Tungsten Deposits of the Hyder District Alaska

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By F. M. BYERS, Jr., *and* C. L. SAINSBURY

MINERAL RESOURCES OF ALASKA

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A description of the mines and prospects

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TUNGSTEN DEPOSITS OF THE HYDER DISTRICT, ALASKA

By F. M. Byers, Jr., and C. L. Sainsbury

ABSTRACT

The Hyder district at the head of the Portland Canal in southeastern Alaska is about 750 miles north of Seattle, Wash. The recovery of gold and silver from Riverside, the only productive mine in the district, continued intermittently from 1925 to 1929, and many claims were staked nearby. With the high prices of tungsten prevailing during World War II, the Riverside was reopened to mine tungsten ore in 1941. During 1941–46, about 3,000 units (60,000 pounds) of WO_3 was produced. During 1947–51 the mine was primarily a producer of sulfide concentrates containing lead, copper, zinc, silver, and gold.

The tungsten mineral, scheelite, is in quartz sulfide veins in the Texas Creek granodiorite of Jurassic or Cretaceous age. One of the veins, the Lindeborg in the Riverside mine, is enclosed within a schist inclusion in the granodiorite, and ore shoots containing scheelite are most abundant in this vein. It is concluded that the schist inclusion was a zone of weakness at the time of mineralization and also was a favorable chemical environment for the deposition of scheelite. The Last Shot claims are on the apparent southeast extension of the Lindeborg vein, but they contain only sparse scheelite exposed in opencuts. The Fish Creek No. 2 vein of the Mountain View property is known to contain one shoot of scheelite ore and may contain others. Several other properties in the district contain scheelite-bearing quartz veins.

During the latter part of 1942 and the early part of 1943 the U. S. Bureau of Mines tested the Lindeborg vein of the Riverside mine by 4,660 feet of diamond drilling and by analyses of 93 ore samples. In 1944 the Bureau extended the lower drift for 180 feet on the Fish Creek No. 2 vein of the Mountain View property and analyzed 70 channel samples taken across the vein. On the basis of these analyses the average grade of tungsten ore shoots on the Riverside and Mountain View properties is slightly greater than 1 percent of WO_3.

Much of the best ore has already been mined at the Riverside property; additional tungsten ore shoots of slightly lower grade than those already mined will probably be found at the depth and in the southeastern part of the vein. On the Mountain View property, the possibility of discovering additional ore shoots comparable in grade to the one now exposed is regarded as good.

INTRODUCTION

The Hyder district (fig. 15) is largely in the Salmon River drainage basin at the head of Portland Canal in southeastern Alaska. The district has 22 miles of graded gravel road, connecting with roads in

British Columbia to the towns of Premier and Stewart, both within 2 miles of the international boundary. Premier is 13 miles by road north of Hyder. Stewart, with a population of 446 in 1950, has

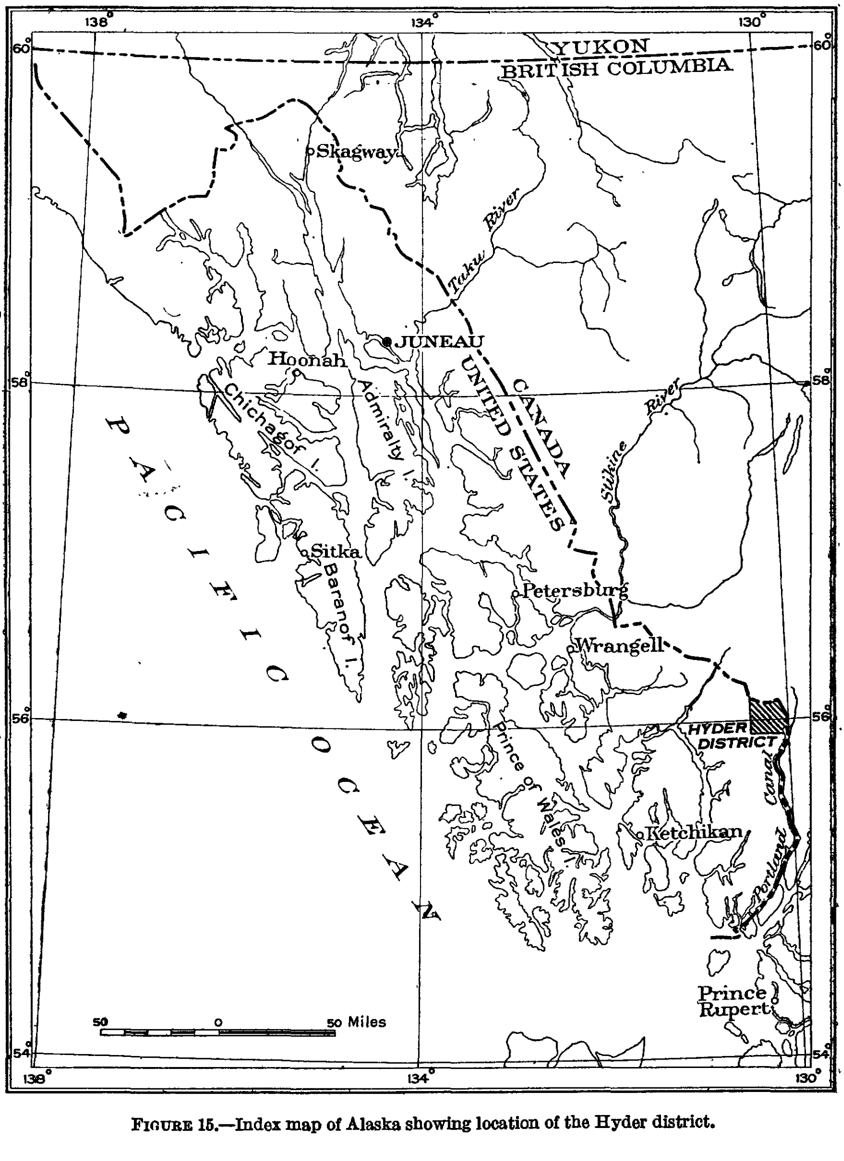

FIGURE 15.—Index map of Alaska showing location of the Hyder district.

adequate dock facilities within 1 mile of Hyder. In 1950 Hyder had 72 inhabitants.

Many claims were located from 1922 to 1929 during the peak of mining activity in the Hyder district. At that time the gold and silver content of the base-metal concentrates was of primary interest, although the tungsten mineral, scheelite, was known to be present in some of the ores. On plate 13 all except one of the claims known to contain scheelite are shown. From 1930 to 1940 there was no mining in the Hyder district. In 1940 the J. H. Scott Co. of San Francisco purchased the Riverside mine, the only productive mine in the district, from H. C. Strong and J. C. Black, of Seattle, and began development work.

Owing to the high unit value of tungsten prevailing just before and during World War II, the milling procedure was modified to produce byproduct scheelite in 1941. About 3,000 units (60,000 pounds) of WO_3 was recovered during the period 1941–46. Subsequently, however, the mine has been primarily a producer of lead-zinc-copper concentrates.

The senior writer worked in the district from June 3, 1942, to February 6, 1943. He was assisted by H. R. Gault until July 1, 1942, and by Clyde Wahrhaftig from August 12 to December 4, 1942. From October 27, 1942, to February 6, 1943, the U. S. Bureau of Mines diamond drilled, sampled, and drove an exploratory raise at the Riverside mine and sampled the Mountain View mine.[1] In the summer of 1944 the Bureau extended to the northwest the Skookum tunnel drift in the Mountain View mine. When the drift was stopped on October 24, 1944, it had been extended 180 feet to the position shown on plate 18.[2]

In September 1951, the junior author and Robert L. Thorne, of the Bureau of Mines, spent 8 days in the district and reexamined the Riverside mine and Last Shot claims. Considerable mining and underground exploration were done at the Riverside mine during 1943–51, and a résumé is included in the present report. The junior author is primarily responsible for collecting data covering the period 1943–51 and for the description of the Last Shot claims.

Thomas Evans, Holger Johnson, Arthur Moa, and Sidney Anderson, of Hyder, assisted in the fieldwork. James Langdon, of the J. H. Scott Co., helped the junior author during his examination and made available all the reports of the company pertaining to the Riverside mine.

GENERAL GEOLOGY

A comprehensive report on the general geology of the Hyder district was prepared by Buddington[3] and published in 1929. From that

[1] Thorne, R. L., and others, 1948, Tungsten deposits in Alaska: U. S. Bur. Mines Rept. Inv. 4174, p. 40.
[2] Idem., p. 47.
[3] Buddington, A. F., 1929, Geology of Hyder and vicinity, southeastern Alaska: U. S. Geol. Survey Bull. 807, 124 p.

report many of the general statements regarding the geology have been abstracted.

The oldest rocks of the district compose the Hazelton group, of Jurassic(?) age, and include greenstone schist, tuff, volcanic breccia, graywacke, slate, argillite, and quartzite. These rocks crop out abundantly between Salmon River and the international boundary. In general they strike west, but many exceptions to this general strike are seen, particularly near intrusive bodies.

The rocks of the Hazelton group are intruded by plutonic rocks of the Coast Range batholith, which are thought to be of Jurassic or Cretaceous age. The Texas Creek granodiorite, which forms a small batholith confined chiefly to the central portion of the district, is the oldest of the several Coast Range intrusives in the district. It is intimately and probably genetically related to most of the mineral deposits. Elongate bodies of sheared greenstone schist and argillite of the Hazelton group, up to at least 100 feet wide and 2,000 feet long, are included in the Texas Creek granodiorite. The largest known of these inclusions constitutes the Lindeborg shear zone at the Riverside mine.

Younger Coast Range intrusives include the Hyder quartz monzonite and the Boundary granodiorite. Granodiorite porphyry dikes, 10 to 1,000 feet wide and related to the Hyder quartz monzonite, intrude the Texas Creek granodiorite and cut some of the scheelite-bearing veins. Dikes of granite aplite, granite pegmatite, malchite, and lamprophyre cut all the batholith intrusives, the rocks of the Hazelton group, and the veins.

Veins and dikes are displaced by faults, such as the two faults followed roughly by Fish and Skookum Creeks (pl. 13). These two faults dip steeply westward. They have zones of gouge and breccia as much as 30 feet wide.

TUNGSTEN DEPOSITS

DISTRIBUTION

Most of the scheelite known in the Hyder district is on the east side of the valley of Salmon River in an area about 1½ miles wide and 3 miles long, which begins 5½ miles north of Hyder (pl. 13). Scheelite is known to be abundant in this area only on the Riverside and the Mountain View properties.

The scheelite-bearing deposits are mineralized shoots in quartz veins that cut the Texas Creek granodiorite and inclusions of the rocks of the Hazelton group in the granodiorite. Most of the veins strike N. 40°–60° W. and dip 50° to 80° NE. The veins, therefore, are at an angle to the gneissic banding of the Texas Creek granodiorite, which in general strikes N. 85° E. and dips steeply northward. The scheelite-bearing veins are as much as 7 feet thick.

The ore minerals include scheelite, galena, pyrite, tetrahedrite, pyrrhotite, chalcopyrite, sphalerite, and native gold. Galena and pyrite are present in nearly all the veins, and in some veins pyrrhotite makes up a notable part of the sulfide minerals. Sphalerite and chalcopyrite are present as accessory minerals in nearly all the veins, and small amounts of tetrahedrite and native gold occur in many of them. The principal gangue mineral is quartz; minor amounts of calcite, ankerite, and barite are also found.

Scheelite in small, sparsely distributed crystals is known in a few deposits in the Hyder district and in adjacent British Columbia outside the 1½ by 3-mile area described. A little scheelite [4] has been recognized in a vein on the Engineer group about 6 miles northwest of the Riverside mine. In the Hazelton group in British Columbia, between 4 and 6 miles southeast of the Mountain View property, scheelite has been recognized in two replacement deposits and in a quartz vein containing tetrahedrite (W. H. Mathews, 1942, personal communication).

LOCALIZATION OF THE TUNGSTEN DEPOSITS

The localization of the richer scheelite-bearing veins in the Hyder district has probably been controlled principally by the presence of schist inclusions in the Texas Creek granodiorite. According to this hypothesis, the schist inclusions not only constituted a zone of weakness along which fissuring took place but also contained calcareous bands that favored deposition of the scheelite.

No veins containing scheelite ore bodies are known in the main rock mass of the Hazelton group surrounding the Texas Creek granodiorite, probably because the Hazelton rocks, which are mainly altered tuffs, were not capable of retaining open fissures during the time that mineralization was taking place elsewhere. Nearly all the scheelite-bearing quartz veins occur in the Texas Creek granodiorite near its contact with the Hazelton rocks. The Fish Creek No. 2 vein on the Mountain View property is within the granodiorite and contains scheelite in greater abundance than other veins that are entirely within granodiorite. However, it is probable that scheelite was deposited in somewhat greater abundance in this vein, because schist inclusions, such as the one exposed in a pit on the surface along the vein fissure (pl. 18, inset 1), provided a more favorable chemical environment for the deposition of scheelite than veins lacking such schist inclusions.

[4] Buddington, A. F., op. cit., p. 110.

The Lindeborg vein of the Riverside mine contains conclusive evidence of the effect of a schist inclusion on the deposition of scheelite. This vein is enclosed within schist (pls. 14 and 15), and it contains several scheelite ore bodies, which apparently are associated with certain zones within the schist. The vein is complex because it is in part a fissure filling and in part a replacement vein. The part that is fissure filling resembles in texture and mineral content those veins, such as the Fish Creek No. 2 vein, which occur in granodiorite. In the typical fissure-filling vein type, large crystals of scheelite, several inches across, occur in veins of white quartz. The deposition of scheelite was probably brought about by calcareous schist in the wall rock nearby. In the Fairbanks district, Alaska, the quartz veins almost invariably contain scheelite in places where the quartz veins are near or adjacent to calcareous wall rock. A similar explanation is suggested for the deposition of scheelite in parts of the Lindeborg and Fish Creek veins of the Hyder district.

The part of the Lindeborg vein that probably was formed by the replacement of schist contains quartz with stringy bands of fine-grained scheelite parallel to the schistosity. The scheelite apparently has selectively replaced some of the thin schist laminae that contained calcite. In the hanging-wall stope (pls. 15 and 16) of the Riverside mine and elsewhere, epidote is a common mineral of the gangue. Inasmuch as both scheelite and epidote are common replacement minerals in calcareous rocks, it is inferred that in the Hyder district these minerals were deposited near or in calcareous bands in schist.

The order of deposition of the vein minerals in scheelite-bearing veins has been studied by Jewell [5] and the present authors. Most of the fine-grained scheelite-epidote-quartz replacement aggregate is fractured and cut by veinlets containing all the sulfide minerals in addition to quartz and a little scheelite. Hence, the periods of deposition of scheelite and part of the sulfide minerals appear to have overlapped slightly in the second period of ore mineralization. The large masses of barren quartz exposed on the Riverside, Mountain View, and other properties were probably deposited at a still later period than the deposition of the sulfides and scheelite, for, in the upper level of the Riverside mine, stringers of barren quartz cut across both sulfides and scheelite in the Lindeborg vein. However, sulfide veinlets in the Last Shot claim (pl. 13) cut large barren quartz pods, similar to those on the Riverside property. Similar relations between sulfide veinlets and barren quartz have also been observed on the Olympia Extension vein on the Last Chance group (Clyde Wahrhaftig, 1952, personal communication). Thus, a sulfide min-

[5] Jewell, W. B., 1927, Mineral deposits of the Hyder district, southeastern Alaska: Econ. Geology, v. 22, p. 494-517.

eralization occurred after the introduction of barren quartz in some of the veins that carry a little scheelite.

MINES AND PROSPECTS

RIVERSIDE MINE

The Riverside mine is 7 miles north of Hyder and is on the east side of the Salmon River road. Slightly more than 1 mile of underground workings are now accessible on several levels, of which about 3,000 feet are in the Lindeborg vein, the principal vein in the mine (pls. 14 and 15). A mill, with a capacity in 1951 of 25 to 30 tons per day, and living accommodations for about 20 men are on the property.

PRODUCTION

The production data recorded for the period 1925–50 are given in table 1. In 1925, 105 tons of concentrates were produced from ore mined from the Cross vein stopes. Subsequent production has come from the Lindeborg vein. Scheelite is reported in the ore mined during 1927 but was not recovered.

TABLE 1.—*Recorded production of the Riverside mine*

[From records of the Bureau of Mines and Geological Survey and information furnished by J. H. Scott Co.]

Year	Ore milled (tons)	Au (ounces)	Ag (ounces)	Cu (pounds)	Pb (pounds)	WO_3 (units) [1]	Zn (pounds)
1925	[2] 105						
1927	6, 500	419. 5	15, 210	none	460, 200		
1941	3, 368					1, 320	
1942	1, 381	23	830	none	29, 000	372	
1943							
1944						976	
1945	1, 300	(3)	(3)	(3)	(3)	(3)	(3)
1946	1, 819	70	6, 996	4, 000	230, 000	415	
1947	5, 064	697	22, 284	24, 000	510, 000	(4)	
1948	4, 005	736	25, 290	28, 000	634, 000	(4)	2, 100
1949	2, 100	151	3, 500	7, 700	97, 000	(4)	3, 800
1950	3, 500	356	12, 700	12, 000	298, 000	99	12, 000
Total	29, 142	2, 452. 5	86, 810	75, 700	2, 258, 200	3, 500	17, 900

[1] A unit is 20 lb. of WO_3.
[2] Tons concentrate, grade unreported.
[3] Not reported.
[4] Small quantities of tungsten concentrates produced, according to Minerals Yearbook, 1947–49.

GEOLOGY

The main geologic feature of the Riverside mine is the Lindeborg shear zone (pls. 14, 15, and 16), an elongate sheared inclusion of schist and argillite in the Texas Creek granodiorite. Tongues of the granodiorite have been intruded into the schist parallel to the schistosity.

The zone strikes N. 45°–55° W. and dips steeply northward. It is exposed for about 2,000 feet along its strike and through a vertical interval of more than 700 feet. Toward the southeast end of its outcrop the shear zone splits and probably pinches out within a short distance. To the northwest the zone extends beneath the Salmon River alluvium. The extent of the zone downward is of economic significance, if, as seems probable, calcareous schist in the zone has caused the precipitation of scheelite. The zone is at least 80 feet thick on the mill level at an altitude of 320 feet (pl. 15) and more than 100 feet thick along the Salmon River road and in drill holes S1 and S2 (pl. 14). Thus the zone does not diminish in thickness downward through its exposed vertical extent.

The Lindeborg shear zone is essentially a well-foliated schist inclusion along which some movement has taken place parallel to the foliation. The principal fault is now occupied by the Lindeborg vein; some movement has taken place along this fault since the emplacement of the vein. The schistosity of the metamorphic rocks of the Lindeborg shear zone is approximately parallel to the zone. The shear zone has within it no persistent stratigraphic or structural units other than the Lindeborg vein. The schist wall rock of the Lindeborg has been altered to sericite, quartz, and minor amounts of calcite and epidote.

A granodiorite porphyry dike and a smaller branch from it are exposed on the surface and in the underground workings, and are penetrated by some of the diamond-drill holes. The large main dike strikes about N. 10° W. and dips west (pls. 13 and 14). This dike probably cuts the Lindeborg vein a short distance southeast of the face of the upper level drift (pl. 16). The smaller branch dike strikes about N. 40° W. and dips steeply southward at the surface (pl. 14). At depth it encounters the Lindeborg shear zone, where its dip is reversed to steeply northward parallel to the schistosity.

Thin lamprophyre dikes strike generally parallel to the schistosity of the shear zone. Malchite dikes cut the shear zone approximately in the middle of its exposed length (pls. 13, 14, and 15). A postmineral fault along the Lindeborg vein has displaced the malchite dikes about 20 feet horizontally (pls. 14 and 15). The pitch of striations and the displacement of the dikes indicate that the hanging wall shifted about 28 feet, 45 degrees downward to the southeast. An attempt was made to trace this fault southeast of the malchite dikes along the vein, but within 100 feet the displacement is taken up along numerous small parallel faults, none of which could be traced more than 50 feet.

VEINS

The Lindeborg shear zone contains the Lindeborg vein, which is not a single continuous vein but a mineralized zone containing discontinuous mineralized quartz veins and stringers. This vein or mineralized zone is generally nearer the footwall of the shear zone (pls. 14 and 15). The vein in its leaner portions consists of pyritized schist or of quartz stringers in a network as much as 6 feet wide with sparse grains of scheelite and sulfide minerals. The large elongate mass of quartz that crops out just below the upper tunnel adits (pl. 14) is barren of scheelite and is probably younger than the scheelite mineralization. The richer portions consist of a quartz vein as much as 7 feet thick, which contains sulfide minerals and scheelite. Below an altitude of about 500 feet the Lindeborg vein splits downward (sections, pl. 16). The separate vein segments just below the split are narrower than the vein above. At the mill level (altitude 320 feet), however, two vein segments are less than 8 feet apart (pl. 15), and they may represent a further branching of the footwall vein observed on the intermediate level. At the face of the northwest drift (altitude 320 feet) the hanging-wall part of the vein contains a scheelite ore shoot, and a large shoot of scheelite-bearing ore formerly occupied the large empty stope just above the northwest drift. Thus it would appear that the Lindeborg vein or vein segments may continue to contain scheelite shoots with depth if, as seems probable, calcareous layers in the Lindeborg zone appear to have caused precipitation of the scheelite.

Other veins in the mine include the Cross and Ickis (also called the Riverview) veins, which are in Texas Creek granodiorite (pl. 15). The Cross vein, exposed on the mill level for 750 feet, has produced sulfide ore but contains only rare grains of scheelite. The Ickis vein, exposed in the mill level for about 260 feet, contains a few scheelite crystals within 100 feet of the portal. No production has come from the Ickis vein. The sparse quantities of scheelite in the Cross and Ickis veins, which are entirely within the Texas Creek granodiorite, provide negative evidence that scheelite in commercial quantities has been precipitated by calcareous bands in the Lindeborg shear zone.

ORE BODIES

At least five scheelite ore bodies, all of which are partly or entirely mined out, are known in the Lindeborg vein. The largest ore body, the extent of which has been determined mainly by diamond drilling, extends about 60 feet northwest and 90 feet southeast of the east raise on the upper level (pls. 16 and 17) and nearly 200 feet above and possibly as much as 100 feet below the level. Approximately one-half of this ore body was removed during 1945–50. The ore body dips northeastward, steepening from 50° or 60° at the top of the east raise to about 70° at the floor of the upper level, and appears to rake southeastward. It is here called the east ore body, in accordance with the usage of the U. S. Bureau of Mines. Judging from the exposures in the upper level, in the east raise, and from diamond-drill cores, both scheelite and galena are more abundant in the upper part of the ore body, 50 to 150 feet above the upper level. The inferred outline of the east ore body shown on plate 16 contains some barren portions, and the vein within this body ranges in thickness from about half a foot to slightly more than 7 feet.

A second ore body, which was opened by the footwall, hanging-wall, and intermediate level stopes (pl. 16), was nearly mined out during 1941. The lean margin of this ore body is partly exposed between the intermediate level and the hanging-wall stopes and in the back of the intermediate level stope (pl. 16). Fifteen feet above the intermediate level the ore body splits downward (section *B–B′*, pl. 16). It is reported that the quartz vein was 2 to 3 feet thick at the intermediate level and thinned to about 1 foot in the footwall and hanging-wall stopes. In several large specimens of the mined-out vein the scheelite is segregated in a nearly solid band, 2 to 4 inches thick, in quartz. In several other ore specimens from this body small grains of epidote were observed in the gangue.

The ore that was removed from the overhead and underhand stopes near the face of the northwest drift and the ore now assumed to be present beneath the underhand stope is referred to as the west ore body (section *A–A′*, pl. 16), in accordance with the Bureau of Mines usage. The ore body is a white vitreous quartz vein containing large crystals of scheelite as much as several inches across, with pyrite and barite. The vein is from ½ to 3½ feet thick, but it has an average thickness of 2½ feet. It extends for 33 feet in the bottom of the underhand stope and is exposed for several more feet to the northwest in the northwest drift. Drill hole S1 penetrated barren schist 50 feet below the ore body.

A fourth scheelite ore body is shown by the scheelite exposed in the pillars between the lower sublevel of the upper level and the upper tunnel level (pl. 17). The probable shape of the original body in longitudinal projection is an ellipse whose axes are 80 by 125 feet. The vein containing the scheelite ore ranges in thickness from 1 foot to 4 feet; its average thickness is about 3 feet. About 50 percent of this body remains; it appears to rake southeast. The barren portions of the ore body may aggregate 50 percent of the total volume. It seems that very little of the scheelite in this ore body was recovered because the ore was milled primarily for lead, gold, silver, and copper. This ore body is designated the upper sublevel ore body of the upper level in accordance with local usage.

A fifth ore body herein called the upper stope body of the upper tunnel level is suggested by the scheelite exposures in the upper stope of the upper tunnel level (pl. 17). The vein in the opencuts above (pls. 14, 16, and 17) contains a veinlet of solid galena and sparse scheelite, which may be the lean extension of this body. The southeast limit of this body has not been determined, but, judging from the dimension of the other scheelite bodies in the mine, it probably does not extend more than 50 to 60 feet beyond the southeast heading in the stope. Exposures are insufficient to define this body; hence it is inferred as an ellipse (pl. 17) with a surface cutoff midway between the underground ore and the sparse scheelite in the opencuts above. The scheelite in this ore body occurs as narrow high-grade bands in white quartz. Little of the scheelite from this ore body was recovered, because the mine was under lease during the mining of the upper stope of the upper tunnel level, and the lessees milled the ore primarily for lead, silver, and gold. Some scheelite-bearing quartz was hand sorted from the lead ore and thrown on the dumps.

In addition to the principal known scheelite-bearing bodies it is probable that the sulfide ore mined in 1927 from the large stope above the northwest drift (pl. 16) contained considerable scheelite. Scheelite-bearing quartz is exposed in many places about the margins of the stope. It has been reported by local miners that a heavy white mineral, presumably scheelite, was observed on the mill tables in 1927 but was not recovered.

TENOR OF THE LINDEBORG VEIN

The Lindeborg vein in the Lindeborg shear zone has been tested by 41 drill-hole samples and 52 channel samples taken by the U. S. Bureau of Mines. The east and west ore bodies (sections *D–D′* and *A–A′*, pl. 16) have been sampled more extensively than the others. Vein samples containing WO_3 have also been taken outside the known ore bodies in the mine.

The diamond drilling, totaling 4,660 feet, consisted of 37 holes that were started from underground stations and 4 holes that were started from stations on the surface. Analyses were made of 36 samples of scheelite-bearing drill cores and 47 sludge samples. In most of the drill holes the core recovery was 95 percent or more. Sludge analyses that are lower than the corresponding core analyses are not considered in the computation of grade in the present report. Sludge analyses from 3 drill holes (holes M2, M32, and M34) in which core was lost are included. The data from the drill cores obtained by the Bureau of Mines are summarized in table 2. Data from 16 drill cores that contain no scheelite are omitted from the table. Cores from drill holes S3 and M18 were also analyzed for other metals by the Bureau and the results of these analyses are given in table 3.

The location and WO_3 content of the 52 channel samples taken by the Bureau of Mines are shown on plate 16. These data are supplemented by one analysis of a channel sample taken by the Geological Survey. The calculated average WO_3 content of selected parts of the ore bodies is shown on plate 16 by bracketing the samples included in the average.

TABLE 2.—*Drill-hole data, Riverside mine*

[Data from U. S. Bureau of Mines]

Drill-hole no.	Depth of sample in hole (feet)	Distance sampled (feet)	Percent of WO_3	Total distance sampled (feet)	Estimated angle, hole to vein	Calculated vein thickness	Weighted average percent of WO_3
S2	260.5–260.7	0.2	0.40	0.2	80°	0.2	0.40
S3	421.0–423.0	2.0	.15				
	423.0–425.0	2.0	7.70	6.3	80°	6.1	2.60
	425.0–427.3	2.3	.30				
S4	299.0–299.3	.3	.25				
	299.3–301.8	2.5	None	3.0	80°	2.9	.04
	301.8–302.0	.2	.16				
M2	54.0–59.5	5.5	.67 .15	5.5	65°	5.0	1.20
	73.0–73.4	.4	1.12	.4	65°	.4	1.12
M6	7.4–7.6	.2	.04	.2	80°	.2	.04
M7	4.8–6.0	1.2	.11	1.2	80°	1.2	.11
M8	7.7–7.9	.2	.50	.2	80°	.2	.50
M10	7.5–7.7	.2	.28	.2	70°	.2	.28
M15	59.0–61.0	2.0	.57	2.0	50°	1.5	.57
M16	57.5–60.3	2.8	.05	4.5	45°	3.0	.04
	60.3–62.0	1.7	.03				
M17	74.5–78.0	3.5	1.43	7.7	30°	3.8	.76
	78.0–82.2	4.2	.20				
M18	88.5–94.8	6.3	.05				
	94.8–97.6	2.8	.03				
	97.6–100.0	2.4	.15	21.3	17°	6.2	1.68
	100.0–103.0	3.0	8.30				
	103.0–106.2	3.2	1.23				
	106.2–109.8	3.6	1.78				
M19	90.7–93.0	2.3	.67				
	93.0–97.4	4.4	.03				
	97.4–98.8	1.4	.04				
	98.8–101.0	2.2	.03	16.3	26°	7.3	.14
	101.0–106.0	5.0	.03				
	106.0–107.0	1.0	.03				
M21	3.4–3.5	.1	.61	.1	60°	.1	.61
M25	36.6–37.2	.6	.20	.6	70°	.6	.20
M28	82.5–86.0	3.5	1.18	3.5	27°	1.6	1.18
	105.0–105.4	.4	.80	.4	27°	.2	.80
M29	128.0–135.2	7.2	.03	7.2	17°	2.3	.03
M32 [2]	20.0–25.0	5.0	.05	5.0	50°	3.8	.05
M33	40.4–41.0	.6	.05	.6	30°	.3	.05
M34 [2]	30.0–35.0	5.0	.03	10.0	30°	5.0	.04
	35.0–40.0	5.0	.04				
M36	35.5–38.0	2.5	.10	2.5	5°	.3	.10

[1] Combined core and sludge analysis.
[2] Sludge analysis.

TABLE 3.—*Partial analyses of vein cores from drill holes S3 and M18, Lindeborg vein*

[Data from U. S. Bureau of Mines]

Drill-hole no.	Lead (percent)	Copper (percent)	Silver (oz per ton)	Gold (oz per ton)
S3	4.05			
M18	3.58	None	4.79	0.017

Only a generalized statement of grade is justified, because the grade ranges widely and changes abruptly and because the locations of the numerous drill-holes are not evenly distributed throughout the ore bodies. The ore in the east ore body above the upper level, according to a weighted average, contains slightly more than 1 percent of WO_3, and ore below the upper level averages slightly less than 1 percent of WO_3; therefore an average grade of about 1 percent of WO_3 is indicated for the entire body as outlined on section *D–D′* of plate 16. The average grade of ore samples from the west ore body is computed from the 9 channel samples taken in the bottom of the underhand stope of the northwest drift (section *A–A′*). The samples average 1.3 percent of WO_3 across an average vein thickness of 2.4 feet and along an exposed strike length of 36 feet.

SUGGESTIONS FOR FURTHER EXPLORATION

The scheelite ore in the east ore body can probably be recovered during continued mining of the sulfide ore, which has been the principal product of the Riverside mine. A raise from the end or a slight extension of the southeast drift of the mill level could be expected to intersect the bottom of the east ore body indicated by the Bureau of Mines drilling (pl. 16). Below an altitude of about 480 feet, two veins are present. Hence a sublevel along the Lindeborg vein at 475 feet, slightly below the split, would explore the most potentially productive part of the vein between the upper level and the southeast drift of the mill level.

The prospects of discovering an additional scheelite ore body or bodies in the part of the vein southeast of the workings above the upper level (pl. 17) is regarded as fair. The upper tunnel level and the lower sublevel of the upper level each could be extended southeast for a few hundred feet to the intersection of the postmineral granodiorite porphyry dike with the vein. On the basis of surface mapping (pls. 13 and 14), however, the Lindeborg shear zone decreases considerably in thickness southeast of the opencuts. Therefore, if the Lindeborg shear zone localized the scheelite ore shoots already discovered in the Riverside mine, any ore bodies discovered southeast of the present workings are likely to be smaller and lower grade.

The finding of additional ore shoots in the Lindeborg vein below the mill level is regarded as speculative, for the Lindeborg vein may further split downward; moreover four of the five drill holes that intersected the vein below the mill level did not contain scheelite. The width and grade of the vein below the mill level could be further tested by drilling several diamond-drill holes from surface stations near the Salmon River road (pl. 14) and from the drift of the Cross vein south of its intersection with the Lindeborg shear zone (pl. 15).

The Lindeborg vein also could be explored at depth by dewatering the two winzes on the Cross vein (see composite map, pl. 15) and drilling a fan of diamond-drill holes from stations at the bottoms of the winzes, or by driving a drift on the Cross vein from the bottom of the winzes northward to the intersection of the Lindeborg vein. Such a drift would be a working drift for any possible ore discovered and would allow the gravity mining of any scheelite ore bodies discovered in the Lindeborg vein below the mill level.

LAST SHOT GROUP

The Last Shot group of 2 claims adjoins the Riverside claims on the southeast extension of the Lindeborg shear zone. An examination was made in 1951 of the adit on the southeast part of the property. (See pl. 13.)

The adit, 20 feet long, is driven east on a vein striking N. 60° W. and dipping 45° NW. The vein in the center of the adit consists of as much as 18 inches of massive galena, pyrite, and chalcopyrite. The hanging wall is a silicified talcose schist that contains a few scattered grains of scheelite through a thickness of about 3 feet adjacent to the sulfide vein. The footwall is dense quartz with scattered pyrite. The schist is a small remnant in a massive quartz pod similar to but much larger than the quartz pod between the upper level and the upper tunnel level at the Riverside mine. Twenty feet southeast of the drift, the vein continues into this quartz pod with galena and chalcopyrite as much as 8 inches wide. A small reverse fault striking N. 10° E. and dipping 80° N. displaces the vein about 8 inches. An analysis by the Bureau of Mines of a channel sample 26 inches long across the slant width of the sulfide vein is as follows: gold, 0.08 ounce per ton; silver, 11.3 ounces per ton; 6.2 percent of lead; and 4.85 percent of copper.

The northwest extension of the vein is traced on the surface 200 yards by 4 opencuts. Three of the cuts contain galena, pyrite, and chalcopyrite in a vein at least 8 inches wide. The similarity of the mineral aggregate in the vein to the Riverside sulfide ores, and its apparent location on the same shear zone, suggests the possibility that scheelite ore bodies may also be found on the Last Shot group of claims as far southeast as the adit. However, no great thickness of schist, analogous to the Lindeborg shear zone, is associated with the Last Shot vein. Hence, it is believed unlikely that scheelite ore bodies, comparable in grade to those in the Riverside mine, will be discovered, although sulfide ore bodies may well be present.

MOUNTAIN VIEW MINE

The Mountain View mine is 5½ miles north of Hyder between Fish and Skookum Creeks (pl. 13). The property has been described by Buddington [6] who recognized scheelite in one of the veins. From 1925 to 1929 a total of 3,600 feet of tunnels were driven at the Mountain View mine. Of these workings, 3,500 feet are on the Skookum tunnel level at an altitude of 540 feet (pl. 18). Buildings on the property consist of a bunkhouse for 12 men, a water-wheel powerhouse, and several small sheds for storage of equipment. The mine is principally in Texas Creek granodiorite within a few hundred feet west of the contact with the main body of rocks of the Hazelton group (pl. 13).

The only vein that contains scheelite is the Fish Creek No. 2 or "Gray Copper" vein (pl. 18), which is wholly within the Texas Creek granodiorite, except for small schist inclusions of the Hazelton group along the footwall (pl. 18, inset 1). The vein strikes N. 45° W. and dips 50° N. It is exposed on the surface for 480 feet by several opencuts and in shallow underground workings by a 50-foot shaft and a 60-foot drift. Pits to the southeast that were dug on the surface along the projected trend of the vein do not reach bedrock. In the Skookum tunnel drift the vein has been followed for 300 feet.

The principal ore minerals in the Fish Creek No. 2 vein are pyrite, pyrrhotite, and scheelite with some chalcopyrite, galena, and a little sphalerite, tetrahedrite, and freibergite. The gangue is mostly quartz with a little barite. The vein also carries some gold and silver.

The following average grade estimates are based on sampling data by Aner W. Erickson, of the U. S. Bureau of Mines.[7] In 1944 the northwest drift of the Skookum tunnel was extended by the Bureau for 180 feet, and 43 channel samples were taken underground on the Fish Creek No. 2 ("Gray Copper") vein (pl. 18, inset 4). The weighted average WO_3 content of these 43 channel samples is 1.23 percent across an average vein width of 1.4 feet and along a strike length of 130 feet. As analyzed by the Bureau,[8] this ore also averages 0.1 and 6.4 ounces per ton of gold and silver, respectively. The Bureau also took 27 samples [9] of scheelite-bearing portions of the vein in the upper tunnel drift and in the surface exposures (pl. 18). The scheelite-bearing portion of the vein in the upper drift and in the surface cuts above the drift (pl. 18, inset 2) contains a weighted average of 0.15 percent of WO_3 across an average width of 1.9 feet and along a strike length of 60 feet. Channel samples across the vein in other surface exposures contain as much as 3.93 percent of WO_3 (pl. 18, inset 3), but

[6] Buddington, A. F op. cit., p. 63-67.
[7] Thorne, R. L., and others, op. cit., pl. 45-48.
[8] Idem, fig. 19.
[9] Idem, figs. 17 and 20.

ore of this grade is confined to small high-grade shoots only a few feet in length.

Additional ore shoots may possibly exist in the Fish Creek No. 2 vein between the Skookum tunnel drift and the vein exposures at the surface. One possible means of exploration would be to raise on the vein from the Skookum tunnel drift to the surface. Sublevels from this raise at appropriate intervals would explore the vein along the strike. The downward extent of the ore shoot exposed in the Skookum tunnel drift could be tested by a fan of drill holes from a station at the face of the Skookum tunnel crosscut on the northeast or hanging-wall side of the vein.

FISH CREEK PROPERTY

On the Fish Creek group of claims along the east bank of Skookum Creek (pl. 13) two veins in Texas Creek granodiorite near the rocks of the Hazelton group contain sparse scheelite. At an altitude of about 1,600 feet, adit 3 has been driven southeastward for 60 feet on a quartz vein that strikes N. 35° W. and dips 65° N. The vein is 4 feet thick at the adit portal but pinches out 10 feet above it. About 20 feet in from the portal, the vein splits into a network of quartz stringers. Scheelite occurs as scattered small crystals in the quartz for 40 feet along the drift. The vein is estimated to contain less than 0.1 percent of WO_3.

According to Buddington:[10]

> about 350 feet northeast of this vein (adit No. 3) * * * is another vein, which has been prospected by three adits (Nos. 4, 5, and 6) at altitudes of about 1,930, 1,900, and 1,800 feet, with lengths of 60, 109, and 185 feet, respectively. The vein strikes N. 50° W. and dips 45°–50° NE. Its width at the portals of the three adits is 19, 24, and 15 inches. A raise connects the middle and upper adits, and the vein has been partly stoped for 30 feet above the upper adit. In these upper workings it averages less than a foot in thickness but contains shoots of ore up to the full width.
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> * * * * * * *
>
> The visible sulphides comprise galena and pyrite with tetrahedrite, sphalerite, and a little chalcopyrite.

The adits are mostly in granodiorite, but near their faces a fault separates the granodiorite from rocks of the Hazelton group and cuts off the veins. Minor amounts of scheelite are in the vein in all the adits. Adits 4 and 6 expose only sparse grains, but in the first 40 feet of adit 5 a 3-inch quartz-scheelite stringer is next to the quartz sulfide vein. This stringer is estimated to average between 1 to 2 percent of WO_3 for about 20 feet along the strike. The scheelite is in distinct crystals as much as 1 inch across. From 40 to 80 feet in from the portal the scheelite is sparse, and the stringer probably contains less than 0.1 percent of WO_3.

[10] Buddington, A. F., op. cit., p. 69.

LAST CHANCE GROUP

The Last Chance group (pl. 13) is on the ridge between Skookum Creek and Salmon River at an altitude between 2,600 and 2,900 feet and about 1 mile east of the Riverside mine. The Last Chance claims, formerly known as the Olympia Extension claims, are described by Buddington.[11] The underground workings comprise 700 feet of tunnels, a 50-foot raise, and two 50-foot winzes. The winzes are now filled with waste rock.

The vein known as the Olympia Extension, has been traced on the surface for several hundred feet by means of a series of opencuts and is exposed underground for a total distance of 180 feet along the strike in 2 drifts, which are 25 feet and 75 feet below the outcrop and 90 feet and 100 feet long, respectively. The east end of the upper drift and the west end of the lower drift are connected by the 50-foot raise. The vein in the lower drift averages 1 foot thick and contains sparsely distributed grains of scheelite for a length of 50 feet; the grade of this part of the vein is estimated to be about 0.05 percent of WO_3. In the upper drift and on the surface above the upper drift the vein is 3 to 4 feet thick and is well mineralized with galena, tetrahedrite, chalcopyrite, and sphalerite. Several small crystals of scheelite were seen in the upper drift, but examination of the surface cuts with the ultraviolet lamp failed to reveal any scheelite.

MONARCH PROSPECT

A 30-foot drift on the Monarch group of claims, has exposed a quartz veinlet containing scheelite, which may be part of the Olympia Extension vein that crops out 1,000 feet to the southeast. The veinlet, which averages 4 inches in thickness, is exposed in the face and along the drift except for a short interval 10 feet from the face. It is estimated to range in grade from 0.5 to 3.0 percent of WO_3 throughout its exposed length. A surface cut on a fissured zone above the drift failed to show any scheelite when examined with the ultraviolet lamp.

BLUEBIRD PROSPECT

In October 1942, the Bluebird claim (pl. 13) was located by Arthur O. Moa. Only hand specimens of the ore were examined. It is reported to be in the Texas Creek granodiorite about 1,500 feet west of rocks belonging to the Hazelton group and at an altitude of about 2,300 feet. According to Mr. Moa, the vein is exposed for only a few feet and is 4 inches wide. It contains quartz with sparsely disseminated pyrite, chalcopyrite, galena, and scheelite in the central

[11] Buddington, A. F., op. cit., p. 69–71.

part; molybednite is present along its walls. Three hand specimens of the vein were estimated to contain about 0.5 percent of WO_3.

OTHER PROSPECTS

Scheelite occurring as rare grains was observed on the Brigadier (Hyder Butte), Liberty, Bear (Lucky Boy Extension), Alaska-Premier (south workings only), and Engineer prospects. The latter is outside the area shown on plate 13. Search with an ultraviolet lamp failed to reveal scheelite on the Helen (Howard), Six Mile, Cantu, Hyder Skookum, Titan, Cripple Creek, Daly-Alaska, 96, Texas Discovery, Hyder Lead, Morning, Lake, Blasher, Edelweiss, and Jumbo prospects. Many of these are outside the area shown on plate 13.

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