

final, corrected

014421

BERG

By: A. Panteleyev, B.C. Department of Mines and
Petroleum Resources, Victoria, ~~British Columbia~~.

A. D. Drummond, Canex Placer Limited,
Vancouver, ~~British Columbia~~.

Peter G. Beaudoin, Canex Placer Limited,
Vancouver, ~~British Columbia~~.*

* Presently with Gibraltar Mines Limited, McLeese Lake, British Columbia.

I. INTRODUCTION AND HISTORY

Exploration on the Berg property has outlined a major porphyry copper-molybdenum deposit. The property is located in the Tahtsa Range (latitude 53 degrees 48 minutes north; longitude 127 degrees 26 minutes west; NTS 93E/14W) in west-central British Columbia on the east fork of Bergeland Creek between an elevation 1,500 to 2,300 metres. The village of Houston lies 93 kilometres to the northeast, Smithers lies 120 kilometres to the north, and Vancouver is about 640 kilometres by air to the south (Figure 1).

Prospecting of a large rusty weathering zone in the vicinity of the present Berg property led in 1929 to staking of peripheral lead-zinc-copper-silver veins. These claims lapsed and the showings were restaked by the Lead Empire Syndicate in 1948. The rusty weathering zone was later found with the aid of improved technology to be the source of a strong geochemical copper anomaly and was staked by Kennco Explorations, (Western) Limited in 1961. Initial property work was discouraging but in 1963 the significance of the leached capping was determined. Subsequent work revealed that the barren leached areas were extensively underlain by a blanket of supergene copper mineralization and potentially economic primary mineralization at depth. Canex Placer Limited optioned the property in 1972. To date, approximately 18,100 metres of diamond drilling has been completed on the property. Geological reserves are in the order of 400 million tonnes at 0.4 per cent copper and 0.05 per cent molybdenite using a 0.25 per cent copper cut-off grade.

II. GEOLOGY

1. Regional Geology

x/ The Berg deposit is associated with Middle Eocene porphyritic rocks that have intruded mainly volcanic rocks of the Middle Jurassic Hazelton Group (Tipper, 1972; Richards, 1974). The Coast Plutonic Complex lies about 14 kilometres to the west (Figure 2) but the Tahtsa Range and surrounding areas are intruded by many stocks ranging in age from Lower Jurassic to Upper Eocene (Duffel, 1959; Carter, 1974). Cretaceous volcanic and sedimentary rocks form ridges northeast of the Berg deposit.

2. Geology of the Berg Deposit

A composite porphyry stock with compositions ranging from quartz monzonite to granodiorite forms the core of the mineralized zone of Berg deposit. The mineralized zone occurs in an annular ring within and around the composite stock and is imposed on both the Hazelton Group rocks and partly on a quartz diorite stock. Distribution of rocks as compiled by surface exposures are limonite stained and deeply weathered. Slopes are devoid of vegetation and are mantled by slide debris and talus.

A. Hazelton Group Rocks

Host rocks for intrusion are Middle Jurassic Hazelton Group volcanic and some sedimentary rocks. These are mainly coarse to medium grained andesitic tuffs as well as subordinate flows and breccias. The sedimentary component consists of reworked volcanic source sandstones (greywackes), minor marine shale, and siltstone. The Volcanic succession

strikes approximately northward and is tilted eastward at about 30 degrees. There is no apparent stratigraphic repetition by faulting or other structural complications in the vicinity of the Berg deposit.

Outside the mineralized area, volcanic rocks are dark grey, grey green, purple, and red with recognizable fragmental textures in well-defined beds. Closer to intrusions, volcanic rocks are recrystallized to a biotite hornfels. Limit of macroscopically recognizable hornfelsing is at least 700 metres to the south but elsewhere the limit of hornfelsed rocks cannot be defined because of overburden.

B. Intrusive Rocks

Intrusive rocks at the Berg are divided into (a) quartz diorite which is in part a host for mineralization, and (b) the composite Berg stock.

(a) Quartz diorite stock

The older pluton is composed of fine grained equigranular quartz diorite which has the following average composition (Figure 5); quartz (13 percent), plagioclase, An_{50+8} (61 per cent), K-feldspar (5 percent), biotite (14 percent), hornblende (3 percent), and accessory minerals (4 percent). In drill holes near the hornfelsed contact where quartz content is locally less than 10 percent, the rock is a biotite diorite. Plagioclase is commonly kalinized and the rock contains disseminated pyrite.

This quartz diorite is part of a large intrusive body about 1 kilometre wide which lies east of the mineralized zone and which extends about 9 kilometres to the south of the Berg deposit. The

intrusive contact is steeply dipping and reasonably continuous without known offshoots or projections. Intruded Hazelton Group rocks are hornfelsed and there is no known inherent mineralization in the quartz diorite stock. It is only adjacent to the composite Berg stock that the quartz diorite is mineralized.

(b) Composite Berg stock

The stock is composed of four intrusive phases in order from oldest to youngest: porphyritic quartz monzonite, quartz-plagioclase porphyry, plagioclase-biotite-quartz porphyry, and quartz-feldspar porphyry (Figure 5). Late basalt dykes intrude both the stock and surrounding host rocks.

The nomenclature used in this paper is one that has evolved over the past few years and is presently in use. Except for the term "quartz monzonite" for the oldest intrusive phase, all other names are descriptive and refer to the main phenocrysts present.

Porphyritic Quartz Monzonite

A pinkish to tan coloured porphyritic quartz monzonite occurs centrally in the composite stock and is exposed on surface and in drill holes as a circular mass about 600 metres in diameter. Phenocrysts, which comprise 40 percent of the rock, are 2 to 5 millimetre grains of quartz (12 percent), 2 to 8 millimetre plagioclase, An_{30} (75 percent), 2 to 5 millimetre K-feldspar (3 percent), and 2 to 5 millimetre biotite (10 percent). Average phenocryst size is about 4 millimetres. Matrix (60 percent) is aphanitic to fine grained, pink to pinkish grey in colour, and characteristically contains disseminated pyrite. Microscopically the matrix contains quartz (30 percent), K-feldspar

(29 per cent), plagioclase (40 percent), and accessory minerals (1 percent). The composition of this rock is quartz monzonite but it lies near the granodiorite field on Figure 5. This rock normally exhibits a stockwork of mineralized veinlets adjacent to which there has been some silica flooding, biotite has been altered to sericite and pyrite, plagioclase has been altered to a mixture of sericite, kaolinite, and montmorillonite, and phenocrysts locally have a ghost-like appearance.

Quartz-Plagioclase Porphyry

A fine grained quartz-plagioclase porphyry outcrops to the west but in contact with the porphyritic quartz monzonite. Quartz-plagioclase porphyry intrudes porphyritic quartz monzonite and fragments of the latter can be found in the quartz-plagioclase porphyry. While the quartz-plagioclase porphyry extends 800 metres east-west and 300 metres north-south on surface, diamond drilling has indicated that it has a funnel shape or volcanic neck configuration centred at about 19,000 N and 8,000 E (Figure 3). The quartz-plagioclase porphyry contained within the porphyritic quartz monzonite (approximately 100 metres east-west and 50 metres north-south) is conceivably another neck.

Phenocrysts, which comprise 30 percent of the rock, consist of 2-millimetre quartz grains (10 percent), 1 to 3 millimetre plagioclase, An_{30-32} (85 percent), and 2 millimetre biotite (5 percent). A grey to tan aphanitic matrix forms 70 percent of the rock. Microscopically it is seen to consist of quartz (29 percent), partially decomposed (serictic) K-feldspar (28 percent), plagioclase (35 percent), biotite (5 percent),

and accessory minerals (3 percent) of which two-thirds is disseminated pyrite (Figure 5). This rock, like the porphyritic quartz monzonite, exhibits a stockwork of fine quartz and/or quartz-pyrite veinlets adjacent to which there has been some silica flooding, plagioclase is sericitized/kaolinized, and biotite is extensively altered to a sericite-pyrite association.

Plagioclase-Biotite-Quartz Porphyry

Around the northern periphery of the porphyritic quartz monzonite lies a 200-metre-wide band of plagioclase-biotite-quartz porphyry which intrudes and contains fragments of both the porphyritic quartz monzonite and the quartz-plagioclase porphyry (Figure 3).

Phenocrysts, which compose 35 percent of the rock, consist of 3 to 7 millimetre laths of plagioclase, An_{31} (74 percent), 2 to 4 millimetre biotite (18 percent), 2 millimetre quartz (7 percent), and 2 millimetre K-feldspar (1 percent). Matrix (65 percent) is aphanitic, buff to grey in colour and contains disseminated pyrite. Locally in the weathering zone, the matrix becomes a pinkish brick colour. Microscopically the matrix is seen to consist of quartz (17 percent), plagioclase (47 percent), K-feldspar (30 percent), biotite (4 percent), hornblende (1 percent), and accessory minerals (2 percent) of which half is disseminated pyrite (Figure 5). The rock, which is well veined, does not appear to be flooded by silica. Biotite may locally be chloritized and plagioclase phenocrysts are locally kaolinized.

Quartz-Feldspar Porphyry

A distinctive quartz-feldspar porphyry that cuts all previously described phases (Figure 3) occurs as several dykes of irregular width

that trend north 50 degrees east and appear to dip steeply to the west. The largest dyke trends across degrees east and appear to dip steeply to the west. The largest dyke trends across the composite Berg stock and continues to the northeast into older quartz diorite.

Phenocrysts which comprise 30 percent of the rock consist of 2 to 10 millimetre quartz grains (15 percent), scattered euhedral 10 to 15 millimetre K-feldspar (3 percent), 3 to 6 millimetre plagioclase, An_{38} (67 percent), 2 to 5 millimetre biotite (10 percent), and acicular 3 millimetre hornblende (5 percent). The smaller quartz grains are rounded whereas the ones 10 millimetres in diameter commonly show re-entrants similar to resorbed quartz of certain volcanic rocks. Near surface, biotite may be chloritized or show an epidote-chlorite pair after biotite.

Matrix (70 percent) is nearly phaneritic and grey within the chilled part of the dyke but pale greenish grey where fresh elsewhere. In weathered zones, the matrix colour is pale orange from iron stain. Microscopically the matrix is seen to consist of quartz (11 percent), plagioclase (43 percent), K-feldspar (20 percent), hornblende (12 percent) biotite (8 percent), and accessory minerals (6 percent) of which a third is disseminated pyrite and less than 2 percent is magnetite (Figure 5). Epidote after mafic minerals in the matrix can be present up to 3 percent and can impart a pale pistachio green colour to the matrix. Rare sphene crystals up to 3 millimetres have been noted. Locally the matrix has a trachytic texture, especially in chilled margins of dykes.

C. Breccia (Pipe)

A satellitic breccia pipe occurs 300 metres and more south of the Berg stock, straddling the quartz diorite/hornfels contact (~~see~~ Figure 3). The pipe has an elliptical surface plan measuring 600 metres easterly by 150 metres northerly. */sketch.*

The pale buff breccia is composed of 40 percent angular to subrounded lithic fragments (1 to 35 millimetres in diameter, averaging about 10 millimetres), and 60 percent matrix consisting of finely comminuted and altered grains of quartz and alkali feldspar. Both matrix and fragments are extensively altered to carbonate, clays (mainly montmorillonite), sericite, and chlorite. As much as 2 percent pyrite is disseminated throughout the matrix with 1 percent, and more, contained in fragments. Recognizable fragments consist of andesite, siltstone, volcanic rocks that have not been seen on surface to date, and quartz monzonite. Rare fragments contain quartz-pyrite and quartz-molybdenite vein material.

In one drill hole a creamy buff coloured felsite that has a chilled contact against the breccia appears to have intruded the pipe. Its significance is not fully understood.

The breccia pipe is thought to be explosive in origin and formed during venting of fluids related in all probability to intrusions of the Berg stock. Presence of mineralized fragments suggests that the pipe formed after emplacement of plagioclase-biotite-quartz porphyry and may possibly be genetically related to the even younger quartz-feldspar porphyry.

D. Basalt

A dark greyish green basalt is noted in a few drill holes. The rock contains 1 to 2 millimetre grains of plagioclase (7 percent) and rare 1 millimetre grains of chloritized hornblende in a dark dense matrix. This rock is considered to be the latest intrusive event in the vicinity of the Berg deposit.

III. INTRUSIVE SEQUENCE AND AGE

A summary of the intrusive sequence into the Hazelton Group, which is based on cross-cutting relationships or presence of fragments of early phases within later, is listed below. The initial intrusion was the quartz diorite stock followed by the composite Berg stock, which from the oldest phase to youngest, consists of porphyritic quartz monzonite, quartz-plagioclase porphyry, plagioclase-biotite-quartz porphyry, and quartz-feldspar porphyry dykes. A breccia pipe that may be related to quartz-feldspar porphyry intruded rocks near the stock, finally basalt dykes intruded all older rocks. To date no primary copper minerals have been found in the quartz-feldspar porphyry^r or is there a quartz stockwork developed in this porphyry phase. Quartz-feldspar porphyry does contain pyrite, some of which is coated by chalcocite in the supergene zone.

Absolute ages of rocks at the Berg deposit using K-Ar analysis have been determined by Carter (1974) for five biotite and one whole rock specimens. Ages determined range from 52.0 to 46.8 million years with an average of 49.0 ± 2.4 million years (Middle Eocene).

IV. MINERALIZATION

1. Primary Mineralization

A quartz-sulphide stockwork centred on the porphyritic quartz monzonite and plagioclase-biotite-quartz porphyry phases of the Berg stock has been outlined by diamond-drill holes. The stockwork is imposed on all phases except the quartz-feldspar porphyry and basalt dykes. The intensity of stockwork development varies in such a way that the area most densely veined forms an annular ring around the composite stock. Within this zone the following vein sequence from oldest to youngest has been observed.

- Stage 1 A. Quartz-pyrite-chalcopyrite-molybdenite-chlorite veins with envelopes of quartz-sericite (common) or of chlorite (less common) or of K-feldspar (rare).
- B. Quartz-pyrite-chalcopyrite-molybdenite-chlorite veins without envelopes.

(The above associations may be modified by various combinations of the vein minerals and may include magnetite, purple anhydrite, traces of bornite, epidote, carbonate, and clay minerals.)

- Stage 2 A. Quartz-molybdenite (or molybdenite alone) veins without envelopes.
- B. Quartz-pyrite veins.
- Stage 3 Quartz-calcite-pyrite-sphalerite-chalcopyrite-tetrahedrite-gypsum-epidote+galena.
- Stage 4 Gypsum-filled fractures.

Cross-cutting relationships of Stage 1 veins allow at least 5 vein stages to be recognized. However, the similar mineralogy of

the various stages and the complex, often contradictory, relationships observed suggest that veins of Stage 1 A and B have filled a previously crackled zone rather than generated a sequential stage stock work system. Stage 1 quartz-pyrite veins are the most common type although quartz-pyrite veins younger than Stage 1 veins might be present. Stage 2 veins cross cut all earlier veins. Stage 3 is weakly developed outside the composite stock and Stage 4 is widespread throughout the mineralized zone.

A fragment of hornfels cut by a quartz-molybdenite vein and incorporated within porphyritic quartz monzonite has been noted. This suggests that an early molybdenum mineralization stage is associated with porphyritic quartz monzonite but significance of this type of mineralization with respect to the main mineralization sequence cannot be appraised at present.

Disseminated chalcopyrite and molybdenite are rare overall. Locally the three main intrusive phases and quartz diorite are mineralized with disseminated chalcopyrite and very rare disseminated molybdenite but truly disseminated ore mineral are greatly subordinate to those in fractures, veins, and quartz stockworks.

Sulphide minerals are distributed in annular zones which are vertical cylinder coaxial with and partly overlapping the porphyritic quartz monzonite and plagioclase-biotite-quartz porphyry phases of the Berg stock. The quartz-plagioclase porphyry is transected by the mineralized zone. The three main primary sulphides (pyrite, chalcopyrite, molybdenite) are best visualized to be present in three separate, overlapping, concentric cylindrical shells (Figures 6, 7, and 8). The

zone of molybdenite mineralization (Figure 8) is the smallest of the three; extending outward from the hornfels-intrusive stock contact for 100 metres to 135 metres. The chalcopyrite zone (Figure 7) also overlaps the contact and extends outward over 260 metres from it but best copper grades are within 130 metres to 170 metres of the contact. The pyrite zone (Figure 6) overlaps all other shells forming a pyrite halo around the entire zone of mineralization and extends about 700 metres to the south of the central stock. The width of the pyrite halo is considerable less in quartz diorite to the northeast.

Outward from the pyrite halo, several quartz-carbonate-pyrite-sphalerite-galena-tennantite veins occur on the ridge to the north and northeast of the Berg stock. In general sphalerite-bearing veins within the stock are rare but a few veinlets up to 3 millimetres in width containing quartz-pyrite-sphalerite-carbonate have been noted.

2. Supergene Mineralization

At Berg deposit a large limonite-stained zone over the mineralized zone is particularly striking because the area is mostly above tree line. Beneath the limonite-stained area, chalcocite (digenite?) and covellite are the most important secondary copper minerals. Chalcocite occurs as thin coatings on pyrite and chalcopyrite in rocks between the leached zone at surface and the gypsum-bearing rocks at depth. Figure 4 illustrates the relative position of the leached and enriched zones, and the gypsum surface in two sections across the Berg stock. The blanket of supergene enrichment (Figure 9) has increased copper grade of the primary mineralization by a factor in

the order of 1.25. There are two areas, in the northeastern and southeastern portions of the mineralized zone, where supergene enrichment persists to depths of 135 metres or more. These areas are characterized by extensive rock fracturing which has allowed excessively deep weathering and solution of gypsum, permitting supergene development.

Vertical zoning is illustrated on Figure 10, which shows (1) copper depletion and partial oxidation of molybdenite in a strongly oxidized zone near surface (leached zone), (2) downward migration of cupriferous groundwater and enrichment by replacement of pre-existing sulphides by chalcocite and covellite (enriched zone), and (3) a clearly defined gypsum surface, the surface below which fractures remain tightly cemented by gypsum and where there has been minimal groundwater circulation (primary zone).

Barakso and Bradshaw (1971) reported that spring and drill-hole discharge waters from the leached zone ranged from Eh 0.4 to 0.9 volts and pH 3.1 to 5.9. During summer dry periods pH was measured as pH 2.8. Under these oxidizing acidic conditions, all sulphides except for molybdenite are leached. Iron from pyrite and chalcopyrite breakdown is precipitated as orange or orange-brown, powdery, amorphous limonite, and locally as jarosite, which stain the rocks and coat all fractures. Transported limonite forms ferricrete blankets up to 1 metre thick where springs emerge at surface. Copper from chalcopyrite is removed in aqueous solution during weathering but molybdenum is immobile under acidic conditions (Garrels, 1954; Sato, 1960; Titley,

1963; Hansuld, 1966). Molybdenite is locally oxidized. Where this occurs, molybdenum is not leached but remains as ferrimolybdenite or molybdenum-bearing limonite. Molybdenum may be concentrated by both chemical and mechanical means in strongly oxidized rocks as is evident in some drill holes (~~see~~ Figure 10, DDH-1). Molybdenum commonly constitutes as much as 7 per cent in the limonite of porphyry deposits but at Berg deposit, Norton and Mariano (1967) reported that crushed limonites contained as much as 15 per cent molybdenum by weight.

In the enriched zone chalcocite and covellite have been deposited along with sparse amounts of cuprite, tenorite, bronchantite, and native copper. Near the top of the enriched zone, azurite and malachite may occasionally be found. Copper carbonates are common in outcrops associated with basic dykes and can also be found in outcropping quartz-feldspar porphyry.

Supergene enrichment appears to be a post-glacial weathering phenomenon formed by contemporary on-going processes in a single cycle weathering-enrichment system. It is unlikely that any pre-Fraser weathering products would be so intimately related to present topography. The author's opinion is that enrichment has taken place during the past 10,000 years or less.

V. ALTERATION

Chemical alteration of host rocks for the Berg deposit is basically two-fold: contact metamorphism (hornfelsing) associated with the stock intrusion and hydrothermal alteration associated with mineralization.

The intrusion of quartz diorite thermally metamorphosed Hazelton Group rocks as did intrusion of the composite Berg stock. Outward from

the intrusive contacts, biotite hornfels grad through albite-epidote hornfels into greenschist or lower facies. The apparent extent of hornfelsing associated with the Berg stock would appear to be in excess of that normally generated by a stock of this size. This suggests that the expected thermal aureole has been expanded through a mechanism involving circulation outward of hydrothermal fluids. Superimposed on the hornfelsed volcanic rock are the effects of hydrothermal alteration associated with the bulk of the mineralization.

Hydrothermal alteration affects all the mineralized phases of the composite Berg stock. The most obvious alteration is the development of envelopes of quartz-sericite (common), or quartz-chlorite (less common), or quartz-K-feldspar (rare) on quartz-sulphide (pyrite-chalcopyrite-molybdenite) veins. The vein sequence is difficult to define because each specific host area appear to be crackled rather than laced by a series of cross-cutting veins. However, there is a definite decrease in veins with hydrothermal envelopes outward from the Berg stock. In the hornfelsed rock where fracture density is high, pyrite veins may have a 7 millimetre wide bleached zones. Bleached zones are distinct from envelopes in that the minerals adjacent to veins are not changed to sericite, chlorite, or K-feldspar and the minerals are only leached of their iron content so that relict primary fabrics remain.

Pervasive hydrothermal effects in the intrusive phases below the gypsum surface consist primarily of sericitization of the mafic and feldspathic minerals and clay alteration of feldspars. The intensity of pervasive chemical changes within the stock varies from strong to weak sericitization, weak sericitization to strong kaolinization, and

to minor chloritization of mafic sericitization to strong kaolinization, and to minor chloritization of mafic minerals in relatively fresh late quartz-feldspar porphyry. Reddish brown euhedral biotite books are commonly present with kaolinized feldspar so that the association of kaolinite/secondary biotite might be common pervasive hydrothermal alteration type in the Berg stock. Outward from the stock in the horn-felsed rocks, disseminated pyrite, chlorite, carbonate, epidote, and magnetite become more common and constitute a propylitic zone. Above the gypsum surface the most pervasive alteration is supergene kaolinization of rock-constituent feldspars, particularly plagioclase phenocrysts in intrusive rocks.

Distribution of hydrothermal alteration facies is somewhat difficult to outline from present diamond-drill hole configuration and it is particularly difficult to extrapolate primary features (below the gypsum surface) to the surface through the supergene leached and enriched zones. The hydrothermal alteration facies are visualized, with the above qualifications in mind, as follows:

- (a) quartz-sericite-pyrite zone - a cylindrical zone overlapping the intrusive contact and border of the porphyritic quartz monzonite and plagioclase-biotite-quartz porphyry phases and extending outward irregularly up to 200 metres;
- (b) kaolinite-secondary biotite - this mineral pair is distributed throughout the entire stock and extends from the centre of the stock outward to where it overlaps or melds into the quartz-sericite-pyrite zone and possibly extends into horn-felsed rocks and quartz diorite for irregular distances up to

450 metres from the stock contact. Much of the kaolinite associated with secondary biotite above the gypsum surface is supergene in origin;

- (c) propylitic zone - an assemblage in chloritized hornfelsed rocks extending outward from the zone in which biotite is abundant and stable. The continuity of the latter zone into and through the quartz diorite is not known through lack of data.

Examination and heating experiments on a number of fluid inclusions have shown that some quartz-sulphide-anhydrite veins of Stage 1 contain highly saline 3 phase (liquids, gas, and NaCl crystal) fluid inclusions. Fluids were entrapped at high temperatures (greater than 450 degrees centigrade) and there is evidence that boiling took place. Other veins (Stage 2) with quartz-molybdenite and quartz-pyrite contain only 2 phase (liquid and gas) inclusions. These also indicate that boiling took place but filling temperatures were 285 degrees to 300 degrees centigrade.

VI. SYNTHESIS

The composite Berg stock intruded Middle Jurassic Hazelton Group volcanic rocks during the Middle Eocene (49.0 ± 2.4 million years). Porphyritic quartz monzonite intruded first followed by quartz-plagioclase porphyry which formed a funnel-shaped neck and a pipe through the porphyritic quartz monzonite and in turn was intruded by plagioclase-biotite-quartz porphyry. The latter formed a partial cylindrical sheath around the northern half of the pre-existing porphyritic monzonite.

Minor evidence indicates an early quartz-molybdenite mineralization. However major mineralization was closely associated with the plagioclase-biotite-quartz porphyry. A quartz-sulphide stockwork was developed in which molybdenite, chalcopyrite, and pyrite were zonally deposited around the margins of the porphyritic quartz monzonite and plagioclase-biotite-quartz porphyry bodies. A pyrite halo extends outward from the stock over a distance of at least 700 metres to the southwest. Hydrothermal alteration and lateral sulphide zonation form sheath-like zones centred on the stock and extending outwards.

Quartz-feldspar porphyry intruded the then existing stock along a northeast-southwest trend. It is pyritic but post-dates development of the quartz-sulphide stockwork.

A breccia pipe near the Berg stock is thought to be genetically related to the stock and formed during venting of fluids. Mineralized fragments within the breccia suggest that formation of the pipe post-dates stockwork mineralization.

Pleistocene glaciation exposed mineralized rocks and weathering-supergene processes were initiated which leached late stage gypsum-filled fractures and allowed formation of supergene copper minerals, silicates, and hydroxides, and resulted in development of pronounced vertical zoning.

ACKNOWLEDGMENTS

Much of our understanding of the Berg deposit is based on and developed from perceptive early studies by geologists of Kennco Explorations, (Western) Limited, notably G. O. M. Stewart and C. S. Ney, as well as A. Sutherland Brown of the British Columbia Department of Mines and Petroleum Resources. Additional material was gathered for a dissertation by one of us (A. Panteleyev) while employed by Kennco Explorations. To facilitate this paper Canex Placer Limited generously made available all needed information. We acknowledge with gratitude the co-operation of Kennco Explorations, (Western) Limited and Canex Placer Limited and for permission to publish this paper. We are especially grateful to those colleagues whose advice and criticism prompted us to revise and clarify earlier drafts of this paper. Illustrations were prepared by the draughting department of the British Columbia Department of Mines.

SELECTED REFERENCES

- Barakso, J. J. and Bradshaw, B. A. (1971): Molybdenum Surface Depletion and Leaching in Geochemical Exploration, CIM Spec. Vol. No. 11, pp. 78-84.
- Carter, N. C. (1974): Geology and Geochronology of Porphyry Copper and Molybdenum Deposits in West-Central British Columbia, unpublished PhD Thesis, UBC; and B. C. Dept. of Mines & Petroleum Resources, Bull. 64, in preparation.
- Duffel, S. (1959): Whitesail Lake Map-Area, Geol. Surv. Canada, Mem 299.
- Garrels, R. M. (1954): Mineral Species as Functions of pH and Oxidation-Reduction Potentials with Special Reference to the Zone of Oxidation and Secondary Enrichment of Sulphide Ore Deposits, Geochem. et Cosmochim. Acta, Vol. 5, pp. 153-168.
- Hansuld, J. A. (1966): Eh and Ph in Geochemical Exploration, CIM Bull. Vol. 59, pp. 315-322.
- Norton, D. L. and Mariano, A. N. (1967): Sibolaite, MoO_2 , A New Mineral from the Sibola Mountains, British Columbia, Berg Examination, Progress Rept. 1966, Appendix B, p. 7; private report, Kennco Explorations, (Western) Limited.
- Panteleyev, A. (): Geological Setting, Mineralization, and Aspects of Zoning at the Berg Porphyry Copper-Molybdenum Deposit, Central British Columbia, B. C. Dept. of Mines & Petroleum Resources, Bull. 65, in preparation.
- Richards, T. A. (1974): Hazelton East-Half, Geol. Surv. Canada, Paper 74-1, Part A, pp. 35-37.

- Sato, Motoaki (1960): (a) Oxidation of Sulphide Ore Bodies - 1, Geochemical Environments in Terms of Eh and pH, Econ. Geol., Vol. 55, pp. 928-961; (b) Mechanisms of Sulphide Ore Bodies - 11, Oxidation of Sulphide Minerals at 25^o C, Econ. Geol., Vol. 55, pp. 1202-1231.
- Sutherland Brown, A. (1967): Berg, Ann^{ual} Rept. of the B. C. Minister of Mines and Petroleum Resources, 1966, pp. 105-111.
- Tipper, H. W. (1972): Smithers map-area, Rept. of Activities, Geol. Surv. Canada, Paper 72-1A, pp. 39-41.
- Titley, S. R. (1963): Some Behavioral Aspects of Molybdenum in the Supergene Environment, Soc. of Mining Eng., Transactions, Vol. 15, pp. 199-204.