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SILVER, LEAD, AND ZINC

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SILVER, LEAD, AND ZINC.

Practically all the gold deposits and many of the copper deposits carry more or less silver. Galena, as has been shown, is not uncommon as an accessory mineral in these deposits. There are also some lodes in Alaska which are regarded as valuable because of their silver and lead contents. These nearly always carry also some subordinate gold values. Argentiferous galena-bearing fissure veins[1] have been developed on the south arm of Cholmondeley Sound--an indentation on the east side of Prince of Wales Island, in the Ketchikan district. These veins cut across both schists and limestone. According to the Wrights, where they crosscut the limestones they are replacement deposits. These veins carry galena, with a small amount of chalcopyrite and sphalerite, in a gangue of quartz, siderite, and calcite. Another group of galena deposits occurs about 12 miles east of Wrangell, in southeastern Alaska.[2] Here there is a slate-schist belt about a mile wide lying between granite areas. These altered sediments are traversed by acidic porphyry and aplite dikes, and in these or along the contacts the galena deposits occur. The deposits are fissure veins, which appear to be persistent. They are heavily mineralized with galena, sphalerite, pyrite, and chalcopyrite.

Some galena deposits[3] have also been opened on Coronation Island, which lies near the entrance to Chatham Strait, in southeastern Alaska. The bedrock of the island, so far as known, consists of Paleozoic limestones

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[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, pp. 187-188.

[2] Idem, pp. 188-190.

[3] Idem, pp. 190-191.

and schists, which have been intruded by granite. The ore deposits are irregular masses within a limestone country rock. Besides the galena, tetrahedrite and sphalerite are present in the ores.

Among the many localities where galena ore deposits have been found in Alaska, that in the Fish River basin, in the eastern part of Seward Peninsula, deserves mention. One of the first attempts at lode mining in Alaska was at this locality, at the Omilak mine, in 1882. According to Smith and Eakin,[1] the country rock consists of crystalline limestone and schists and also some more or less schistose igneous rocks which are classed as greenstones. The galena ores occur in a zone of fracture in the limestones, near the contact with some of the schistose greenstones. Within this zone they are irregularly distributed in masses and blebs. The galena carries gold and a large amount of silver.

Some galena deposits have also been found in the western part of Seward Peninsula, in the Lost River and Brooks Mountain regions.[2] These occur in shattered zones which traverse limestones of early Paleozoic age. Some of them are clearly contact-metamorphic deposits of granite and limestone; others are more or less intimatley associated with quartz porphyry dikes.

No deposits valuable for their zinc contents have been found in Alaska. As has been noted in the preceding pages, sphalerite is a common accessory mineral in the gold, silver, and some of the copper deposits.

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1 Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Peninsula and the Norton Bay-Nulato region: Bull. U. S. Geol Survey No. 449, 1911, pp. 130-133

2 Knopf, Adolph, The mineral deposits of the Lost River and Brooks Mountain regions of Seward Peninsual: Bull. U.S. Geol. Survey No. 345, 1908, pp. 268-271.

Excerpted From: U. S. Geological Survey Mineral Resources of Alaska, Report on Progress of Investigation in 1910. (pp. 87-88)

STRATIGRAPHY

Birch Creek Schist

Some of these veins have been traced along the surface for several hundred feet, and throughout their exposed length they maintain rather constant strike and dip. Furthermore, they are much more generously mineralized than the older, distorted veins and in places show abundant sulphides, the commonest of which are pyrite, arsenopyrite, sphalerite, galena, and stibnite. Less abundant minerals are scheelite, free sulphur, melanterite, pyrargyrite, scorodite, stephanite, stromeyerite, freibergite, bournonite, and gold, as well as antimony ochers, stibiconite, and kermesite. These veins have been extensively prospected at Mount Eielson and in the Kantishna district, where veins containing encouraging amounts of gold, silver, lead, zinc, and antimony have been found, and a considerable tonnage of ore valuable chiefly for its silver and lead content has been mined and shipped. These veins may be termed fissure veins, in contrast to the older contorted gash veins, and were formed much later than the gash veins, after the metamorphism of the inclosing schist was completed. They are believed to be of deep-seated origin and probably are genetically related to the intrusion of igneous rocks.

Some pyrite is scattered throughout the schist itself, and the oxidation of such finely disseminated pyrite no doubt yields the red and brown colors that the schist assumes on weathering.

Excerpted From: U. S. Geological Survey Mineral Resources of Alaska Report On Progress of Investigations in 1930 (p. 245)

LEAD

Lead, in several places associated with zinc or with copper, has been reported from the following localities:

At Brooks Mountain.[25]
North of Rapid River, a tributary of Lost River.[25]
On Tin Creek, a tributary of Lost River.[25]
On Kruzgamepa River, at the mouth of Iron Creek (lead and zinc.).
Northeast of Mount Bendeleben (lead and copper).
At Omalik.[26]
At the head of Steep Creek, on Mount Distin (lead and zinc.).
On Kugruk River, at the forks of Independence Creek.
On Fish River, 5 or 6 miles above the mouth of the Niukluk.[27]
On Waterfall Creek.[27]

Most of the galena discovered on the peninsula has been reported to be silver-bearing. The property on Kugruk River has been actively exploited for several years and is the best-developed silver-lead prospect on the peninsula. A considerable tonnage of high-grade ore is reported to have been mined, but no shipments have been made. This property has not been visited by a member of the Survey.

ZINC

The presence of sphalerite with galena at Mount Distin and on Kruzgamepa River has been referred to in connection with the occurrence of lead. Mertie[28] reports zinc to be present on the ridge between Penny River and the head of Oregon Creek. The ore consists of sphalerite and a little pyrite in a gangue of quartz.

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25 Knopf, Adolph, op. cit. (Bull. 358), p. 42.

26 Mendenhall, W. C., A reconnaissance of the Norton Bay region, Alaska: U. S. Geol Survey Special Pub., pp. 213-214, 1901.

27 Mertie, J. B., jr. op. cit. (Bull, 662), p. 446

28 Idem, p. 447

Excerpted From: U. S. Geological Survey Mineral Resources of Alaska, Report on Progress of Investigations in 1920 (pp. 182-183)

ZINC

Practically the only zinc mineral in southeastern Alaska is sphalerite, commonly known as zinc blende. It is usually dark brown, red, or nearly black. When examined with the microscope much of it is found to contain abundant dots or rods of chalcopyrite oriented along its cleavage planes. The sphalerite from the zinc deposits of the Groundhog Basin is reported to be the variety ~~martite~~ Marmatite with considerable iron.

Sphalerite is a common accessory mineral in the gold quartz veins of southeastern Alaska and is usually associated with sulphied bodies, including galena or chalcopyrite, where they occur in fissure veins and shear and impregnation zones. It is not an abundant constituent of the contact copper deposits and is usually present there only as an accessory mineral. At the Complex mine, between Mineral and Dora Lakes, on Kitkum Bay, Prince of Wales Island, some of the ore is essentially sphalerite, with a little chalcopyrite and galena, in a banded quartz fissure vein carrying gold and silver. Sphalerite has been found in considerable amounts at some prospects on Beaver Mountain, Prince of Wales Island. At no place in the Alexander Archipelago has sphalerite yet been mined by itself as an ore.

At the Groundhog Basin, east of Wrangell, on the mainland, extensive low-grade deposits of sphalerite with pyrrhotite and a little galena have been found as tabular replacement veins in a band of the metamorphic complex; they are discussed on page 361. Sphalerite is abundant in other metalliferous zones in this formation, and it seems highly probable that zinc will eventually be produced from bodies occurring in the Wrangell-Revillagigedo belt of metamorphic rocks.

ZINC

The extensive low-grade zinc replacement veins of the Groundhog Basin,[89] about 13 miles east by northeast of Wrangell, occur in a belt of gneiss and schist within the western border zone of the Coast Range batholith. The main vein has been traced for a length of about 3,200 feet, through a range in altitude of 1,140 feet, and has been sampled for a length of 1,800 feet. The width for the 1,800 feet sampled ranges from 1½ to 9 feet and averages about 3 feet; the average of 24 assays, each made on the full width of the vein, is approximately zinc 17 per cent, lead 2.5 per cent, silver 1.25 ounces to the ton. The metallic minerals comprise pyrrhotite and dark-brown sphalerite, with small and variable amounts of pyrite and galena. The gangue is made up largely of unreplaced remmants of the country rock and includes plagioclase, pyroxene, hornblende, epidote, quartz, and biotite. The sphalerite is reported to be a variety carrying considerable iron. The veins are of the high-temperature type and are allied to contact-metamorphic deposits in origin. Small replacement bodies of magnetite slightly earlier in age than the sulphieds are locally associated with the sulphide veins. The sulphide veins have a tabular form parallel to the banded structure of the inclosing crystalline schist and gneiss and are not located on a contact. The deposits in part replace intercalated limestone beds and in part replace injection gneiss.

89 Buddington, A. F., Mineral deposits of the Wrangell district, southeastern Alaska: U. S. Geol. Survey Bull. 739, pp. 57-63, 1922.

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On Tracy Arm, in the Juneau district, about 1 mile south of the point at the first elbow, there is a prospect known as the Neglected Prize. The vein lies within a narrow belt of injection gneiss between the quartz diorite of the western border of the Coast Range batholith and an outlying quartz diorite sill. Assays of samples from the full width in several prospect pits are reported to range from 1.5 to 4.1 per cent of copper and from 4.7 to 14.6 per cent of zinc. The sulphides predominate over the gangue and comprise pyrrhotite, sphalerite, chalcopyrite, and pyrite.

On Lynn Creek,[90] north of Vancouver, in British Columbia, in a belt of crystalline schist bordering the west side of the Coast Range batholith, a zinc body is being developed. The veins occur near the contact with quartz diorite and are tabular deposits that have replaced limestone beds. The metallic minerals comprise a large amount of sphalerite, chalcopyrite, pyrite, and pyrrhotite.

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90 Burwash, E. M. J., The geology of Vancouver and vicinity pp. 56-60, Univ. Chicago Press, 1918

Excerpted From: U. S. Geological Survey Geology and Mineral Deposits of Southeastern Alaska (pp. 361-362) (p. 328)

ZINC

General Occurrence

A mineralized belt of metamorphic rock occurs on the mainland about 14 miles east of Wrangell. This belt is 1 to 1½ miles wide and lies between two masses of quartz diorite intruded parallel to the foliation planes of the metamorphic rocks. These rocks are predominantly fine-grained gneisses and crystalline schists, with sheets and dikes of quartz porphyry, rhyolite, and diabase porphyry. Narrow aplite veins, injected parallel to the foliation planes are locally abundant, expecially toward the eastern mass of quartz diorite. The gneisses comprise interbedded dark hornblende-plagioclase gneiss and purplish-brown gneiss consisting of layers of plagioclase feldspar and quartz. Thin layers of green pyroxene granulite or of a diopsidic hornstone are found locally along some of the ore veins. In the mountain above Berg's Basin are hornblende-feldspar schist and thick beds of garnetiferous kyanitic quartz-mica schist intimately penetrated parallel to the schistosity by quartz veinlets. A few thin intercalated beds of crystalline limestone are also found here. The whole group of rocks represents a series of sedimentary strata such as calcareous shale and impure sandstone with some layers of slate and limestone which have been metamorphosed to gneiss and schist by the rise of temperature and pressure and the widely wandering highly heated solutions accompanying the intrusion of the quartz diorite, aplite veins, and porphyry sheets and dikes.

The portion of the belt of gneiss and schist in which ore veins have been reported is the only portion in which sheets of quartz porphyry, rhyolite, and diabase porphyry have so far been found. It may therefore be surmised that the ores and these intrusive rocks may have had a common origin.

Bands of rock with disseminated pyrite and pyrrhotite of the "fahlband" type are found throughout the gneisses and schists. They are conspicuous on weathering because of the rusty-brown or red belts to which they give rise. The ore veins are found in a mineralized zone at least 7½ miles long. The main bodies (Ground-hog group) are tabular replacement veins of pyrrhotite and sphalerite in the gneiss, but at Glacier Basin there are replacement veins consisting of sphalerite and galena, and at Glacier Basin and Berg's Basin sphalerite, galena, and pyrite are found in veinlets and pockets in sheets of fractured rhyolite and in crosscutting quartz veins having a comb structure. The zinc replacement veins of Groundhog Basin and the zinc-lead-silver replacement veins in Glacier Basin appear to be older than the quartz porphyry and rhyolite dikes and sheets, but the mineralized quartz veins are younger. This indicates two periods of vein formation here, the deposits of the older period being high-temperature replacement deposits and those of the younger period comprising fissure fillings accompanied by some replacement deposits formed under intermediate conditions of temperature and pressure. The replacement deposits of Groundhog and Glacier basins are in their mineral associations allied to ore deposits of the contact-metamorphic type, but in structure they resemble high-temperature replacement veins.

Groundhog Basin

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The Groundhog Basin group of claims is on the mainland about 13 miles east by northeast of Wrangell. The claims are reached by a trail that starts from the mouth of Mill Creek, on Eastern Passage, and follows the left bank of Mill Creek for three-quarters of a mile to the mouth of Lake Virginia, at an altitude of about 100 feet above high-tide mark; thence by boat across the lake for about 2 3/4 miles to the head; and thence by trail about 6 miles up Porterfield Creek to an altitude of about 800 feet. The main workings are at an altitude of about 2,000 feet and lie along the face of a mountain 5,100 feet in height.

The original discovery of ore here was made by Ole Johnson and John Oleson, of Wrangell, in 1904, after following the strike of the rocks from the veins in Glacier Basin. A tunnel 104½ feet long was driven by them to crosscut the main vein, but work was stopped before the vein was reached. The title to their claims was purchased by W. D. Grant and associates in 1912, and in 1915 the property, comprising four claims was bonded to the Bon Alaska Mining Co. This company located 31 additional claims along the extension of the veins and on veins in Glacier Basin, to the southeast. Five claims along the extension of the main vein northwest of Porterfield Creek and two claims on a gash vein on the south side of the south branch of Porterfield Creek have been located by McKay & Leeds.

From 1915 to 1917 the Bon Alaska Mining Co. was actively engaged in developing the claims, chiefly the four claims leased by W. D. Grant and associates, known as the General Sherman, General Grant, General Logan, and General Lee. During the war period the company's option on these claims was not exercised owing to unfavorable conditions, and they reverted to their owners, by whom they are now held.

The claims are equipped with an air compressor and 4,000 feet of 4-inch pipe and 600 feet of 1-inch pipe to convey air to the workings. The compressor is driven by a 36-inch Pelton water wheel, which operates under a head of 280 feet, the water being supplied by 750 feet of 13 to 11-inch steel penstock pipe and a flume 500 feet long.

The main vein has been prospected by open cuts for a length of 3,200 feet and by three tunnels. An upper tunnel 14 feet long crosscuts the main vein at an altitude of about 2,280 feet on the General Sherman claim. Tunnel No. 1, about 80 feet almost vertically beneath the upper tunnel, is 159 feet long and likewise crosscuts the main vein. It starts on the General Grant claim and extends across the end line into the General Sherman claim. This tunnel was started by Johnson & Oleson and was completed by Bon Alaska Co. in 1915 and 1916. Tunnel No. 2 is on the General Sherman claim at an altitude of about 1,914 feet, 430 feet northwest of the upper tunnel. It is 180 feet long, extends in a northeasterly direction, and crosscuts the main vein. Drifts have been driven on the main vein from this tunnel for 21 feet to the northwest and 52 feet to the southeast. A crosscut has been run back for 16 feet to the southwest from the end of the southeastern drift. Work on this tunnel was done by the Bon Alaska Co. in 1917.

Another vein about 125 yards distant horizontally parallels the main vein and lies on the southwest side of the south fork of Porterfield Creek. The General Lee tunnel crosscuts this vein and is on the boundary line between the General Lee and General Logan claims.

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The ore bodies are tabular replacement veins in fine-grained gneiss. They conform in strike and dip with the gneiss, which trends north-northwest and dips about 60° -80° E.

The wall rocks of the main vein are in general fine-grained ribbon-banded injection gneisses consisting of alternating layers of purplish-brown micaceous plagioclase feldspar or of quartzite, layers of dark hornblende schist, and veins of light-colored aplitic rock locally with some epidote resulting from the alteration of hornblende or from the contact metamorphism of limestone. Sheets of quartz porphyry with connecting dikes are common in the gneiss. A dense, compact dark-brown hornfels comprising alternating bands of micaceous quartzite and of plagioclase feldspar is found in places in immediate contact with the ore.

The main vein has been exposed by surface cuts and natural exposures for a length of about 3,200 feet, It has been sampled in the tunnels and by 19 trench cuts at the surface for a total length of about 1,600 feet. A report has been made on the property for the Bon Alaska Co. by Campbell, Wells & Elmendorf, of Seattle, Wash., and from this report the following data have been compiled. The width of the vein ranges from 1½ to 9 feet and averages about 3 feet. The northwesternmost portion of the exposed vein is more than 1,140 feet lower than the southeastern portion. The average of 24 assays, each made on the full width of the vein, is approximately zinc, 17 per cent; lead, 2½ per cent; silver, 1¼ ounces. The zinc content ranges from 9.4 to 30.8 per cent; lead from a trace to 12.5 per cent; and silver from a trace to 4.35 ounces. D. C. Campbell reports that preliminary experiments in the concentration of these ores by means of preferential flotation after roasting gave a concentrate of 45 per cent zinc and 14 per cent iron, and that this grade could probably be materially improved with some further work.

About 25 feet below the main vein is a parallel vein of similar character which pinches and swells and ranges from 10 inches to 4 feet in width. About 60 yards southeast of tunnel No. 1 this vein appears to die out into the country rock as a series of narrow stringers. It was not found in tunnel No. 2, 430 feet northwest of tunnel No. 1, and may die out in this direction or swing in to join the main vein. A layer of magnetite 6 inches thick, layers of pyroxene granulite, and a fine-grained to dense banded gneiss consisting of alternating layers of light-colored aplite, yellowish-green pyroxene granulite, and purplish-brown plagioclase feldspar are found at the southeast end of this vein.

About 350 feet beneath the main ore vein, measured at right angles to the dip, is another parallel vein. This has been crosscut by an adit where it is from 1 to 2 feet thick and of similar character to the others. An average sample of ore from both sides of this vein in the adit is reported by the Bon Alaska Co. to yield 8.60 ounces of silver to the ton, 4.85 per cent of lead, and 16.34 per cent of zinc. The immediate wall rock of this vein is a dense banded green and white hornstone consisting of alternating layers of light-green pyroxene, feldspar, and white quartzite with a trace of sphalerite and pyrrhotite. There is about 2 feet of such rock in the hanging wall, overlain by a compact ribbon-banded black and white quartzite. The black layers consist of very fine grained quartzite with a trace of feldspar and pyroxene and abundant disseminated particles of carbonaceous matter, from which they derive their color. The white layers are almost exclusively plagioclase and are locally adjoined by thin borders of pyroxene.

The ore in general consists essentially of pyrrhotite interstreaked and banded with gangue minerals (remnants of unreplaced country rock), dark-brown sphalerite, and a small and variable amount of galena and pyrite. A trace of chalcopyrite is present as dots and rods of microscopic size included in the sphalerite and locally as sparse grains in the ore. Minute veinlets of quartz and chalcopyrite cross the banding of the ore, and one 2-foot vein of this character is reported to have been found. The galena occurs as veinlets parallel to the banding of the other minerals, was brought in by solutions after the formation of the other minerals, and is irregularly distributed. The silver content varies roughly with the percentage of lead.

High-temperature replacement pyrrhotite-sphalerite deposits like this one are not common. The zinc deposits of Ammeberg, in Sweden, seem to bear the closest resemblance to it, and a summary description of their mode of occurrence will be of interest. The ore there is described[3] as occurring in fahlbands, layers, or zones in a banded gray "granulite" or fine-grained gneiss. Graphite, pyroxene, hornblende, and garnet are common accessory minerals. Small bands of grayish-green rocks composed essentially of diopsidic pyroxene are frequently seen in the banded "granulite." Some of the deposits contain essentially sphalerite; others are almost pure pyrrhotite formed by impregnation. Many of the smaller layers contain both sulphides in variable proportions. Pyrite is only locally present,

[3] Johansson, H. E., The Ammeberg zinc ore field: Cong. geol. internat., 11e sess., Guide des exc. No. 35, Stockholm, 1910.

and chalcopyrite is of exceptional occurrence. With the sphalerite traces of galena are usually present. Pyrrhotite does not occur in the zinc ore itself but is almost constantly seen in the footwall of the sphalerite deposits, where together with some galena and pyrite it impregnates a narrow band of silicate rock, usually associated with seams of siliceous limestone. The pyrrhotite does not everywhere form the definite footwall of the ore belt but may occur also within it, separating different branches or bands of the ore. The sphalerite deposits have a marked layer-like appearance and may be traced as a practically continuous band, generally not many meters in width, for almost 3 3/4 miles. Only the richer portions are worth mining. Some of the lenticular swellings are as much as 30 to 50 feet wide. The sphalerite is mostly of varieties poor in iron and hence of light-brown color. The low-grade milling ore averages about 21 per cent of zinc and forms the bulk of the product. The high-grade hand-picked ore averages 38 per cent of zinc. The total production from this field from 1857 to 1909 was 1,968,729 tons.

The country rock of the Swedish deposit, called "granulite," is similar to the banded gneiss described as occuring in association with the Groundhog ore. The mineral association, essentially pyrrhotite and sphalerite, is similar at both deposits. In the Swedish deposits, however, the sphalerite is an iron-poor variety and in the workable ore bodies is not intimately interstreaked with the pyrrhotite, like that of the Alaskan deposit. In their layer-like character and great extent in length the two deposits are similar. The veins of the Ammeberg deposit have been followed down the dip for 1,000 feet; and the great length and the present exposures of the Alaskan vein at greatly differing altitudes and its general character are favorable to its persistence in depth. The origin of the Swedish deposits is in doubt, but the mineral association indicates that they have been subjected to high temperatures

Excerpted From: United States Geological Survey Mineral Resources of Alaska Report On Progress of Investigations in 1921 (PPs 57-63)

MINERAL ASSOCIATIONS

Mineral associations constitute another valuable criterion in separating deposits belonging to the early and intermediate periods of metallization. Gold and silver are common to both groups of deposits. It has been shown by Brooks[3] that the stibnite ores were formed later than the Mesozoic metallization of Alaska and are probably of Tertiary age. Cassiterite, the common ore of tin, is believed by the writer[4] to have been formed only during the Mesozoic or early period of metallization, although the tin deposits near Hot Springs, in the Rampart district, may present a possible exception to this general statement. Tungsten occurs in the early group of deposits as wolframite and scheelite. Molybdenite, so far as known, occurs only with the granitic intrusives of Mesozoic age. Silver lead ores, accompanied in places by other ore minerals, such as stibnite, chalcopyrite, bornite, sphalerite, pyrite, arsenopyrite, jamesonite, and bismuthinite, occur in associations which suggest that they originated mainly in the intermediate period. The sulphide ores of the Fairbanks and Kantishna districts are believed also to fall within the intermediate group.

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3 Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, pp. 14-17, 1916.

4 Mertie, J. B., Jr., and Harrington, G. L., The Ruby-Kuskokwim region, Alaska: U. S. Geol. Survey Bull. -- (in preparation).

Excerpted From: U. S. Geological Survey Mineral Resources of Alaska Report on Progress of Investigations in 1921 (p. 154)

METALLURGY

Sphalerite is by far the most common ore mineral, and any future mine will probably be operated primarily as a zinc mine, though as considerablbe galena is present lead would undoubtedly be one of the products. The assays given on pages 273-284 show that the silver content of the ores is extremely variable, but silver is usually present in recoverable quantity, and local bodies of ore rich in silver could probably be found.

McCarty[44] ran a series of tests on ore from the Mount Bielson district that according to O. M. Grant came from the Jiles claim and summarizes his results as follows:

Owing to the highly disseminated nature of the lead and zinc in this ore it is impossible to make high recoveries without grinding the ore so that about 80 percent will pass a 200-mesh screen. When ground to this mesh good recoveries of both lead and zinc may be obtained by the proper flotative mixtures.

The best results were obtained when potassium xanthate was used in an alkaline circuit with sodium cyanide, zinc,sulphate, and steam-distilled pine oils. This flotative mixture yielded a 61.74 percent lead concentrate with a 85.4 percent extraction and containing 12.10 percent zinc; and a 49.10 percent zinc concentrate with a 77.8 percent extraction and containing 13.80 percent lead. Other tests showing slightly lower lead recoveries but containing only about 7.0 percent zinc might prove better for practical purposes. This depends on economic conditions such as the distance from smelter and smelter rates and penalties for different grades of concentrates. The grade of any of the concentrates, however, could be improved by treating in cleaner flotation cells. The silver extraction has been found to parallel quite closely the percent of the total silver content of the ore. The greater part of the chalcopyrite is recovered with the lead, the rest being floated with the zinc concentrate.

Recoveries obtained in this laboratory investigation would warrant construction of a pilot mill, in which further metallurgical testing should be carried on to perfect a flow sheet. Such testing work would at the same time improve both recovery and grade of the lead and zinc concentrates.

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44 McCarty, W. J., Differential flotative treatment of a complex silver-lead-zinc ore (thesis submitted to the Alaska Agricultural College and School of Mines, 1927).

THE PROPERTIES

In the following detailed descriptions of the individual prospects, the present claims, as shown in figure 37, will be used for convenience, although it is realized that the locations of many are temporary, as none are patented or even surveyed.

Hugh John

KH66-35

The Hugh John claim of O. M. Grant and Joe Henderson forms the northwest corner of the group of claims shown in figure 37. There has been no development. The claim is in a moraine area, and no bedrock is exposed except in the bed of a small brook where it crosses the northern boundary of the claim. A 10-foot thickness of epidote rock, carrying considerable sphalerite and galena, is exposed. No chalcopyrite was seen, and the sphalerite predominates over the galena.

CHRISTENIA

KH66-35

Grant & Henderson own the Christenia claim, which lies just south of the Hugh John. The claim is developed by two very small prospect pits, in the upper one of which about 5 feet of ore-bearing material is exposed. Most of the claim is buried beneath moraine. The strike of the ore-bearing beds is nearly east-west, and the dip is about vertical. There appears to be very little galena on the Christenia, and no chalcopyrite was noticed. Sphalerite is the principal metallic mineral, but a little pyrite was seen. An assay of a picked specimen of sphalerite to determine its silver content showed no copper, no lead, 41.37 percent of zinc, and 0.20 ounce of silver to the ton. The principal gangue minerals are epidote and calcite. A little pale-green andradite is also present.

SOUR DOUGH

KX66-35

There is one small prospect pit on the Sour Dough claim, which belongs to Hugh Matheson. A little low-grade zinc ore is exposed. The claim lies south of the Christenia, and is likewise mostly covered with glacial moraine.

Copper Base

KX66-35

The Copper Base claim, which forms the southwest corner of the group, also belongs to Hugh Matheson. There are two prospect pits on the claim, both of which are caved so that no rock was seen in place. Some good ore was seen on the dumps of the pits. It consists of a banded aggregate of epidote, sphalerite, galena, and pyrite. There appears to be relatively more pyrite and galena here than in most other places.

Snowdrift

KX66-2

The Snowdrift claim extends across Grant Creek just below the mouth of the canyon, where the creek leaves the mountain proper and flows across the bench above Copper Mountain Bar. Grant Cabin is on this claim, most of which is covered with fan material from the mountain. There are showings of ore near the southern boundary of the claim in the creek bank and also near the southwest corner as revealed by small prospect pits. The claim is owned by Grant and Henderson. The pit in the creek bank exposes epidotized sediments with a little pyrite, chalcopyrite, and sphalerite.

Virginia

KX66-2

The Virginia claim abuts the Hugh John on the east and lies just south of the Snowdrift. It includes the mouth of Grant Creek and a portion of the canyon. In addition to the excellent exposures in the canyon the claim is developed by 7 prospect pits and 2 small adits, 20 and 10 feet long. This is one of the claims of Grant & Henderson. The ore shows the usual epidote-sulphide association, and the original bedding is well preserved in most places. Vein quartz is rare at Mount Eielson, but a little was seen here.

The sediments lie nearly horizontal in the canyon on this claim and are cut by large numbers of the granodiorite dikes. Sills are not very common at this particular locality. Many of the beds do not appear to be much changed by replacement. The dikes carry xenoliths of the sediments at least 10 feet in diameter, most of which are altered to ore.

Mineralization has occurred especially at three places on the claim--(1) on the east side of the creek near the southern boundary of the claim, (2) on the east side of the creek near the middle of the claim, and (3) at the mouth of the canyon on the west side. At the first locality a stratigraphic thickness of 12 feet of ore is exposed for a horizontal distance of 30 feet. An assay of a chip sample shows 0.90 ounce of silver to the ton, and 0.14 percent of copper, 3.56 percent of lead, and 3.99 percent of zinc. Both the top and the bottom of this bed are concealed, but beginning about 40 feet above the top of the exposed part three other bands of ore crop out, each about 2 feet thick.

At the second locality an ore zone about 3 feet thick borders a granodiorite dike and cuts across the bedding. This is practically the only crosscutting ore body that was observed in the district. The exposures at the third locality indicate weak mineralization.

Denver

Kx 66-2

The Denver claim also includes part of the Grant Creek Canyon. It lies south of the Virginia and east of the Christenia. It is developed by about half a dozen small prospect pits and open cuts, in addition to which there are many excellent exposures in the canyon walls. The Denver belongs to the Grant & Henderson group.

The strike of the sediments across Grant Creek on the Denver is N. 85° E. and the dip is 55° N. The dip flattens quickly downstream, so that on the Virginia the beds are nearly horizontal. The beds are locally crumpled in this vicinity.

An ore-bearing bed at least 10 feet thick and having the attitude given in the preceding paragraph is well exposed on the west side of the creek near the middle of the claim. What is apparently the same bed may be traced up the east bank to a point about 500 feet away horizontally. It is possible that this is the same bed that appears at locality 1 on the Virginia claim. Some good ore shows in the bed of Grant Creek near the Virginia line. The Denver ore is of the usual type but locally appears to carry more chalcopyrite than the ore from many other localities. Locally chalcopyrite has weathered to malachite and azurite. An assay of a chip sample from the open cuts on the west side of the creek shows 6.00 ounces of silver to the ton, 0.10 percent of copper, 10.45 percent of lead, and 16.28 percent of zinc for a 10-foot thickness at that place.

Marjorie

Kx 66-35

Grant & Henderson's Marjorie claim lies south of the Denver and east of the Sour Dough. There is one small open cut to bedrock on the east side of Grant Creek about 100 feet above the stream level, in which are exposed epidotized sediments carrying sphalerite and porphyritic granodiorite. Townsend[45] mentions an outcrop on the west side of Grant Creek on what was then the Caribou claim and which now must lie on the Marjorie or on the Denver claim. One assay from a 6-foot cut showed 0.03 ounce of gold to the ton, 0.3 percent of copper, 1.5 percent of lead, and 2.56 percent of zinc; and another assay from a 10-foot width, 0.03 ounce of gold and 0.6 ounce of silver to the ton, 2.3 percent of copper, 3.5 percent of lead, and 7.0 percent of zinc.

Matheson

Hugh Matheson owns the Matheson claim, which lies south of the Marjorie. A small prospect pit beside the creek exposes about 10 feet of epidotized rock which strikes N. 85° E. and dips 75° N. and which is impregnated with some sphalerite. Assay returns show 0.3 ounce of silver to the ton, no copper, no lead, and 2.21 percent of zinc.

Carrie

The Carrie claim of Grant & Henderson abuts against the Denver on the east. The development consists of half a dozen small pits and open cuts along the crest of the bluff in the southern part of the claim. The sediments that form the country rock are crumpled in places but in general display a low dip to the south. There are many granodiorite dikes and sills. Exposures are too poor to determine the areal extent of the ore-bearing beds, but some high-grade ore may be seen in some of the prospect openings. Sphalerite seems to be more plentiful than galena. No chalcopyrite was observed on this claim.

Tennessee

Grant & Henderson own the Tennessee claim, which lies south of the Carrie and east of the Marjorie. It is developed by half a dozen pits and open cuts, two of which are near the east end, close to the Jiles claim, and the rest are above the openings on the Carrie. The pits show considerable fair ore of the usual type. No structural observations could be made.

Georgia

The Georgia claim, which lies east of the Matheson and south of the Tennessee, is also owned by Grant & Henderson. It is developed by three open cuts and two prospect pits. There are some good exposures near the west end of the claim, but much of the rest of it is covered with talus. The sediments near the common corner of the Matheson, Marjorie, Tennessee, and Georgia claims strike N. 80° E. and dip 50° N. A few hundred feet east, near the discovery post of the Georgia, the strike is N. 70° W. and the dip is very steep to the north or vertical.

Considerable mineralization has occurred along the common boundary of the Matheson and the Georgia. Here there appears to be but little galena. One grab sample assayed 0.8 ounce of silver to the ton, 0.57 percent of copper, 0.11 percent of lead, and 21.0 percent of zinc. The open cuts near the discovery post expose ore-bearing beds for about 150 feet along the strike and 40 feet across it. A composite chip sample from these cuts, estimated to be average for the band exposed, shows 0.02 ounce of gold and 2 ounces of silver to the ton, 0.22 percent of copper, 2.33 percent of lead, and 5.46 percent of zinc. Another band of ore is exposed for about 150 feet near the southwest corner of the claim. This band is about 10 feet wide, and the ore is similar to that from the 40-foot band.

The talus slopes below the visible ore-bearing bands contain ore minerals in conspicuous amounts. There are undoubtedly other ore zones that are covered. A particularly rich part of the slope, with an area of at least 120,000 square feet, was roughly sampled by taking many grab samples, and the composite result showed 1.30 ounces of silver to the ton, 0.52 percent of copper, 6.66 percent of lead, and 12.28 percent of zinc.

KX 44-25

Kelly

The Kelly claim of Grant & Henderson lies south of the Georgia. The only metallic mineral that was observed was a little chalcopyrite, partly weathered to malachite, from the one small prospect pit.

KX 66-2

Jiles

The Jiles claim lies east of the Georgia and south of the east end of the Tennessee. It has been developed by eight pits and open cuts and three small adits, two of which are about 100 feet long and the third about 70 feet long. About half of the claim, the east end, lies on the piedmont slope above the Thorofare River; the other half is on the lower slopes of the mountain. The development is confined to the western half. The three adits and some of the surface workings are in the small gulch south of the southeast corner of the Tennessee; the rest are in or near the gully near the northwest corner of the claim. The two lower adits were inaccessible, but in the upper one nothing was observed that could not be better seen on the surface, in the gulch just above.

The usual type of geology is represented, altered sediments and many dikes and sills of porphyritic granodiorite. A 16-foot thickness of sulphide-bearing material is exposed near the northwest corner of the claim. The strike here is about N. 16° E., and the dip is 45° W. An assay of a chip sample across the face reveals 0.6 ounce of silver to the ton, 0.16 percent of copper, 4.78 percent of lead, and 13.12 percent of zinc. Sulphide-bearing material can be traced continuously by float and by outcrop from this pit to the prospects in the gulch where the adits are driven. A 12-foot face above the upper tunnel was roughly sampled and showed 2.4 ounces of silver to the ton, 0.12 percent of copper, 8.33 percent of lead, and 14.49 percent of zinc. The band here exposed may be 40 feet wide. Other mineralized beds occur farther down the gulch. Some high-grade galena ore lies on the dump of the middle tunnel, and Grant reports that it came from an 8-foot bed. A grab sample assayed 8.70 ounces of silver to the ton, 62.11 percent of lead, and 7.35 percent of zinc. A composite sample of a rich talus slope on the Jiles assayed 0.01 ounce of gold and 3.80 ounces of silver to the ton, 8.89 percent of lead, and 10.82 percent of zinc. The area of the slope is at least 100,000 square feet.

Isobel

KX66-33

The Isobel claim is east of the Kelly and south of the Jiles. It is developed by several small prospect pits and belongs to Mrs. Isobel Stanford. The only evidence of mineralization observed was on the north side of Granite Creek. There is much intrusive material in this vicinity. The sediments strike N. 25° W. and dip 30° SW., but this attitude is not certain for any but a very small area. The mineralization was weak, and garnet and vein quartz are present in addition to the ordinary epidote and sulphide replacement deposits. Chalcopyrite is the most abundant sulphide at this outcrop.

Mackenzie

Kx66-39

No evidence of mineralization was observed on the Mackenzie claim of Hugh Matheson. The entire claim is on the slope that borders the north and northwest base of Mount Eielson. A little pyrite and chalcopyrite were observed in the creek bank in altered sediments in intimate association with fine-grained granodiorite and porphyritic granodiorite, in the area between the northeast line of the Isobel and the south line of the Mackenzie.

Mary

Kx66-39

The Mary claim also belongs to Hugh Matheson. It lies east of the Mackenzie and is developed by two small prospect pits. The only showings are along the small tributary to the Thorofare River that enters the river east of Granite Creek. At one pit the strike is N. 75° E. and the dip is about 75° N. The epidotized sediments carry sphalerite, galena, and chalcopyrite. Chip samples of an 8-foot face showed 0.3 ounce of silver to the ton, 0.2 percent of copper, and 2.31 percent of zinc. In the other pit there is considerable copper stain.

Highlander

Kx66-39

The Highlander is one of the claims of Hugh Matheson. It lies east of the Mary. There are few outcrops on the claim, but an excellent section is exposed along the east line of the claim in the cliff along the west side of the Thorofare River, and it is along this cliff that the development work, which consists of a small open cut, has been done.

The section reveals altered and in places unaltered sediments, which in general strike about N. 75° W. and dip 50° N., and many sills of porphyritic granodiorite. A few strike faults with displacements apparently too small to map were also observed here. A bed about 60 feet thick, carrying sulphides throughout, crops out near the middle of the east line. Half of this thickness is richer than the rest, and a chip sample of it assayed 0.01 ounce of gold and 1.50 ounces of silver to the ton, 0.83 percent of copper, 2.89 percent of lead, and 5.67 percent of zinc. The ore is of the usual type. Several more stringers of ore were seen between this locality and the north boundary of the claim, and boulders of high-grade ore appear in the slide rock along the river near the line between the Highlander and the Cleary claim.

Cleary

KX 64-3d

The Cleary claim, which lies south of the Highlander, belongs to Ben Cleary. It is developed by one small prospect pit along the river near the center of the east line of the claim. The geology is typical of the district. The sediments strike about N. 70° E. and dip 40° N. The mineralized bed is about 5 feet thick, the richest 2 feet of which assayed 0.01 ounce of gold and 15.3 ounces of silver to the ton, 0.78 percent of copper, 4.22 percent of lead, and 20.16 percent of zinc. There appears to be some faulting at this locality.

SUMMARY AND RECOMMENDATIONS

The ore deposits of the Mount Eielson district have been formed by the selective replacement of thin-bedded limestone and calcareous shale by minerals of the epidote group, pyrite, chalcopyrite, sphalerite, galena, and other minerals. The main ore-bearing zone exhibits a definite relationship to the granodiorite mass of Mount Eielson. A large part of the zone has been described in detail by reference to the unpatented claims that cover most of the better showings.

Very little development work has been done in the district, and as much of the potentially valuable ground lies beneath a cover of post-mineral deposits, the most urgent need is for much more systematic prospecting. The present natural exposures and prospect pits indicate a reserve of many hundreds of thousands of tons of zinc and lead bearing material, which, from the indications of the few assays, should carry at least 10 percent total sulphides. Silver would no doubt be recovered from any ore mined at Mount Eielson, but the assays show that the silver content of the ores is in general low and spotted. The silver content does not seem to bear any very definite relation to the lead content, and, although some of the silver undoubtedly occurs in the galena, either in solid solution or as inclusions of definite mineral species, some of it is probably in association with sphalerite. It is possible that copper would also be recovered, but it would be a very subordinate product.

The mining conditions at Mount Eielson are generally good, especially for a large-scale operation. Most of the ore zone could be developed to a depth of several hundred feet by a tunnel. The rock and ore are massive and would require little timbering. The individual ore bodies are large enough to lend themselves to some caving method of mining. Some of the conditions, however, are not favorable. There is no timber in the district. Sufficient coal could probably be mined a few miles to the north, but it would have to be transported to Mount Eielson in winter over frozen ground unless a road was built. It is possible that Grant Creek could be developed on a small scale for power. The winter season is long and cold, but operations could no doubt be carried on all the year round.

The ore would probably be concentrated in a mill at Mount Eielson. Its mineralogy is simple, and galena, sphalerite, and chalcopyrite could be separated.

Transportation of concentrates would be one of the greatest problems in any mining venture in the district. The concentrates could be trucked during the summer over the park highway to McKinley Park station. Perhaps a cheaper way would be to haul them by tractor in winter, either through the same passes that the road follows but by a shorter route making greater use of stream bars, or by a longer but not so hilly route down Stony Creek to the low country and thence east to Kobe. The cost of this part of the journey would be nearly negligible as compared with the cost of shipment to Seward by the Alaska Railroad according to the present quoted rate of $1.63 per 100 pounds of lead concentrates for a 50,000-pound minimum shipment from McKinley Park station to Seward and $1.22 for corresponding zinc concentrates. From Seward lead concentrates would probably go to Selby, copper to Tacoma, and zinc to Trail, British Columbia, or some more distant smelter equipped to handle such concentrates.

It seems doubtful that a successful mining enterprise could be carried on at Mount Eielson under the existing prices of metals and the adverse transportation conditions. However, the cost factors are many and variable, and as a large ore reserve exists at Mount Eielson it is entirely possible that with changed conditions profitable operations could be instituted there.

Excerpted From: U. S. Geological Survey Investigations in Alaska Railroad Belt, 1931 (276-286)

MINERALOGY

Gangue minerals.--The mineralogy of the ores from Mount Eielson is simple. The only abundant gangue minerals are members of the epidote group, and of these clinozoisite appears to be the most common, although in places either zoisite or epidote may predominate. The fine-grained dark greenish-gray clinozoiste aggregates appear cherty and were often mistaken for chert in the field. Quartz and white calcite are minor gangue minerals.

Ore minerals.--Sphalerite, galena, chalcopyrite, malachite, and azurite are the ore minerals that were definitely recognized. They are listed in the order of decreasing abundance. In addition Davis[41] mentions an occurrence of native copper, and Moffit[42] lists tetrahedrite. Pyrite is a common metallic mineral in the district but is of no value. Sphalerite appears to be the earliest of the ore minerals. Galena was deposited in part contemporaneously with the sphalerite and in part after the sphalerite deposition was complete. Chalcopyrite has been observed veining sphalerite and galena, and wherever associations of the three minerals were studied the chalcopyrite was the latest. Assays show the presence of some silver, and microscopic examination of polished sections reveals minute specks in galena of a mineral which has tentatively been referred to pyrargyrite. Some galena assays show very little silver, but some of the sphalerite appears to carry considerable.

The typical ore consists of alternating bands of fine-grained minerals of the epidote group and sulphidds. In most places the sphalerite is fine grained, but the galena in some places is coarsely crystalline. The widths of the bands are with rare exceptions between one sixteenth inch and 1 inch. The bands are defined in barren contact rock by slight difference in color or texture of the epidote minerals or by thin, dark seams which may be carbonaceous material. Lean ore shows stringers, patches, and isolated crystals of sulphides in the epidote. Whole bands are replaced to form richer ore, and in some places the replacement has been complete and only sulphides remain, though even in these the original banding is ordinarily apparent.

Chalcopyrite cuts across the bands in little stringers more commonly than the other sulphides.

Genesis of the Ores

The ore deposits of Mount Eielson are the result of one phase of a large-scale replacement process which affected a zone about 2,000 feet thick in Paleozoic sediments consisting of thin-bedded limestone, shale, graywacke, and sandstone, when the sediments were intruded in Mesozoic (probably late Mesozoic) time, by a stock of granodiorite. The main mass of the intrusion probably never reached within several thousand feet of the surface, for it was capped by a considerable thickness of the limestone formation and also by a thick lava series. The mineral associations also point to a rather high temperature of formation. According to Lindgren the temperature range for deposits of this type lies between 400° and 600° C. The replacement zone is cut by a myriad of dikes and sills of porphyritic granodiorite which have a wide range in size. Many of these may be feeders to a large sill-like mass of porphyritic granodiorite which lies stratigraphically above the replaced zone. The porphyritic granodiorite represents material given off from the main stock, but the replacement processes appear to be related to the main intrusive body.

only and not to the dikes and sills in the zone nor to the large overlying sill. The time relation between the apophyses of the stock and the formation of the ore is not certainly known.

As the intrusion came into place a vigorous exchange of material occurred because of the chemical and physical differences between the intruding and the intruded rocks. The replacement was selective, however, and practically unchanged limestone beds occur within the zone. One of the chief processes was the introduction of large quantities of silica. Quartz, however, is a very uncommon gangue mineral. General conditions, such as the absence of quartz veins and areal distribution, indicate that the silication preceded ore deposition. Therefore, either the silicated beds were not those into which the ore was later introduced, or some of the silicated bedw were in turn completely replaced by other minerals into which the ore was introduced. There is some evidence that many of the beds which are at present siliceous were originally siliceous sediments.

The most widespread process of replacement was that of epidotization--that is, the formation of any member of the epidote group. Large volumes of limestone have been replaced with the loss of CO_2 and the addition of SiO_2 and Al_2O_3, but the details of bedding and structure have been faithfully preserved. The epidotized rocks were later partly and in places completely replaced by sulphieds. Incipient stages of ore replacement show sphalerite and in places also galena in sporadic bunches in the epidote rock or, more commonly, as thin discontinuous streaks parallel to the bedding. Locally the replacement of epidote by sulphides continued until an end product was formed which consists of an aggregate of sphalerite, galena, and chalcopyrite.

The deposit appears somewhat unusual because of the scarcity or complete absence of other common contact minerals such as garnet and amphibole.

Excerpted From: U. S. Geological Survey Investigations in Alaska Railroad Belt, 1931 (272-274)