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Manson-Germansen Rivers and Tributaries

As a result of the study of the bedrock geology and mineral deposits of the Manson-Germansen Rivers placer area it has been concluded that most of the placer gold probably resulted from the erosion of carbonate-quartz-mariposite-chlorite rocks, less altered rocks, and quartz veins along the Manson fault zone and associated branch faults. This conclusion is based on the following observations: (1) The placer deposits exhibit a linear arrangement along the Manson fault zone in a belt about 25 miles long by 3 miles wide. None of the deposits is more than 2 miles from an observed or projected major fault zone, and all are probably much nearer minor fault, shear, and fracture zones. (2) Much of the gold in the placers is coarse and angular, indicating that it has not been transported far. One nugget weighed 24 ounces, and many others up to 2 and 3 ounces. Many of the deposits occur on the downstream side of outcrops of carbonate-quartz-chlorite-mariposite rocks. For example, Discovery Bar on Manson River, reported to have been one of the richest deposits in the area, is directly below a wide carbonate zone. Unexposed fault zones containing mineralized veins probably occur above other known deposits. (3) Assays on specimens of carbonate-quartz-chlorite-mariposite rocks yield a trace to 0·01 ounce of gold a ton. These rocks could be the source of much of the fine gold. (4) The most productive placers lie near fault zones containing quartz veins with a valuable gold content. Many of the larger nuggets contain vein quartz attached to the gold, and this quartz appears to be identical with that in the veins.

Sowchea and Dog Creeks

The gold on Sowchea and Dog Creeks is fine, and has evidently been transported far. It is believed to have been derived from the concentration of the gold in the overlying glacial drift.

Lode Deposits

Deposits Related to Major Fault or Shear Zones

Pinchi Fault Zone

MERCURY DEPOSITS

About fifteen cinnabar (sulphide of mercury) deposits have been found along the Pinchi fault zone, including those of Pinchi Lake and Bralorne Takla mercury mines. During the field season of 1937, cinnabar was discovered by J. G. Gray of the Geological Survey in Cache Creek limestone on the north shore of Pinchi Lake where the main showings of the Pinchi Lake mercury mine were later developed. The property was optioned to the Consolidated Mining and Smelting Company of Canada, Limited, and in June 1940 a reduction plant with a rated capacity of 50 tons a day was brought into operation. In 1943 the plant had a capacity of more than 1,000 tons a day. The grade of the ore treated is reported to average 10 to 15 pounds of mercury a ton, and production during the years 1940 to 1944 inclusive exceeded 4,000,000 pounds. The Bralorne Takla mercury mine was brought into production in November 1943, with the completion of a 50-ton mill. Production of mercury from these two properties was far in excess of Canadian requirements, and Canada was able to supply the United Kingdom and the United States with part of their war needs. Both properties ceased operations during the summer of 1944, due to an over supply of mercury.

Although the cinnabar deposits occur in rocks of quite different character, all have been found in crushed rocks of, or related to, the Pinchi fault zone. Cinnabar deposits have been found along this fault zone for more than 100 miles. The mercury deposits may be grouped on the basis of associated rocks, as follows: (1) deposits in limestone; (2) deposits in serpentine; and (3) deposits in other rocks.

Deposits in Limestone

The principal cinnabar deposits are found in brecciated fault zones in Cache Creek limestone. Solution cavities, ranging in size from mere pits to openings several feet across and partly filled with calcite, are common in the limestone. The cinnabar occurs as veinlets, blebs, and individual grains filling pre-existing openings such as fissures, solution cavities, and interstices between grains and breccia fragments. Most of the cinnabar is the red, massive variety that weathers purplish red. Some bright red, earthy, "paint" variety films fracture surfaces in the orebodies, and occur mainly near the surface. Scattered grains of pyrite are found in most deposits. The common gangue minerals are quartz and calcite. Quartz and cinnabar seem to have been deposited contemporaneously, and the calcite both earlier and later. Most of the quartz is fine grained, but crystals have also formed in open cavities. The amount of quartz varies greatly from one deposit to another; in the deposits of the Bralorne Takla mercury mine it is only a minor constituent. Limestone has been replaced to some extent by cinnabar, especially along minute fractures in the rock. In solution cavities, on the other hand, cinnabar forms on the faces and cleavage planes of calcite crystals, and shows no evidence of replacement. In general the relative amount of limestone replacement by cinnabar varies indirectly with the size of pre-existing openings, the smaller the openings the greater the proportion of replaced wall-rock. Replacement, however, is not an important factor in the grade of the ore, and the best ore occurs in limestone that contains the greatest percentage of openings available for cinnabar deposition. Included in this group are the main deposits at the Pinchi Lake mercury mine, the deposits of the Bralorne Takla mercury mine, and the Lil, Bron, and Snell showings. The orebodies at the two productive mines vary greatly in size and shape. Many of them have no definite boundaries with the wall-rock but depend on assay values only. Others are bounded or partly bounded by faults. Although no figures are available, the larger orebodies at the Pinchi Lake mercury mine probably were in excess of 100,000 tons averaging 5 to 15 pounds of mercury a ton. The largest orebody mined at the Bralorne Takla mercury mine contained about 6,800 tons of 7-pound ore.

Deposits in Serpentine

Cinnabar deposits are commonly associated with small, sill-like bodies of serpentinized rock. Zones of shearing and brecciation along the contacts of many of these bodies have provided channelways for hydrothermal solutions. At an early stage this has resulted in extensive carbonatization of the fractured rocks, in which process much of the serpentine has been replaced by quartz and chalcedony, ankeritic carbonate, and mariposite, in widely varying proportions. This alteration has resulted in forming a brittle rock and, consequently, a favourable host rock for cinnabar deposits. At a later stage, following further brecciation, mineralizing solutions deposited cinnabar and chalcedonic quartz in the carbonatized and fractured rocks. The cinnabar and chalcedony occur in minute veinlets filling the fractures and coating the breccia fragments. No replacement of the wall-rock is evident, and no other metallic minerals were observed. The cinnabar-chalcedony veinlets are cut by calcite stringers, and in many places it is difficult to distinguish carbonates and silica formed at various stages. Included in this group are minor deposits at the Pinchi Lake mercury mine, and the Dan and Indata Lake showings.

Deposits in Other Rocks

A few, small, non-commercial deposits of cinnabar were observed in relatively massive, non-calcareous, sedimentary rocks. In these the cinnabar occurs in stringers of dolomite at or near the contacts of sills or dykes, these contacts acting as channelways for the mineralizing solutions. The Indata and Kwanika showings are of this type.

Mineralogy of the Mercury Deposits

The principal metallic mineral in all mercury deposits is cinnabar. It occurs as veinlets, blebs, and individual grains, and mostly as the red, massive, and crystalline varieties that weather a purplish red. Some of the cinnabar is sufficiently coarse grained for crystal faces to be visible. Some bright red, earthy, "paint" variety of cinnabar films fracture surfaces in the upper parts of the Pinchi Lake and Bralorne Takla mercury mines. Ross (109, p. 447) states that although some paint cinnabar is undoubtedly hypogene, some may be supergene.

Stibnite is fairly abundant at the lower levels in the Pinchi Lake mercury mine. A few specks of realgar and native arsenic were observed in a small dolomite stringer along Kwanika Creek. Scattered grains of pyrite are found in all deposits.

Arquerite, a natural amalgam of mercury and silver containing 86·6 per cent silver, has been panned on Silver, Vital, Kenny, and Kwanika Creeks, and has provided nuggets up to several ounces in weight. As yet this mineral has not been found in place.

The common gangue minerals in all types of mercury deposits are calcitic, ankeritic, and dolomitic carbonates. Quartz, generally fine grained, is abundant in some deposits, especially at Pinchi Lake mercury mine, but almost none occurs in the Bralorne Takla mercury mine. Chalcedony is common in the serpentine type deposits. Minor amounts of alunite (basic hydrous sulphate of aluminium and potassium) occurs in some of the orebodies at the Pinchi Lake mercury mine. A few grains of barite were observed in the serpentine type deposit at the Pinchi Lake mercury mine.

Structure and Origin of the Mercury Deposits

All the mercury deposits occur within the Pinchi fault zone, but most of them are along what appear to be faults subsidiary to the main break. It is quite obvious that at the time of mineralization these structures permitted easy passage of solutions that lacked the power to make openings for themselves or to move appreciably through the pores of unfractured rocks. All of the major orebodies at the Pinchi Lake and Bralorne Takla mercury mines consist of aggregates of numerous fillings of openings existing at the time of mineralization. Replacement of the host rocks has taken place only to a limited extent. These openings were most prevalent in the crush zones along subsidiary faults of the Pinchi fault zone and along complementary tension fractures. Ross (109, p. 455) describes similar conditions in many of the mercury deposits in the United States.

Schuette (110, p. 49) has pointed out that mercury deposits are usually found under a cap rock of gouge more dense than the receptacle rock in which the ore forms. In many places along the Pinchi fault zone relatively impervious cap rock and fault gouge have acted as traps to rising mercury-bearing solutions, and have induced concentrations of cinnabar. At the Pinchi Lake mercury mine the large orebodies are in limestone overlain by schists. More detailed underground study may reveal similar conditions in other deposits. Although "trapping" is undoubtedly an important factor in localizing ore, the relative permeability of solution channels is of equal or greater importance.

No genetic relationship is apparent between the mercury deposits and any nearby volcanic or intrusive rocks. The source of the ore-forming solutions is not known, but is probably connected with some deep-seated intrusion. The Pinchi fault zone provided abundant channelways for mineralizing solutions, and deposition occurred wherever other conditions were favourable. In many mercury deposits there is evidence to indicate that cinnabar is precipitated at temperatures varying between 100 and 150 degrees centigrade; at nearly atmospheric pressures; and from mineral-bearing alkaline solutions. Chemical analyses of the Pinchi Lake mercury mine limestones show a considerable increase in sodium and potassium where they have been mineralized with cinnabar. Also, the occurrence of alunite and glaucophane in the mineralized rocks of the Pinchi Lake mercury mine supports the belief that the ore-bearing solutions were alkaline at one stage during the formation of the mercury deposits.

In discussing the formation of cinnabar deposits, Ross (109, p. 464) came to the following conclusions: "that mercury deposits of the types mined in the United States are formed at geologically shallow depths and at relatively low temperatures and pressures. Dilute hydrothermal solutions of relatively simple composition commonly are modified by mingling with ground water before precipitation occurs. The fact that few other metals are associated with cinnabar deposits and that such deposits tend to be remote from those of other metals suggests that cinnabar lodes may be end-products formed after any other constituents that may have been in the hydrothermal solutions, when they left their magmatic source, had been precipitated in the course of earlier reactions. Precipitation of cinnabar is caused by any changes that decrease the temperature and alkalinity. The factors dominant in precipitation differ with the local conditions, but decrease in alkalinity may be one of the principal factors in most deposits. In some places, at least, precipitation is aided by encounter with cool water descending from above the water table. Such water even where not actually acid, is so low in alkalinity that dilution by it promotes precipitation."

Presumably the mercury deposits of the Pinchi Lake belt formed in Tertiary time as they are later than the faulting, and faulting has involved all the rocks in the area except those of Pleistocene and Recent age.

GOLD-SILVER DEPOSITS

The only deposit found along the Pinchi fault zone that is not a mercury deposit is the Kay gold-silver showing west of the Bralorne Takla mercury mine. The deposit consists of sulphide lenses lying along a fault zone in Cache Creek argillite and limestone. The largest lens is several feet wide and 20 feet long. The ore minerals comprise stibnite, jamesonite, arsenopyrite, sphalerite, pyrite, andorite, freibergite, native silver, and realgar. Andorite is a rare, argentiferous, antimony-lead sulphide.

The fault zone crossing this property probably forms part of the Pinchi fault zone, and the showings possibly originated from solutions ascending along channelways in it.

Manson Fault Zone

As previously pointed out, the Manson fault zone consists of buff-coloured carbonate-quartz-chlorite-mariposite rocks across a width of about 200 feet. These carbonate rocks have been formed by hydrothermal alteration of the wall-rocks, resulting in the replacement of all the original minerals, except quartz, by ankeritic carbonate. Similar carbonate rocks occur along some of the subsidiary fault and shear zones, whereas along others the alteration is much less complete and the wall-rocks have retained much of their original appearance. These carbonatized rocks formed relatively rigid bands along which later fault movements developed open fractures and breccia zones, rather than closed shears. Subsequent mineralizing solutions traversing these fractures and breccia zones resulted in further carbonatization and the deposition of sulphides. Many of the mineral deposits are along subsidiary faults.

Assays on carbonate-quartz-chlorite-mariposite rocks from eight places along the Manson fault zone yielded a trace to 0·01 ounce of gold and 0·03 to 0·69 ounce of silver a ton. None of these samples was from quartz veins, and the only metallic mineral apparent in them was pyrite in scattered grains. Quartz veins and stringers were observed at many places along the fault zone and in subsidiary faults. In the carbonate rocks they occur commonly as stock-works of intersecting stringers and veins of milky, comb, and sugary white quartz. They vary in width from a fraction of an inch to 12 feet or more, most of them being less than 6 inches. Some are mineralized with sulphides and free gold, and contain values in gold, silver, lead, and zinc. On the basis of mineral association they may be classified as: (a) deposits containing tetrahedrite; (b) deposits containing galena and sphalerite; and (c) deposits containing pyrite and galena.

Deposits Containing Tetrahedrite

The veins containing tetrahedrite consist of grey, vitreous, and white sugary quartz sparingly mineralized with tetrahedrite, chalcopyrite, and minor pyrite, malachite, azurite, and native gold. Principal values are in gold and silver. Some of the more promising prospects in the area, including the Fairview, Farrell, and Flag properties, are of this type. The most persistent vein on the Fairview property averages 1·5 feet in width for a length of about 200 feet, and is in carbonate rock. A selected sample assayed 0·28 ounce of gold and 22·3 ounces of silver a ton. The best vein on the Farrell property is in sheared andesite, is 2 feet wide, and may be more than 100 feet long. Picked samples have assayed 0·3 to 0·8 ounce of gold a ton. The veins on the Flag group vary in width from 2 inches to 5 feet and have a maximum length of 35 feet. Selected samples from the best showing assayed up to 0·19 ounce of gold and 37·1 ounces of silver a ton.

Deposits Containing Galena and Sphalerite

The galena-sphalerite deposits consist of quartz veins and quartz-rich zones mineralized with patches of galena, sphalerite, and minor pyrite, averaging half an inch or less in diameter. A quartz zone on Manson River near Discovery Bar is 12 feet wide, and occurs in sheared andesite along a subsidiary fault. It consists of parallel stringers of quartz $\frac{1}{4}$ to $\frac{1}{2}$ inch wide, separated from one another by $\frac{1}{2}$- to 1-inch layers of wall-rock. The sulphides are in the quartz stringers. A grab sample assayed 1·58 per cent lead, 0·49 per cent zinc, and 1·32 ounces of silver and 0·005 ounce of gold a ton. A 4-foot vein sparsely mineralized with galena and pyrite occurs in carbonate rock near this quartz zone. Several other minor occurrences were observed elsewhere along the Manson fault zone.

Deposits Containing Pyrite and Galena

The Berthold property affords the only example of pyrite and galena deposit, which consists of a silicified fracture zone, 10 feet wide, in argillaceous quartzites near a probable branch of the Manson fault zone. The fractured zone is mineralized with fine-grained pyrite and minor amounts of galena. Assays indicate 0·01 to 0·06 ounce of gold and 6 to 13 ounces of silver a ton across 10 feet.

ORIGIN OF DEPOSITS ALONG MANSON FAULT ZONE

No genetic relationship is apparent between the mineral deposits of the Manson fault zone and any nearby volcanic or intrusive rocks. The source of the ore-bearing solutions is not known, but is possibly some deep-seated phase of the Omineca or later Tertiary intrusions. The Manson fault zone provided abundant channelways for mineralization, and deposition occurred wherever conditions were favourable; carbonatization preceded mineralization in many places along it.

Other Major Fault or Shear Zones

In addition to the zones of carbonatized rocks occurring along the Pinchi and Manson fault zones, many exposures of similar rocks have been observed elsewhere in the Fort St. James area. All of them are believed