a limonite residuum. Scheelite occurs in most exposures as small scattered crystals in the vein matter. Commonly these are one-fourth to one-half inch in cross section and lack any particular orientation or trend; in a few places they form irregular masses as much as 3 inches across.

An open cut, No. 1 on plate 23, about 400 feet northwestward from the portal of the Lower Bird adit shows some scheelite and seems to be on the "Bird vein". No. 2 open cut 100 feet to the south shows good scheelite in a vein that does not appear in the Bird openings.

Some 400 feet west of No. 2 is a shallow open cut, No. 3 on plate 23, revealing three shear zones, hydrothermally altered. These are between 2 and 3 feet wide and are reported to carry some scheelite.

The opening known as the Dobbs cut lies about 300 feet southwest of No. 3 and was dug about five years before tungsten had been recognized in this district. It trends northwest for some 20 feet along a hydrothermally altered zone less than 10 feet wide in the granodiorite. Rock on the northeast shows alteration and at the back face a 4- to 8-inch zone of gouge indicates a nearly east-west fault with 30° dip northward. Scheelite in minute specks shows in this zone. On the southwest side of the pit the rock is fresh but shows some northward-dipping joints, which carry one-eighth-inch spots of scheelite. Between these rock walls in this zone of hydrothermally altered rock, are narrow quartz lenses mostly horizontal but interfingering somewhat. They are half an inch thick and up to 18 inches long but carry no visible scheelite.

Open cut No. 4 is only 30 feet northwest of the Dobbs. It reveals a brown-weathering sheared and hydrothermally altered zone in granodiorite. The hanging wall is marked by a fault surface dipping 40° northward, beyond which the granite shows slight sericitization for only 6 inches. A nearly vertical fault with east-west trend is shown on the west wall of the pit. No scheelite or other ore minerals were noted.

Open cut No. 5 is west some 30 feet from No. 4. It exposes a zone of reddish to yellow hydrothermally altered granodiorite which includes a narrow ore zone about 10 feet long dipping due north at 46°. On the hanging wall a 6- to 8-inch lens of gray cryptocrystalline quartz, reddish in weathered portion, carries considerable scheelite.

The open cut mapped as No. 6 is still farther west but some 75 feet up the slope from No. 5. It is a 6-foot east-west trench in bleached granodiorite, which weathers yellow brown. Near the north wall the face shows a narrow gouge-filled shear zone dipping due north. The south wall reveals another northward-dipping shear zone which, below a 6-inch zone of gouge, contains a narrow band of dark gray cherty quartz with some patches of white glassy vein quartz on its footwall surface. In this trench only the cherty band showed any scheelite and here only a few minute spots were seen. In two near-by shallow cuts the granodiorite showed no evidence of any mineralization.

Still farther up the hillside, on west from No. 6, an inclined shaft has been sunk 30 feet on a mineralized shear zone which here dips 30° north at the portal and steepens to 35° at the bottom. It is reported that four sacks of hand-picked scheelite were taken from

this opening. Some was seen, especially on the hanging wall, but much more may well have been concealed beneath the heavy coating of limonite.

Open cut No. 7 trends west from the inclined shaft for about 40 feet along the 4-foot zone of hydrothermally altered granite. A vein of quartz 8 to 10 inches thick is separated from the hanging wall by a foot of altered granite. The west end of this zone is truncated by a southwest-trending fault surface which dips 70° to the northwest. The westward continuation of the sheared zone of altered granite was picked up, about 30 feet to the southwest along the fault, in an open cut made in 1916. Here the shear zone trends slightly north of west, dipping 40° northward. As in No. 7 cut, the tungsten in this opening is confined to the hanging wall.

About 40 feet farther west open cut No. 8 exposes the sheared zone for about 10 feet. As elsewhere along this zone the altered granite has fresh rock on either side. The footwall shows apparent introduction of cryptocrystalline quartz, while an iron-stained quartz vein, 4 inches wide, on the hanging wall carries arsenopyrite in crystals up to 1 inch long.

About 30 feet west of No. 8 the open cut mapped as No. 9 exposes only about 2 feet of the fault zone. The mineralized quartz vein, 4 inches wide, is still on the hanging side but is a few inches nearer the center of the shear zone than in Nos. 7 and 8. Also there is more silicification near the hanging wall than appears in cuts just east.

At the crest of Miners Ridge, still farther west, the apex of the sheared zone is exposed in a 9-foot pit. It is here less than 2 feet wide and shows more intense alteration along the hanging wall. Scheelite appears near this side as in cuts previously described.

About a thousand feet northward along the crest of the ridge a narrow quartz vein is exposed in a cut known as the Garibaldi. This is a small opening on the west side of the crest line. The vein, less than 6 inches wide, strikes northwest, dipping 35° northeast. It carries considerable scheelite, some of it in ideomorphic crystals. Arsenopyrite is prominent also.

Two other prospects on Miners Ridge merit brief mention, the Pasco and New Find.

The Pasco adit is about 3,500 feet north of Copper City camp on the road to the Clara camp. The portal is 500 feet east of the road and the 30-foot opening is westerly. There is exposed a 6- to 8-inch iron-stained vein zone showing several narrow pyrite stringers. Some chalcopyrite appears with chlorite, and scheelite is reported but was not seen when this opening was examined in 1941. Scheelite was noted, however, in the continuation of this zone across the stream to the east. The zone trends northwest, dipping about 45° to the northeast.

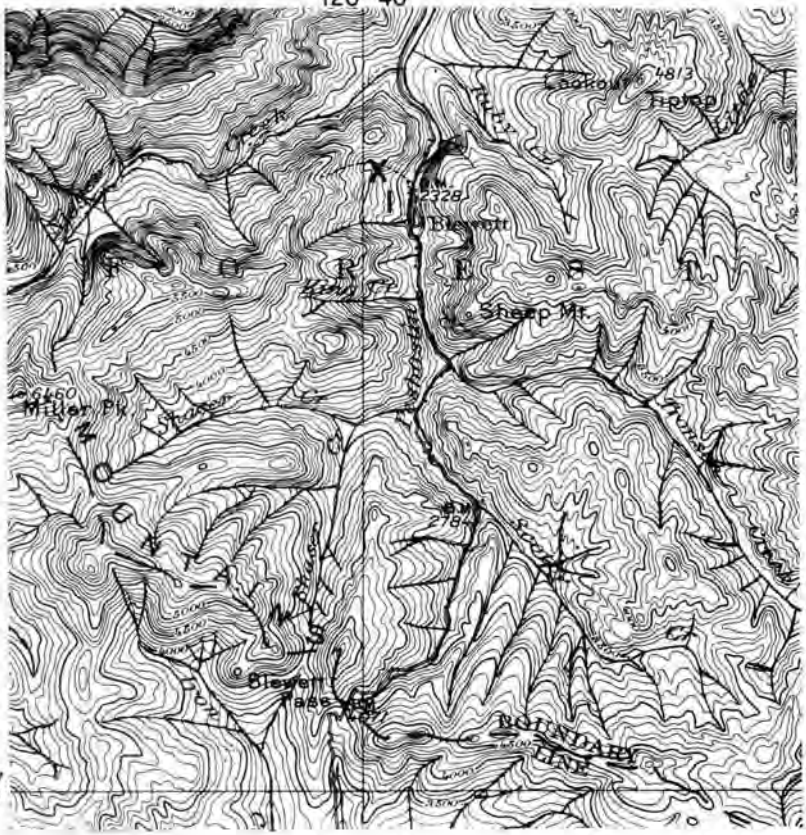
The New Find openings comprise two adits and some open cuts along a mountain stream a few hundred yards west of Copper City. The stream has exposed the granite of Miners Ridge in which a fracture zone several feet wide trends N. 80° W. and dips 70° NE.

This zone contains quartz veins with tourmaline, chalcopyrite, arsenopyrite, pyrite, and scheelite. The geologic conditions here closely resemble those at the Bird workings a mile and a half to the north. There is the same granite country rock and the same gray porhyry dike rock. The former shows the same westward-trending fracture zones and the latter is paralleled by veinlets of quartz with a little chalcopyrite and tourmaline. It appears that the mineralized westward-trending shear zones are interrupted by the later, and barren, north-south faults.

INDEX

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

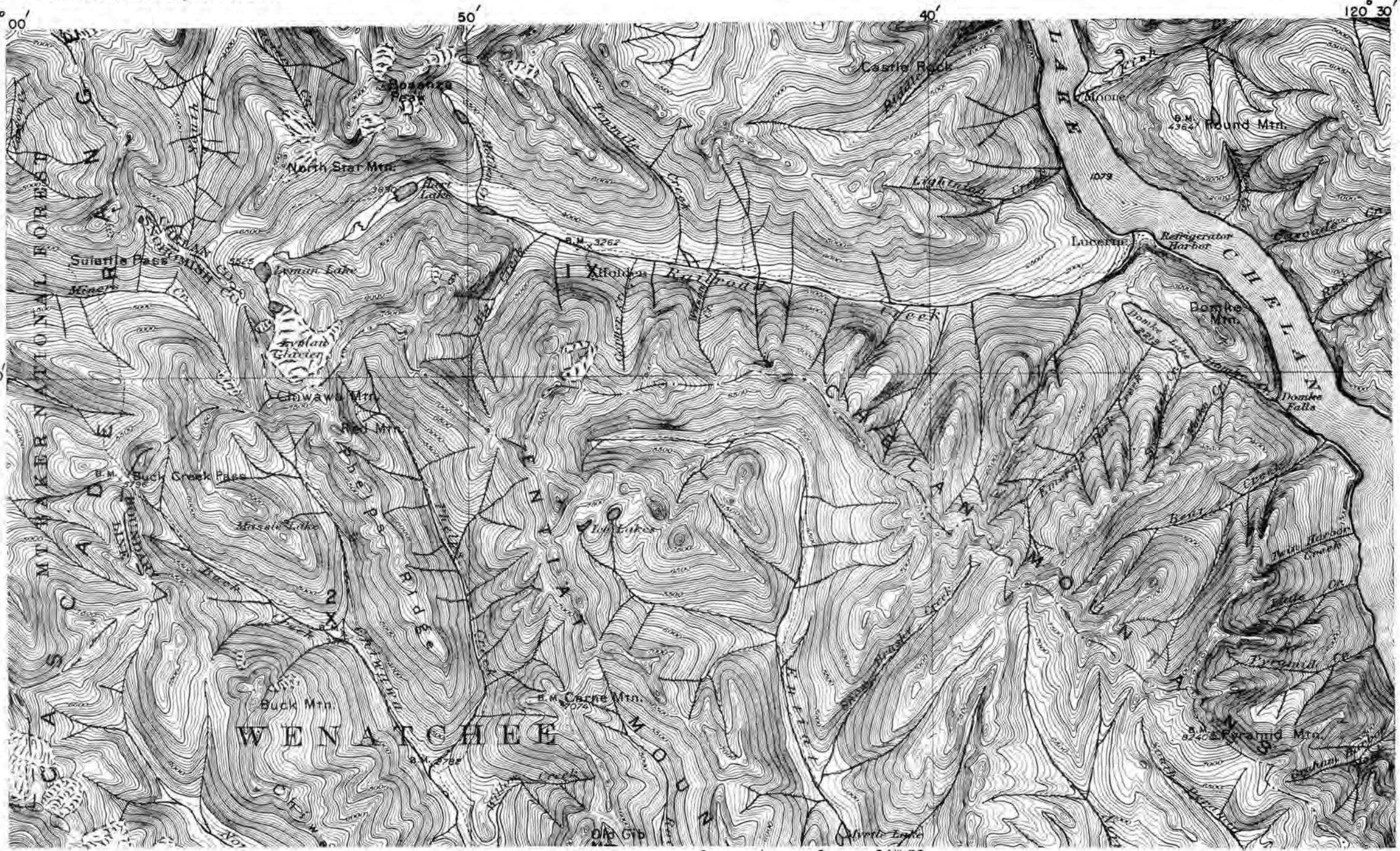
BULLETIN 34
PLATE 1
1945



TUNGSTEN OCCURRENCES IN BLEWETT AREA. 1-CULVER GULCH. (BASE FROM U.S.G.S. TOPOG. ATLAS MT. STUART SHEET)

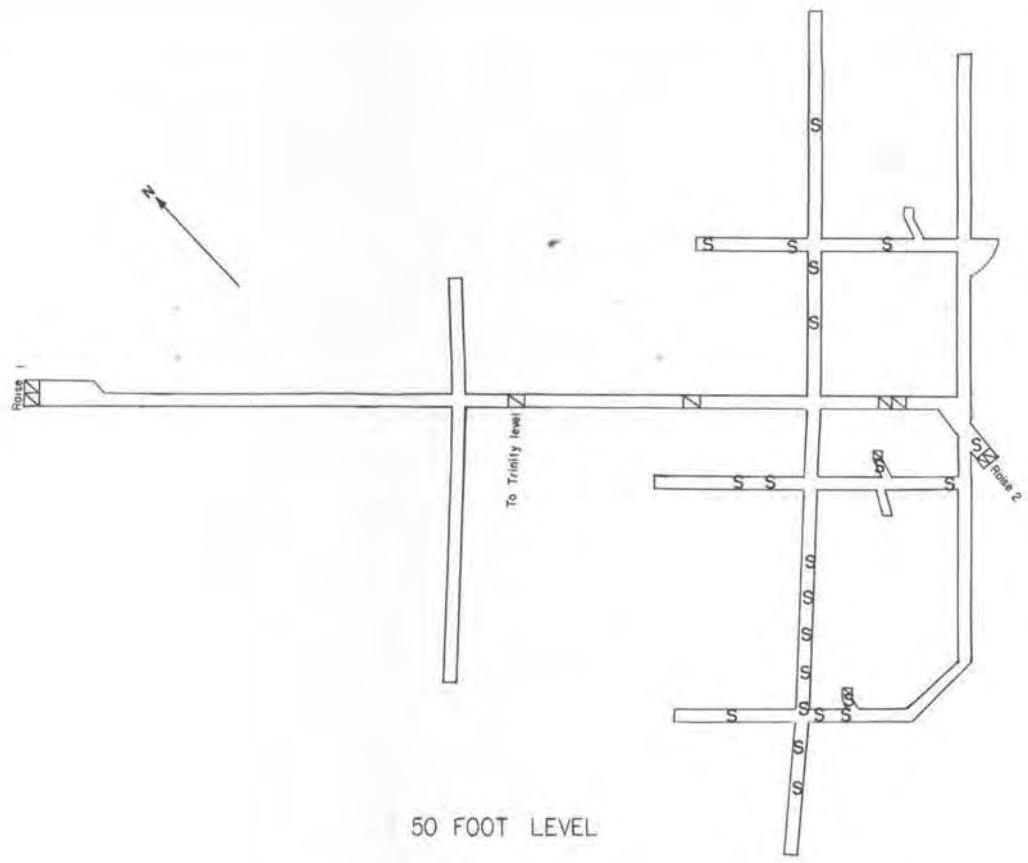
STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

BULLETIN 34
PLATE 2
1945



STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

BULLETIN 34
PLATE 3
1945

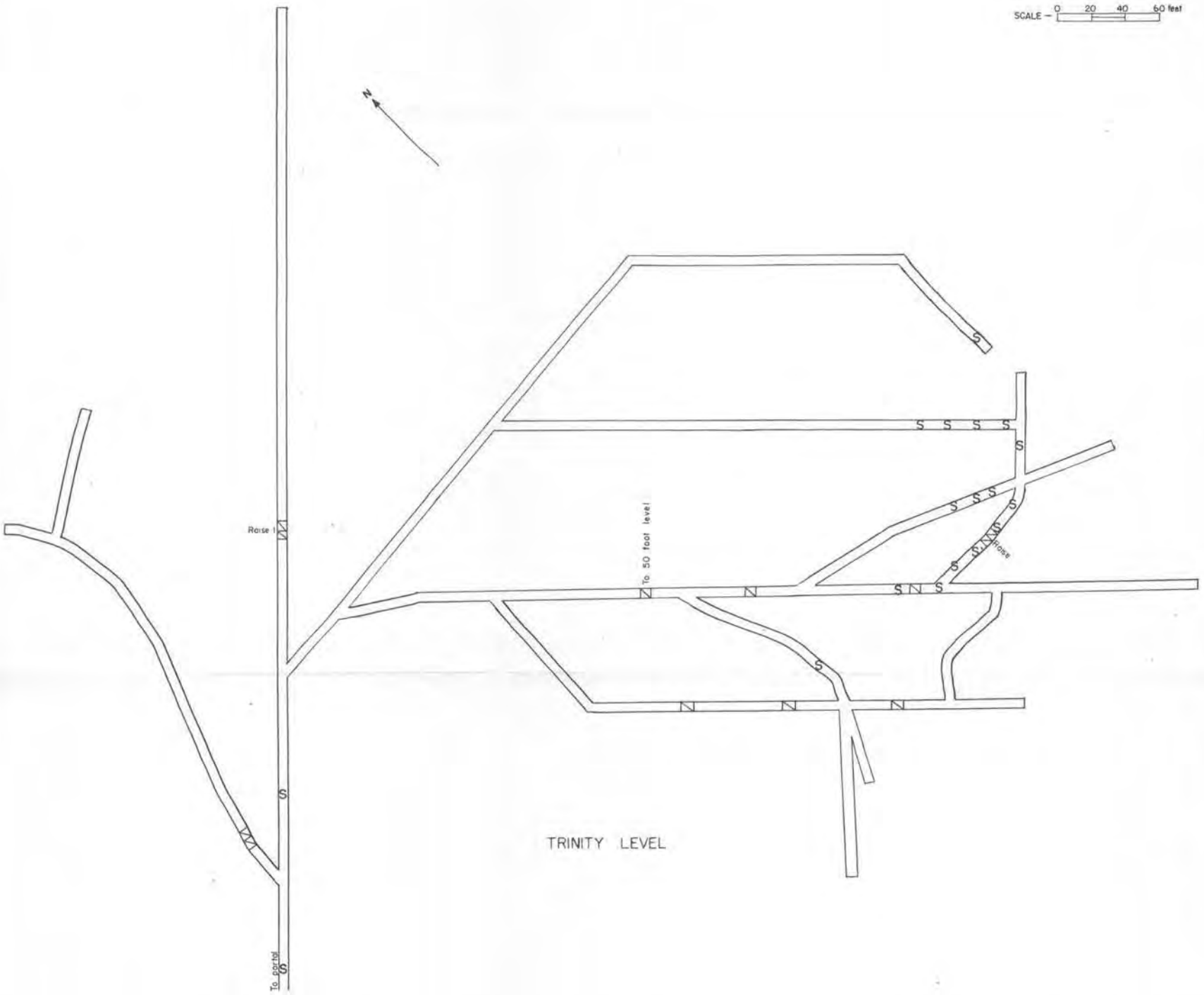


50 FOOT LEVEL

EXPLANATION

SCHEELITE OCCURRENCE S

SCALE – 0 20 40 60 feet



TRINITY LEVEL

BASE FURNISHED BY ROYAL DEVELOPMENT COMPANY

SCHEELITE OCCURRENCES MAPPED BY HAROLD E. CULVER AND M.T. HUNTTING

DETAILS OF TUNGSTEN OCCURRENCE, TRINITY WORKINGS, ROYAL DEVELOPMENT COMPANY

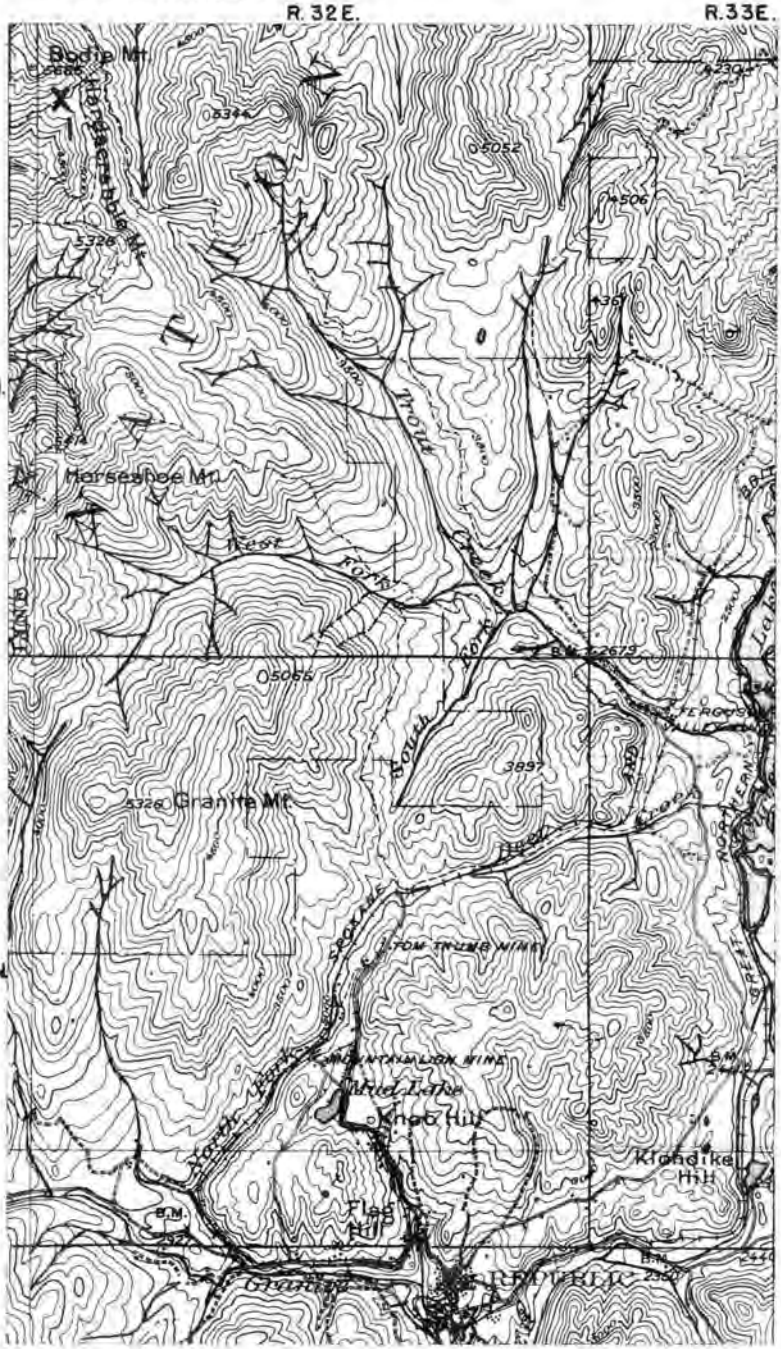
STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

BULLETIN 34
PLATE 4
1945

TUNGSTEN OCCURRENCES IN DANVILLE AREA. 1- MORNING STAR.
(BASE FROM U.S.G.S. TOPOG. ATLAS REPUBLIC SHEET)

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

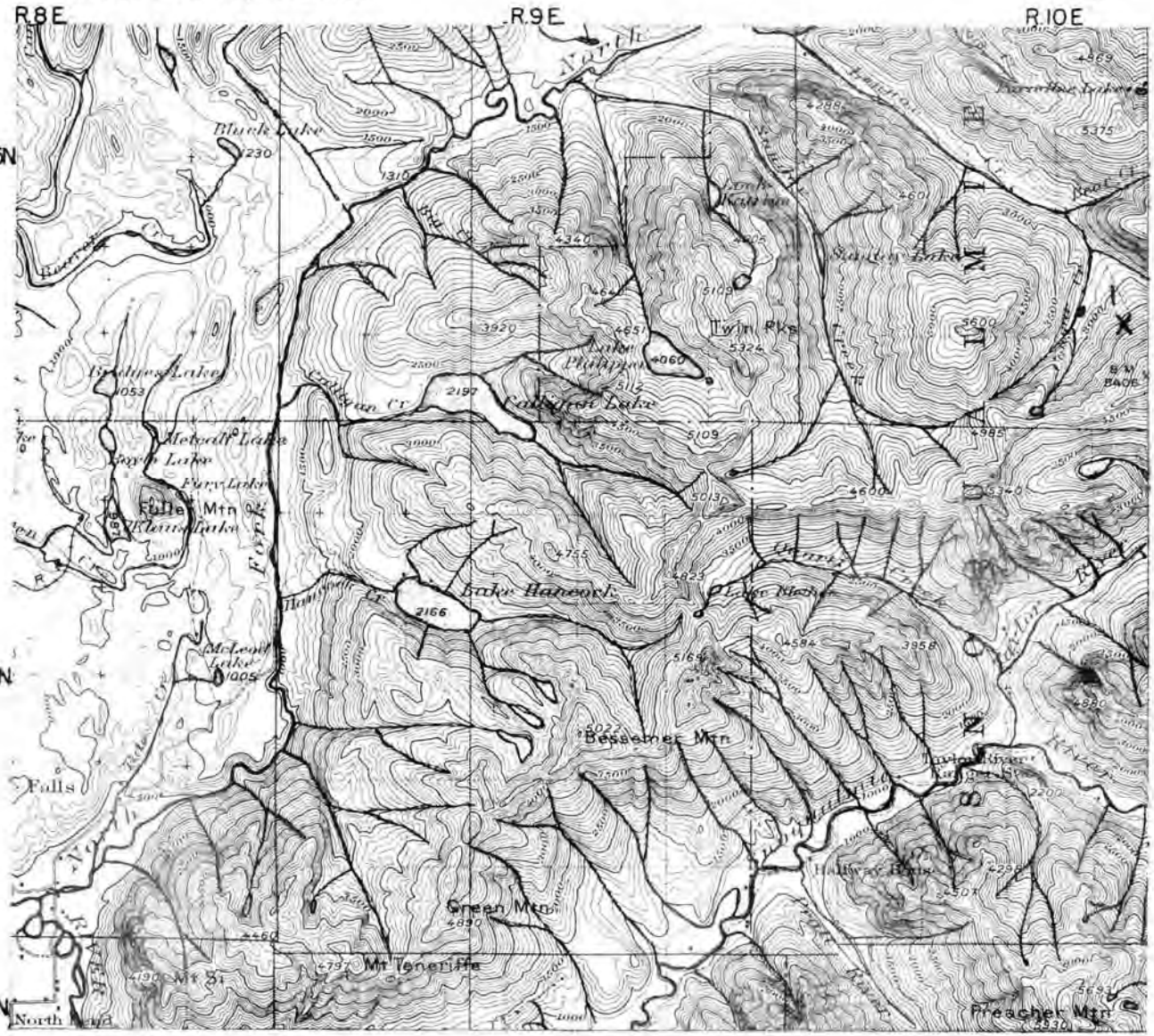
BULLETIN 34
PLATE 5
1945



TUNGSTEN OCCURRENCE IN REPUBLIC AREA. I—KELLY. (BASE FROM U.S.G.S. TOPOG. ATLAS REPUBLIC SHEET)

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

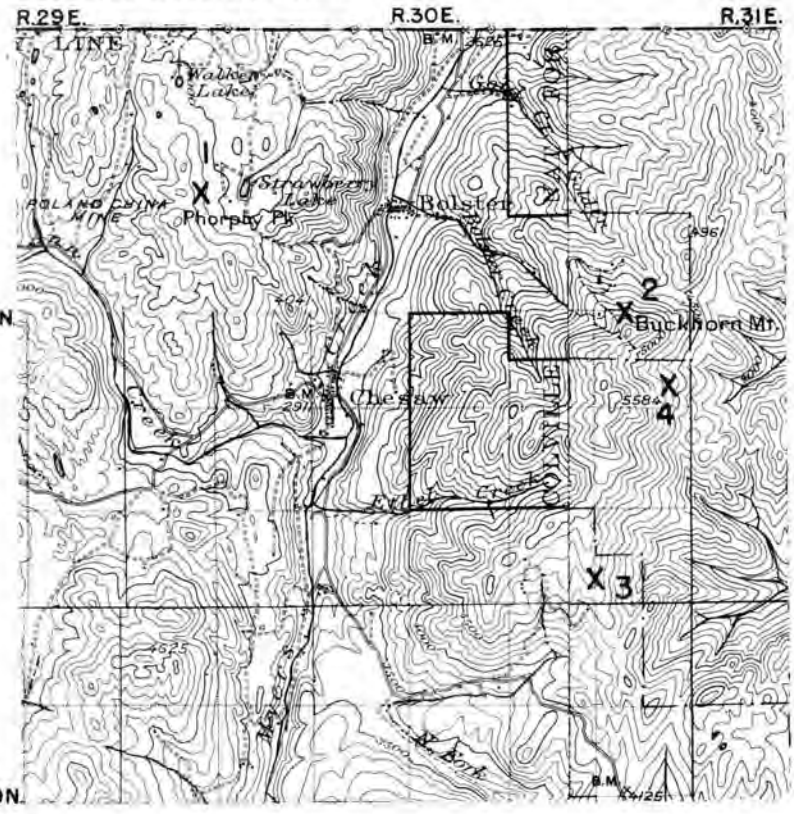
BULLETIN 34
PLATE 6
1945



TUNGSTEN OCCURRENCE IN NORTHEASTERN KING COUNTY. I – DEVILS CANYON. (BASE FROM U.S.G.S. TOPOG. ATLAS SULTAN SHEET)

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

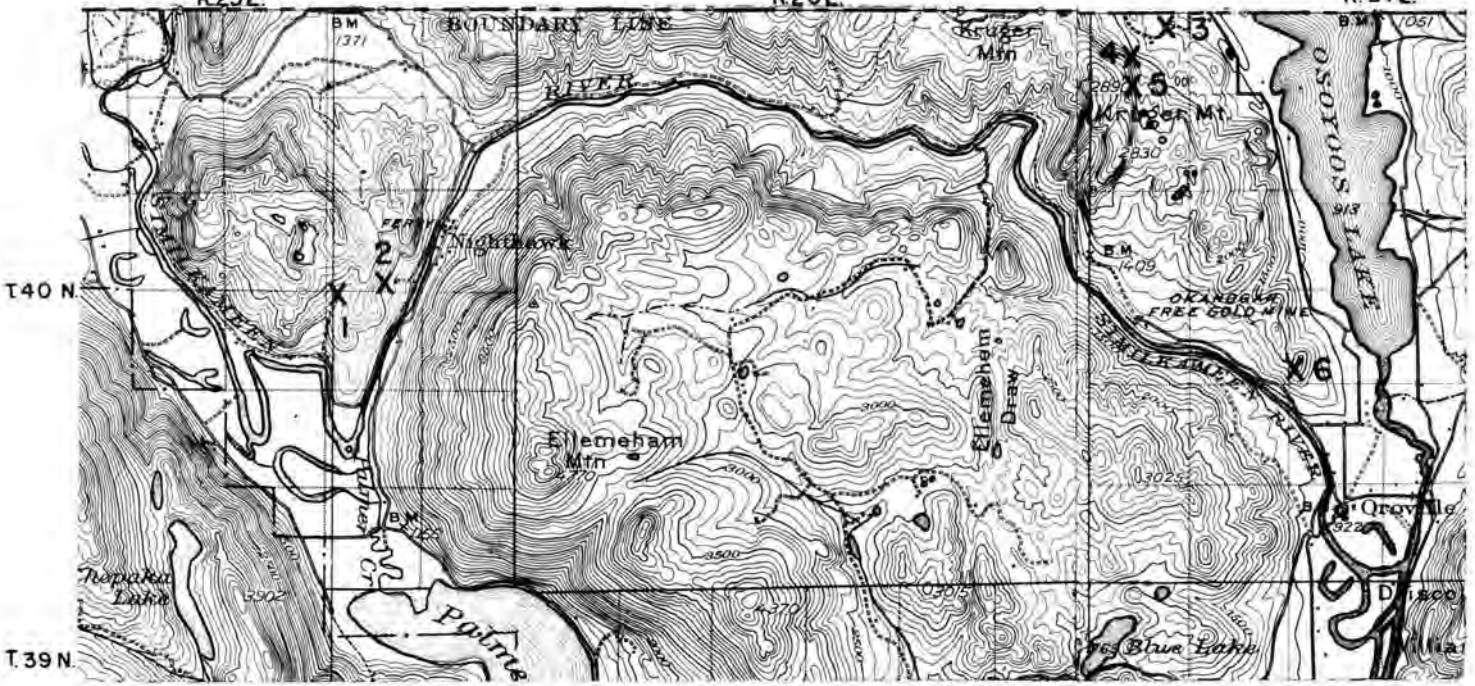
BULLETIN 34
PLATE 7
1945



TUNGSTEN OCCURRENCES IN MYERS CREEK AREA. 1-STRAWBERRY LAKE, 2-MAGNETIC, 3-CRYSTAL BUTTE, 4-ROOSEVELT. (BASE FROM U.S.G.S. TOPOG. ATLAS REPUBLIC AND OSOYOOS SHEETS)

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

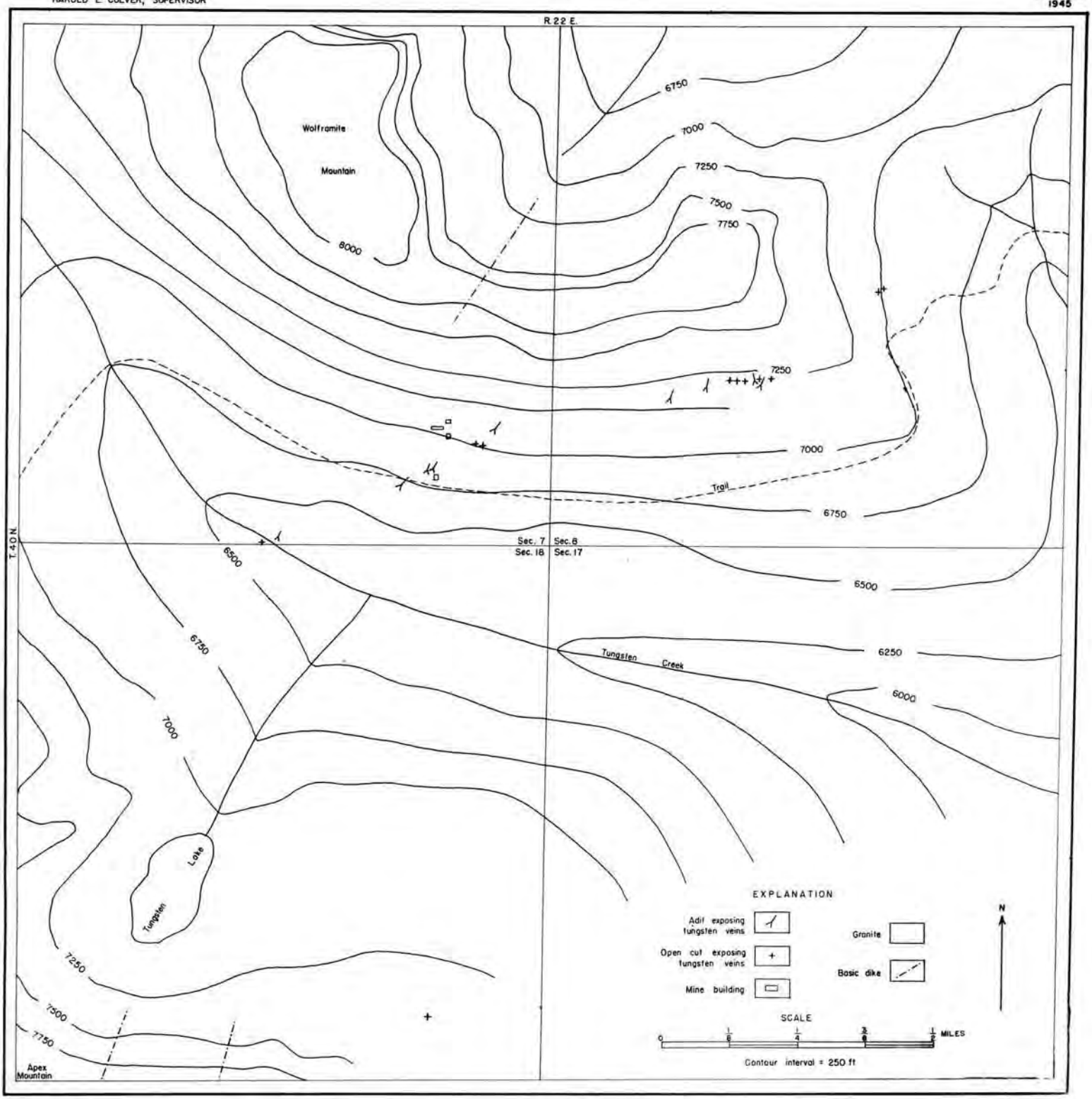
BULLETIN 34
PLATE 8
1945



TUNGSTEN OCCURRENCES IN OROVILLE AND NIGHTHAWK AREAS. 1-FOUR METALS, 2-KAABA-TEXAS, 3-49th. PARALLEL, 4-O.K. COPPER, 5-GOLDEN CHARIOT, 6-MONCOSILGO. (BASE FROM U.S.G.S. TOPOG. ATLAS CHOPAKA AND OSOYOOS SHEETS)

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

BULLETIN 34
PLATE 9
1945



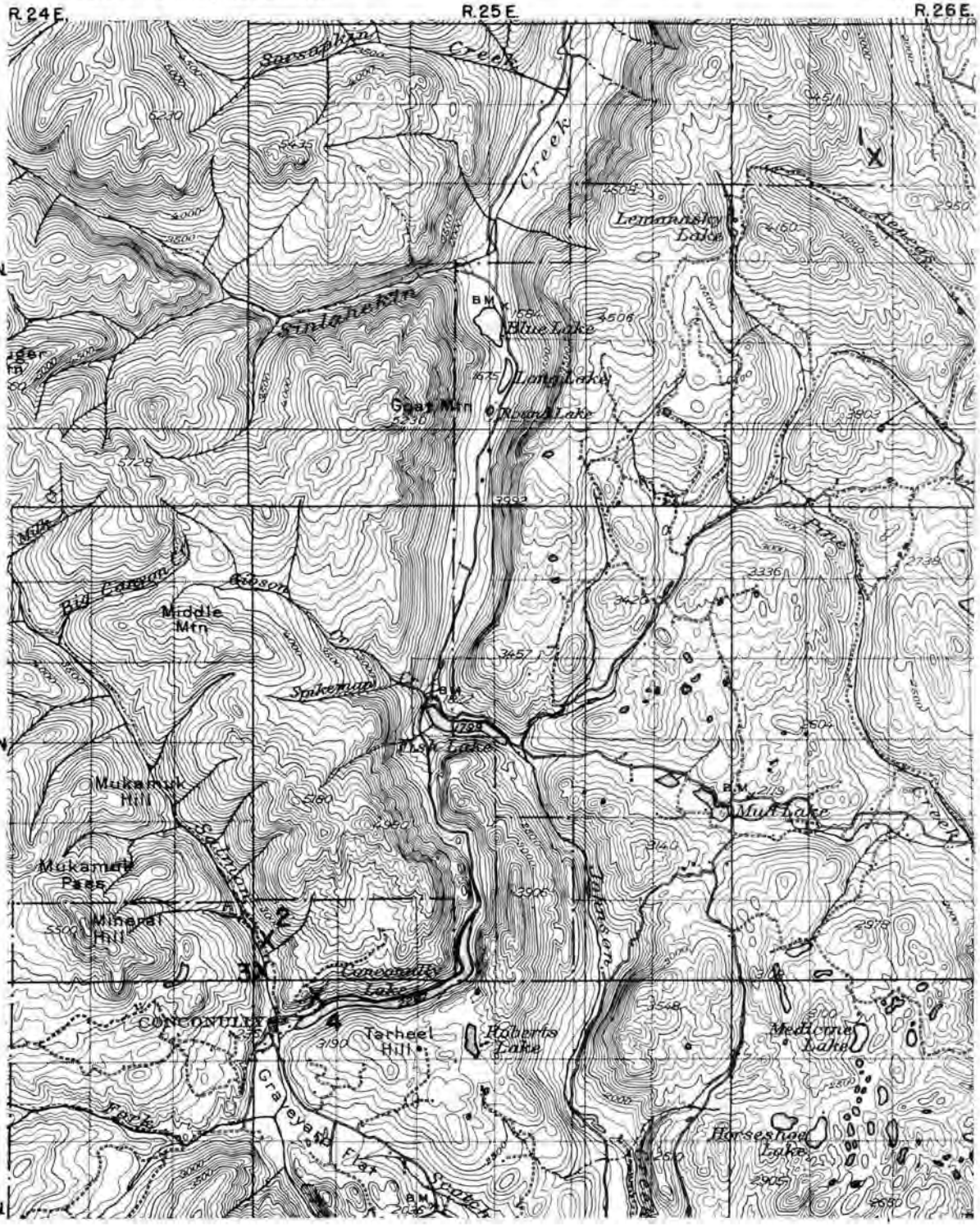
BASE AND TOPOGRAPHY FROM
DALY, R.A., G.S.C. MEMOIR 38, PT. 3, SHEET 13

GEOLOGY AND WORKINGS MAPPED BY W. A. G. BENNETT

DETAILS OF TUNGSTEN OCCURRENCES IN WOLFRAMITE MOUNTAIN AREA

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
HAROLD E. CULVER, SUPERVISOR

BULLETIN 34
PLATE 10
1945



TUNGSTEN OCCURRENCES IN CONCONULLY AREA. 1-STARR, 2-SILVER KING, 3-GUBSER, 4-LADY OF THE LAKE. (BASE FROM U.S.G.S. TOPOG. ATLAS CHOPAKA SHEET)

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DEPARTMENT OF CONSERVATION AND DEVELOPMENT
DIVISION OF GEOLOGY
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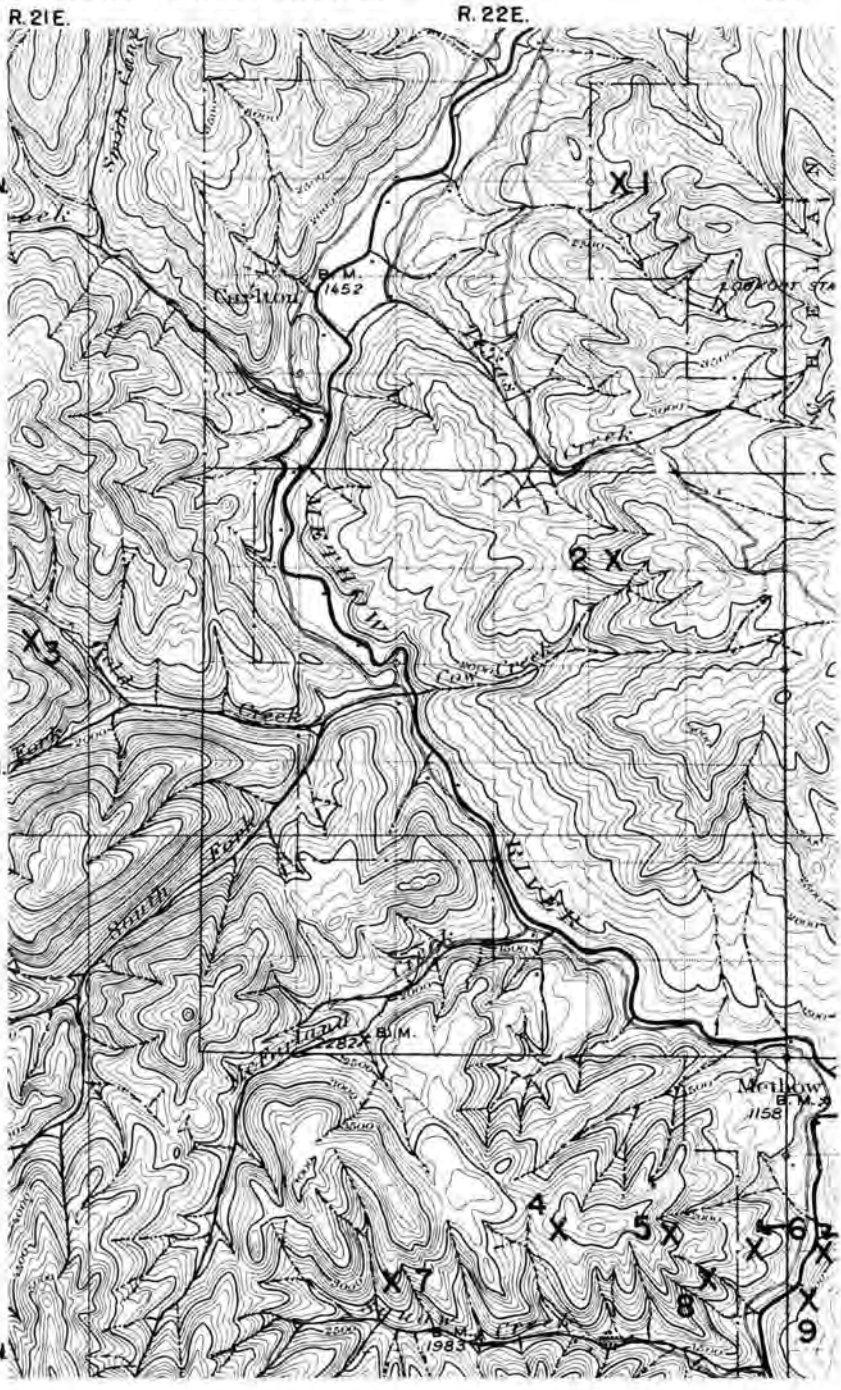
BULLETIN 34
PLATE 11
1945



TUNGSTEN OCCURRENCES IN SQUAW CREEK AREA. 1 - MINNIE, 2 - DUTCH JOHN, 3 - NEW DEAL, 4 - HOLDEN-CAMPBELL, 5 - HIGHLAND, 6 - METHOW, 7 - CHELAN, 8 - GOLDEN EAGLE, 9 - WASHINGTON. (BASE FROM U.S.G.S. TOPOG. ATLAS METHOW SHEET)

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BULLTIN 34
PLATE 12
1945

EXPLANATION

Exposure of scheelite-bearing garnet bed. Number indicates thickness. 5 ft.

Scale – 0 100 200 300 feet

Contour interval = 20 feet

N

Center of sec.2, T31N., R.22E.

DIORITE

METASEDIMENTARY ROCKS

3+ ft.

5 ft.

1+ ft.

2+ ft.

3 ft.

8 in.

4 ft.

Cabin

Adits

5 ft.

6 ft.

3 to 10 ft.

10 in.

2 to 4 ft.

7 to 12 ft.

Shaft

1 ft.

2 ft.

3700

3600

3500

3400

3300

TOPOGRAPHY BY M.T. HUNTTING, DIVISION OF GEOLOGY

GEOLOGY BY W. A. BROUGHTON

DETAILS OF TUNGTEN OCCURRENCES IN VICINITY OF DUTCH JOHN PROPERTY

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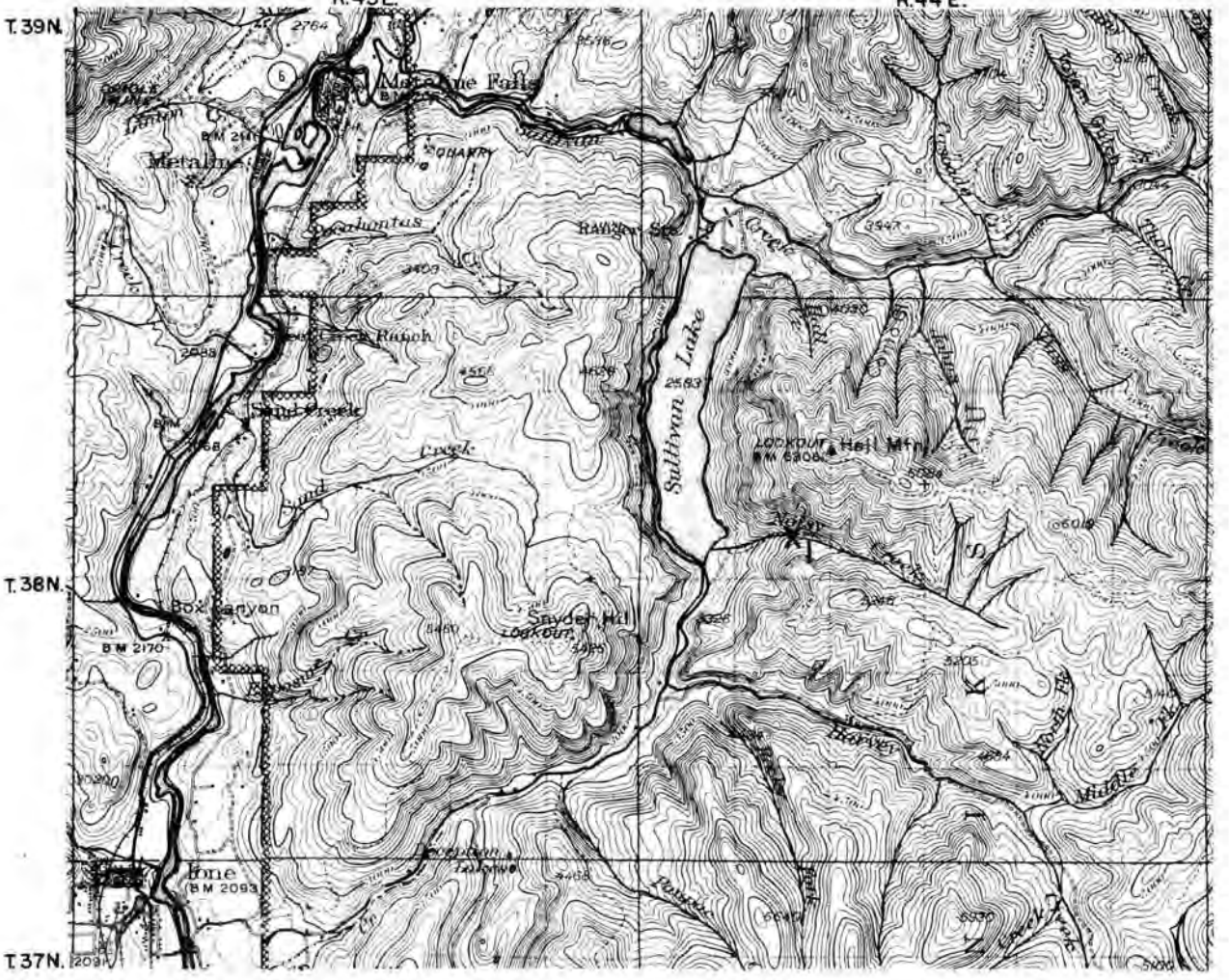
BULLETIN 34
PLATE 13
1945



TUNGSTEN OCCURRENCES IN METALINE AREA. 1-LITTLE NOISY. (BASE FROM U.S.G.S. TOPOG. ATLAS METALINE SHEET)

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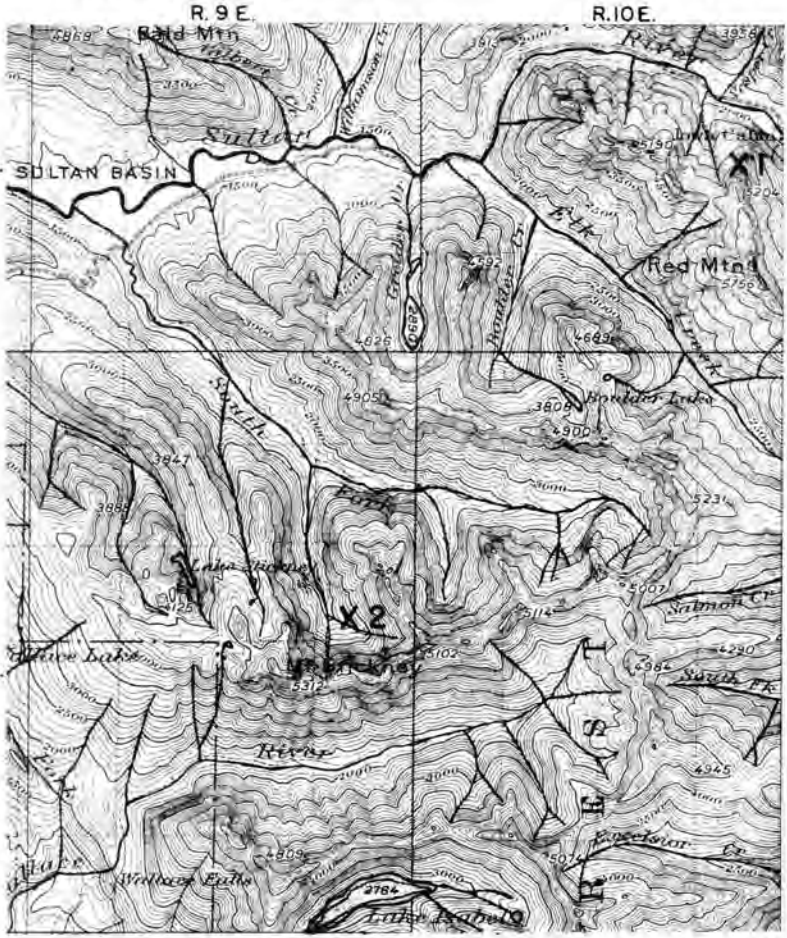
BULLETIN 34
PLATE 14
1945



TUNGSTEN OCCURRENCES IN SULTAN BASIN. 1- MINT (IOWA), 2- KROMONA. (BASE FROM U.S.G.S. TOPOG. ATLAS SULTAN SHEET)

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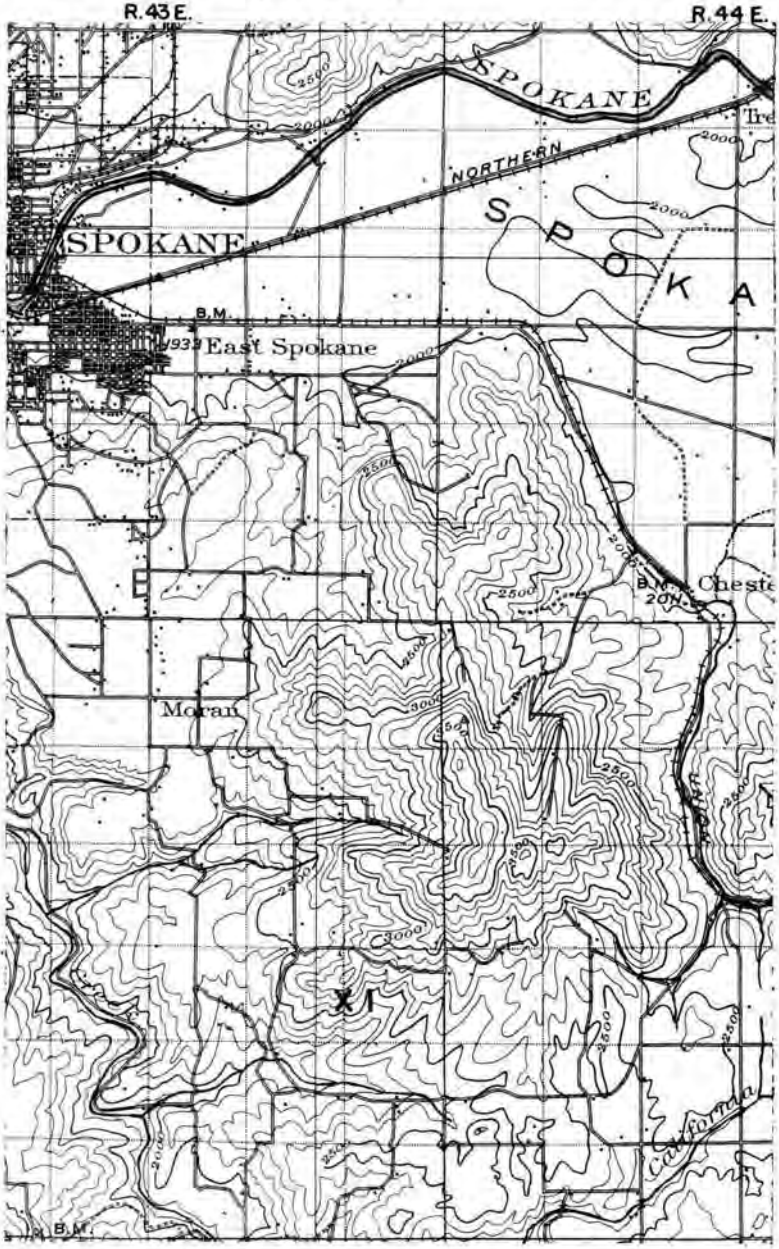
BULLETIN 34
PLATE 15
1945



TUNGSTEN OCCURRENCE IN SILVER HILL AREA. I-SILVER HILL. (BASE FROM U.S.G.S. TOPOG. ATLAS SPOKANE SHEET)

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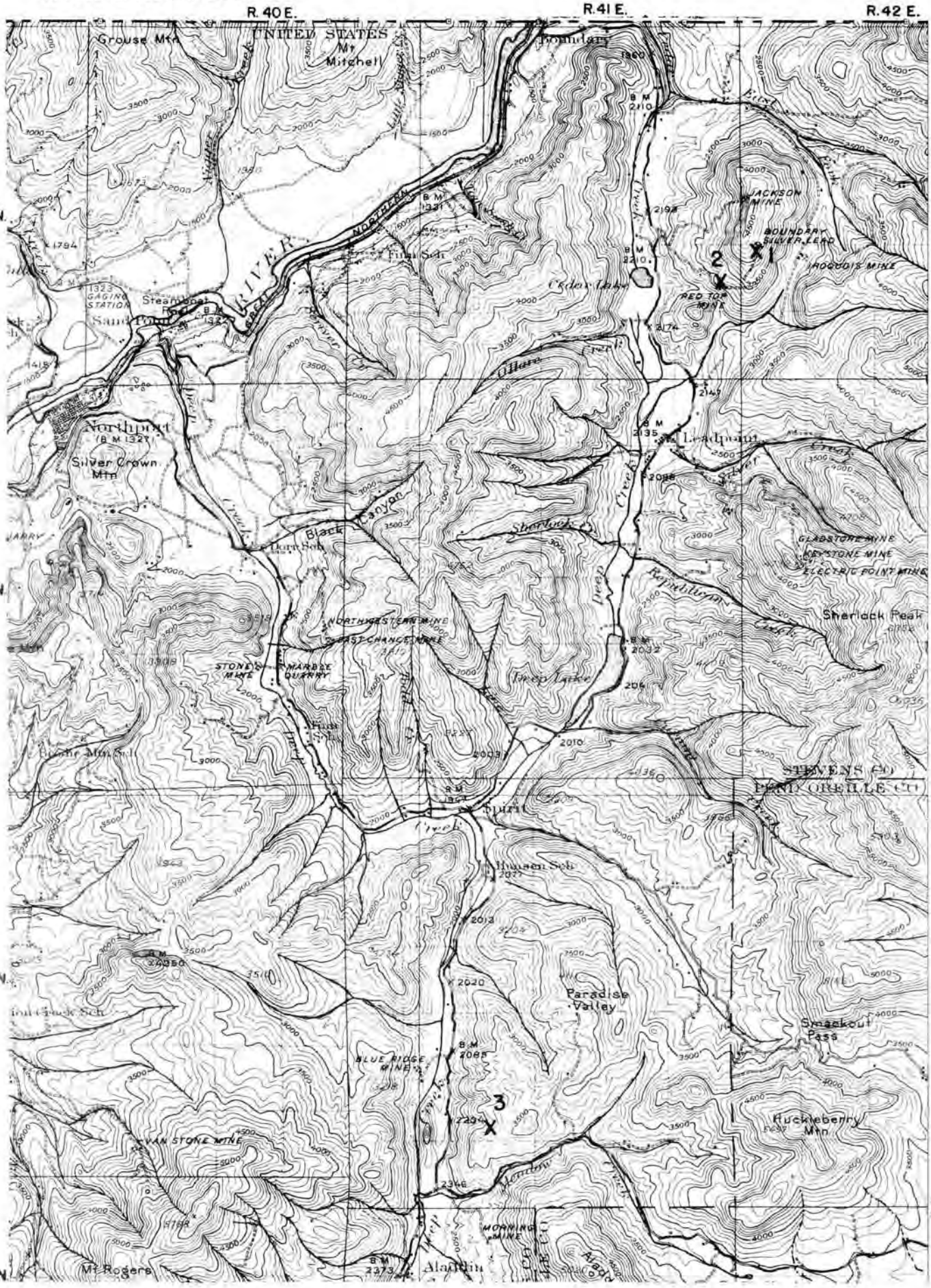
BULLETIN 34
PLATE 16
1945



TUNGSTEN OCCURRENCES IN NORTHPORT AREA. 1-LUCILE, 2-RED TOP, 3-MAGMA. (BASE FROM U.S.G.S. TOPOG. ATLAS COLLVILLE SHEET

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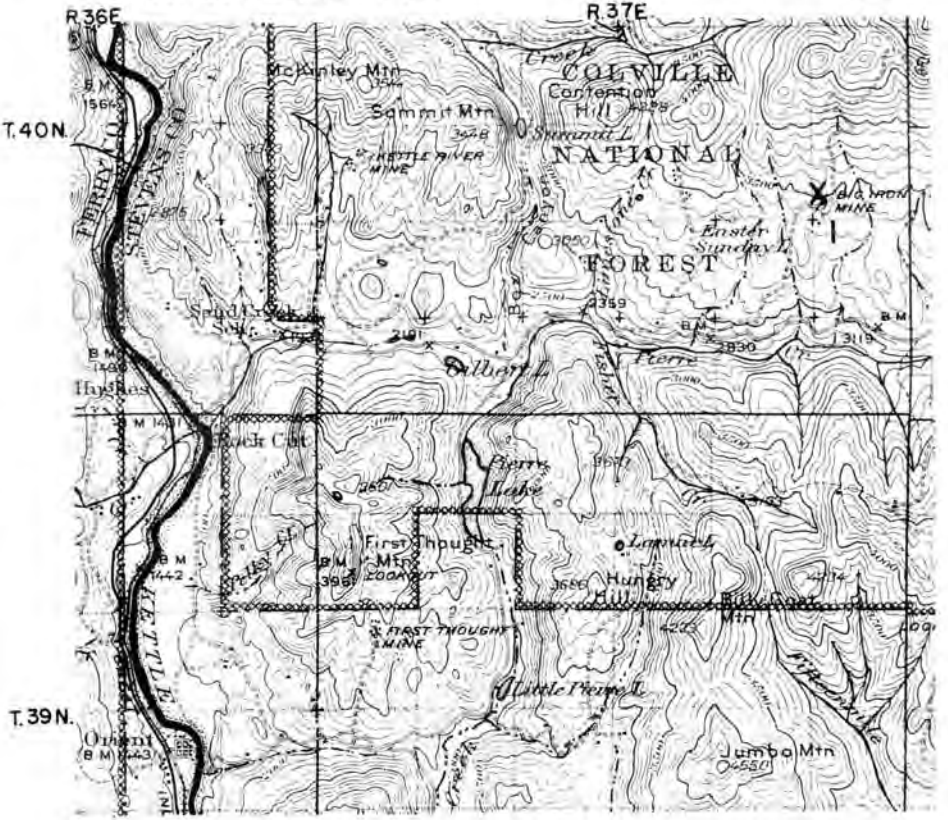
PLATE 17
1945



TUNGSTEN OCCURRENCE IN ORIENT AREA. 1-BIG IRON. (BASE FROM U.S.G.S. TOPOG. ATLAS MARCUS SHEET)

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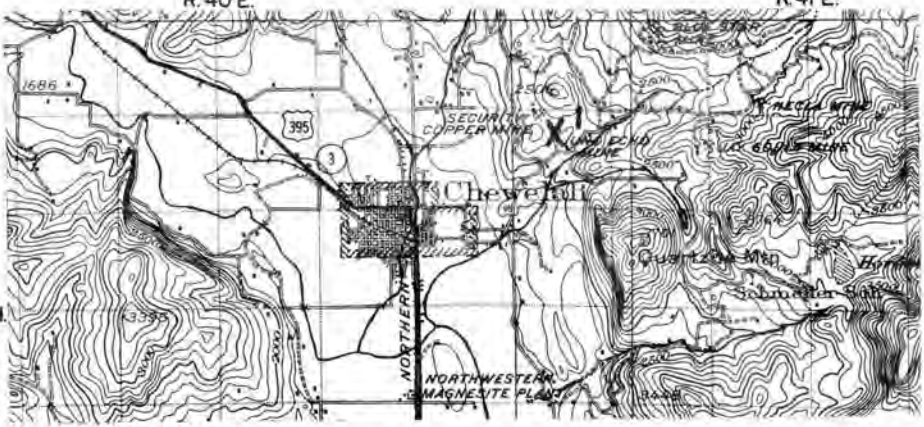
PLATE 18
1945



TUNGSTEN OCCURRENCE IN CHEWELAH AREA. 1- JUNO-ECHO. (BASE FROM U.S.G.S. TOPOG. ATLAS CHEWELAH SHEET)

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BULLETIN 34
PLATE 19
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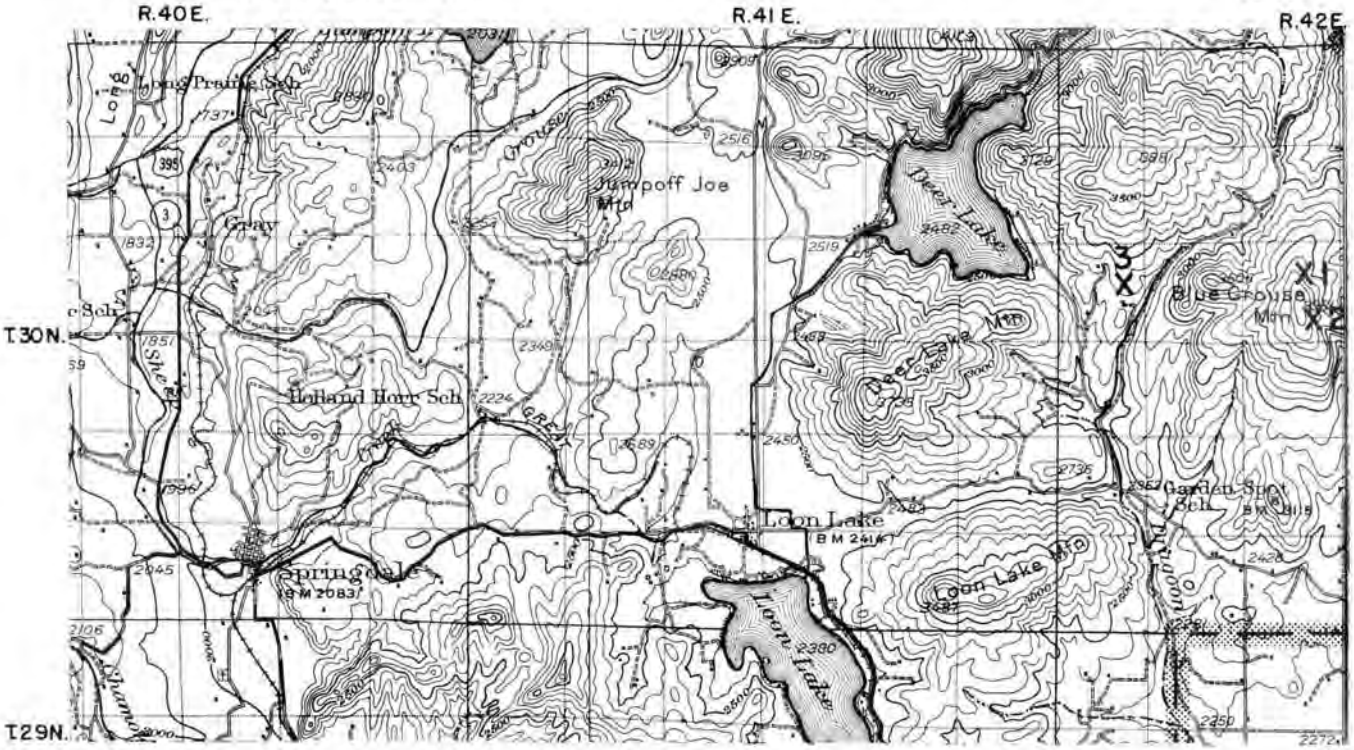

TUNGSTEN OCCURRENCES IN SPRINGDALE AREA, EAST HALF. 1-BLUE GROUSE, 2-TUNGSTEN KING, 3-GABER. (BASE FROM U.S.G.S. TOPOG. ATLAS CHEWELAH SHEET)

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BULLETIN 34
PLATE 20
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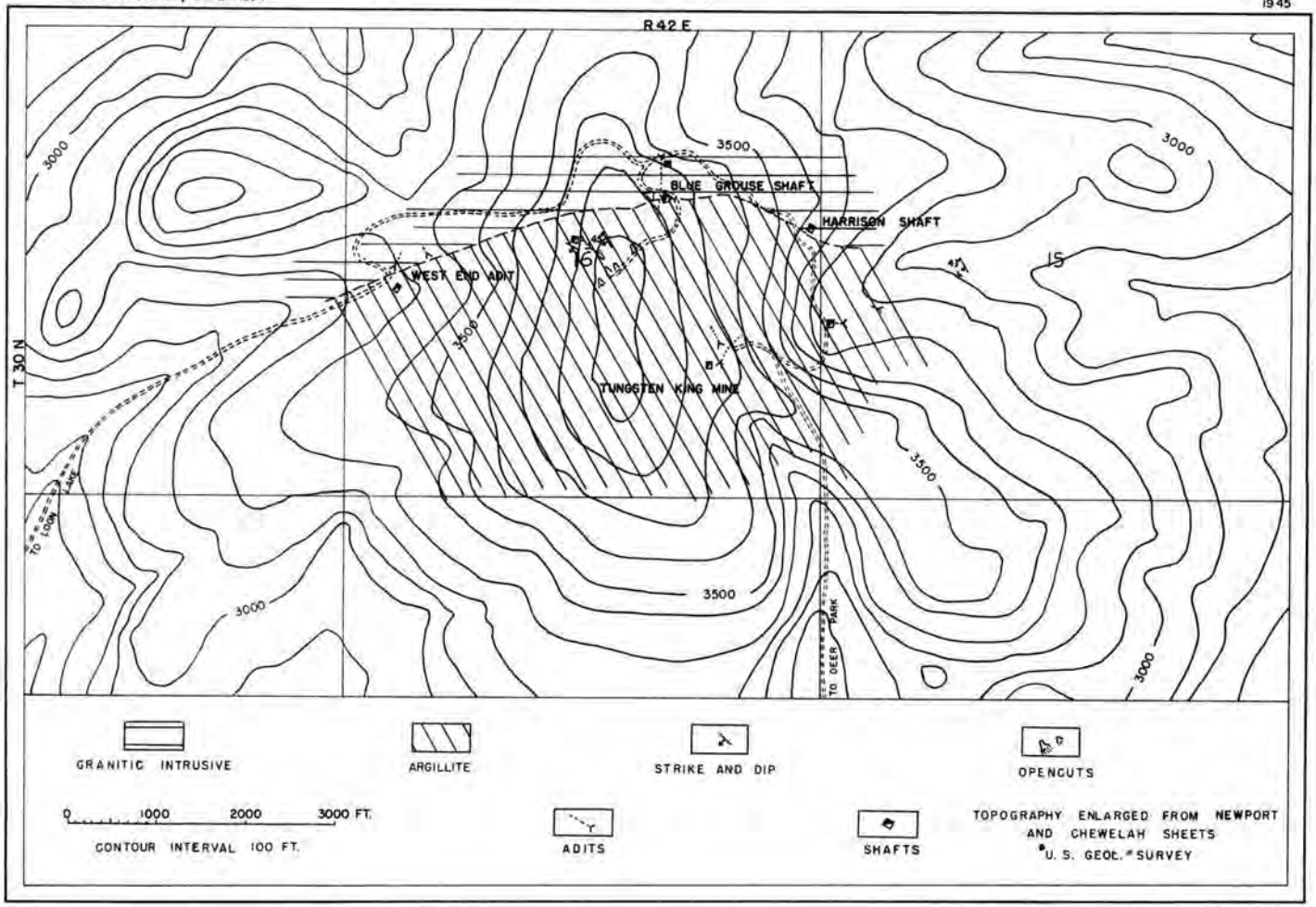

GEOLOGY BY W. A. G. BENNETT

GEOLOGY OF BLUE GROUSE MOUNTAIN

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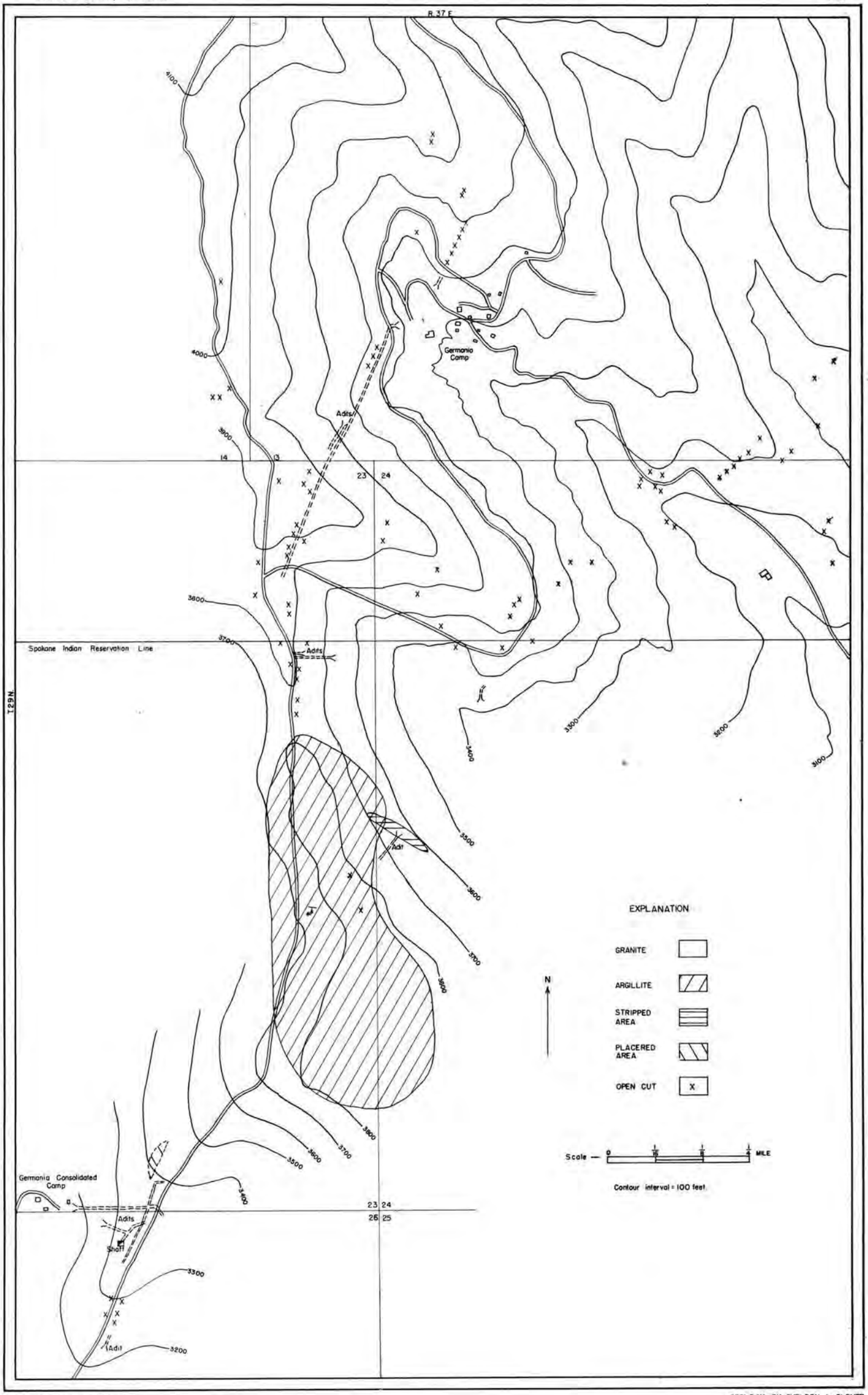
PLATE 21
1945



BASE FROM MAP BY G.D. EMIGH

GEOLOGY BY SHELDON L. GLOVER

GEOLOGY OF GERMANIA AREA

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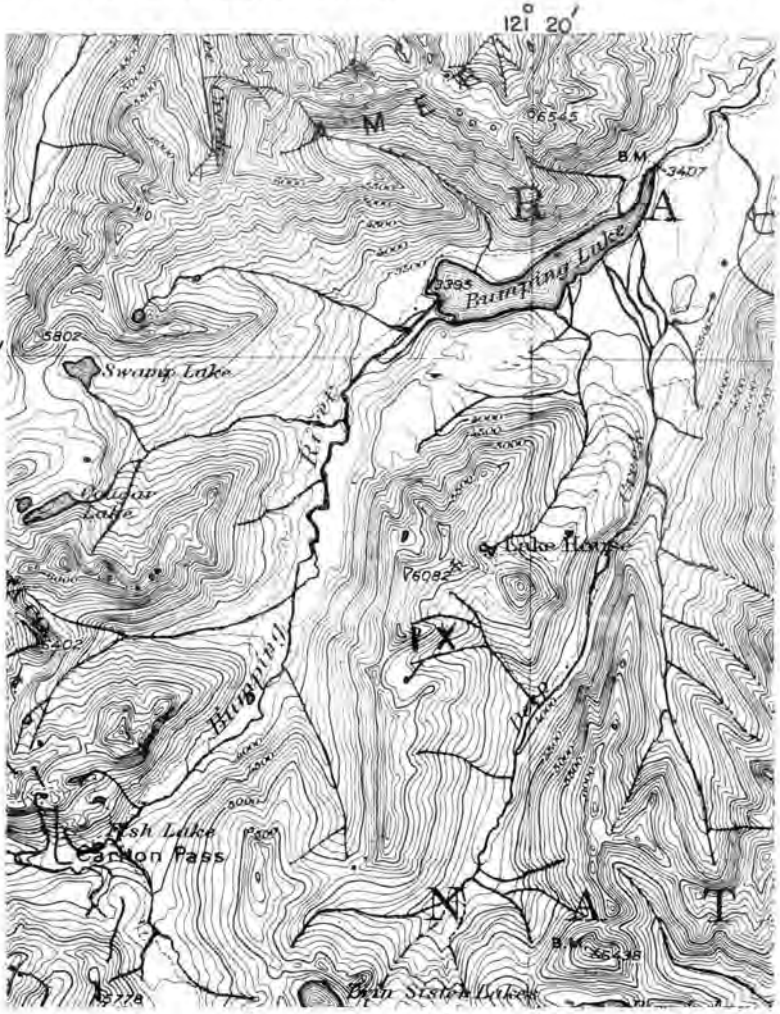
PLATE 22
1945



TUNGSTEN OCCURRENCE IN BUMPING LAKE AREA. 1-COPPER CITY. (BASE FROM U.S.G.S. TOPOG. ATLAS MOUNT AIX SHEET)

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PLATE 23
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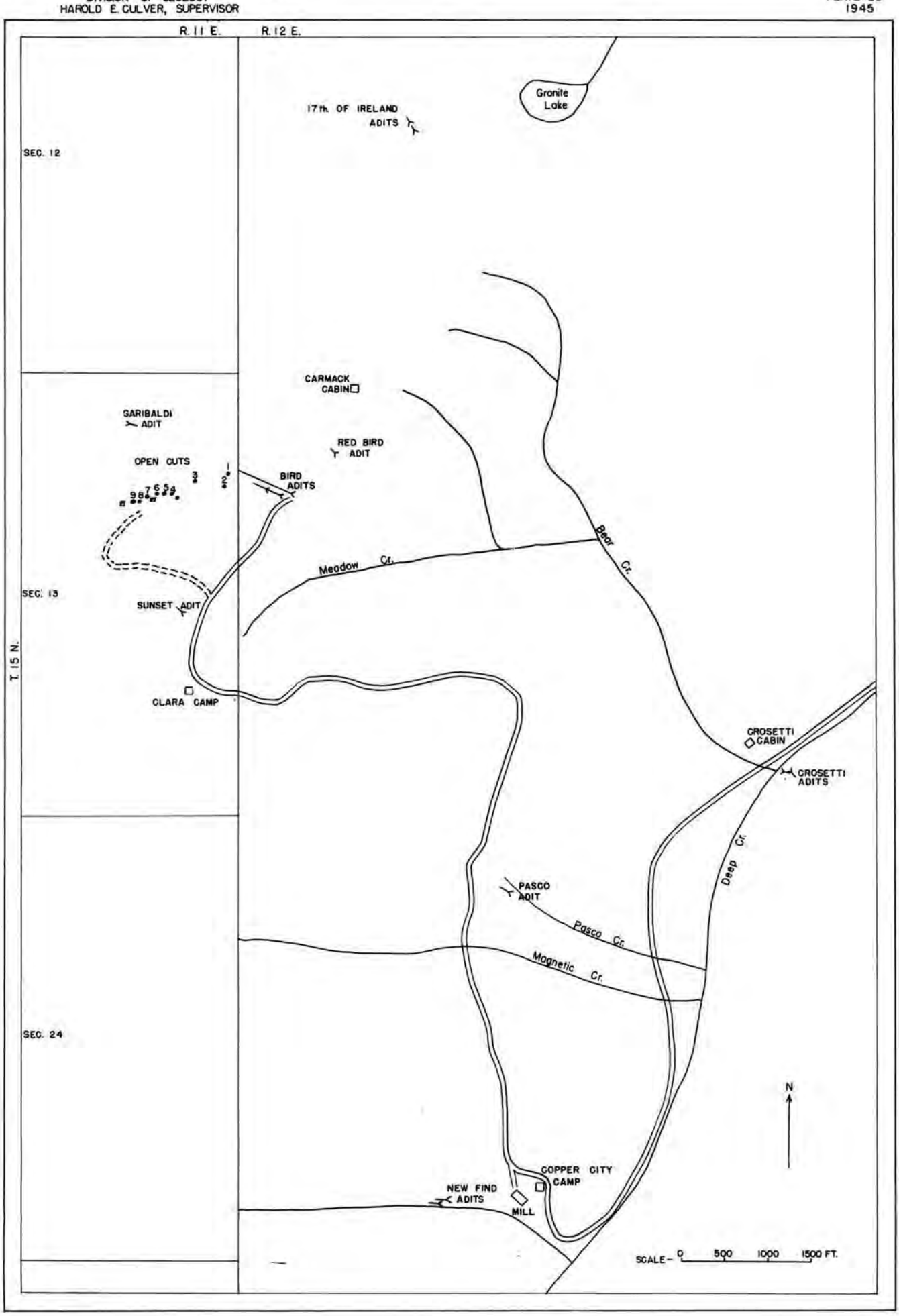

SKETCH MAP OF COPPER CITY AREA
SHOWING OPENINGS