Title GEM Kamloops Valley Copper

Author McMillan

Date and Typist April 19, 1971 rm 1

896388

VALLEY COPPER (No. , Fig.) By W. J. McMillan

LOCATION: Lat. 50° 29' Long. 121° 03' (921/6E)

Highland Valley, west and southwest of Quiltanton Lake, at approximately 4,000 feet elevation.

CLAIMS: HH, AL, DF, GRR, MD, LTK totalling 15 claims and 300 claims in three other groups.

ACCESS: On the Highland Valley highway, 25 miles southeast of Ashcroft.

OWNER: Valley Copper Mines Limited.

OPERATOR: COMINCO LTD., 1155 West Georgia Street, Vancouver 5.

METALS: Copper, molybdenum.

DESCRIPTION:

Acknowledgments

The writer gratefully acknowledges many valuable discussions with and the cooperation of Cominco staff geologists, particularly Dr. J. M. Allen and R. Nichols, associated with the Valley Copper project. Thanks are also extended to D. Miller of Bethlehem Copper Corporation Ltd. and Darkhawk Mines Ltd. for their cooperation. X-ray analyses were done by N. Colvin of the Department of Mines and Petroleum Resources

Introduction

The Valley Copper deposit underlies the Highland Valley west of Quiltanton Lake. The surface projection of the deposit extends from the valley floor to elevation 4,350 feet on the southwest slope and is slightly elongated to the northwest (Fig.). The Highland Valley is floored by Pleistocene glaciofluvial sands and gravels which contain till layers. Overburden is less than 100 feet thick over much of the deposit but thickens to more than 500 feet near its northeast edge. Under Quiltanton Lake, Pleistocene deposits reach a thickness of more than 850 feet.

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The mineral deposit is entirely in quartz monzonite of the Bethsaida phase of the Guichon Creek Batholith and is west of the Lornex fault (Fig.). The rocks of the deposit were subjected to argillic alteration, followed by extensive quartz veining, quartz-sericite veining, and silicification. Bornite and chalcopyrite were introduced with the quartz and quartz-sericite veins and typically fill angular openings in them. Molybdenite which occurs with the copper sulphides is widespread but sparse. Pyrite is uncommon but up to 2 per cent hematite occurs in the deposit (Allen and Richardson, 1970). Pre-ore porphyry and aplite dykes and post-ore porphyry and lamprophyre dykes are present but not common. Apparently dykes have little influence on ore deposition.

History

According to Allen and Richardson (1970) the area of the deposit was considered interesting in 1966 because regional geologic mapping begun in 1964 suggested that:

(1) Ore deposits in Highland Valley are structurally controlled.

(2) The fault which apparently cuts off the west side of the Lornex deposit passes through Quiltanton Lake.

(3) Offset on the Lornex fault was right lateral and of the order of 2 miles.

(4) Highland Valley might be underlain by a fault which could produce conditions favourable to ore deposition at or near its junction with the Lornex fault.

Percussion drilling on the Bethsaida claims began in 1967 and continued in 1968. The Valley Copper deposit was discovered in 1968 as a result of percussion drilling of a target area outlined by an induced polarization survey (Minister of Mines, B.C., Ann. Rept., 1968, p. 181). Extensive diamond drilling was also begun in 1968. At that time Carr (op. cit., p. 181) suggested that the Valley and Lornex deposits are segments of of one orebody which was split by post-mineral faulting. In 1969, an underground exploration and bulk sampling programme was begun which was completed in mid-1970. Surface and underground diamond drilling was also continued into 1970. At completion of the programme the company announced that the deposit contains 600,000 tons per vertical foot grading 0.48 per cent copper to a depth of 1,450 feet; that is, ore reserves are more than 850 million tons. Subsequently, the property has been idle pending the outcome of feasibility studies.

Host Rock

The Valley Copper deposit is within essentially one rock type, Bethsaida quartz monzonite. This has been extensively shattered, altered, veined, and mineralized. In much of the underground workings (Fig.) and in much of the drilling (Figs. and) veins are so abundant that the rock consists of angular fragments separated by veins. Fragments have not been rotated but only ~~expanded~~ separated hence the area of the deposit is best termed a shatter zone (Allen and Richardson, 1970).

Beyond the deposit, Bethsaida quartz monzonite consists of coarsely crystalline euhedral complexly zoned plagioclase, euhedral biotite books, and subhedral quartz with interstitial anhedral quartz and perthitic microcline (Northcote, 1969, p. 37). In the deposit, feldspars are clouded by alteration, plagioclase zoning is commonly destroyed, biotite is altered, and microcline may be destroyed. Quartz crystals are generally enlarged, most markedly so near veins (Plate).

Local textural and mineralogical variations occur in the Bethsaida quartz monzonite at Valley Copper but evidently do not influence ore distribution. Mafic areas are seen in drill core which contain up to 40 per cent combined magnetite and biotite as well as abundant apatite. Similar mafic areas which were mapped outside and west of the orebody form ill-defined bodies which grade into normal Bethsaida quartz monzonite. Local areas are also seen in drill core in which the Bethsaida quartz monzonite is porphyritic with aplitic or subaplitic matrix. Similar porphyritic areas which were studied elsewhere in the Bethsaida quartz monzonite are patchily distributed and grade into normal Bethsaida. They do not form mappable units. It is surmised that in the mafic areas heavy minerals were concentrated by current action, as the crystal-liquid mush which now constitutes the Bethsaida phase was emplaced. Porphyritic zones probably resulted from uneven distribution of volatiles throughout the crystal-liquid mush. Areas relatively poor in volatiles would solidify at higher temperatures with less crystal growth and resultant porphyritic textures.

Dykes

Both pre- and post-ore dykes occur in the Valley Copper deposit but dykes are volumetrically insignificant. Within the orebody, pre-ore dykes are veined and mineralized like the country rock. At the northwest edge of the deposit, however, they seem to have been only semi-permeable to mineralizing solutions and now virtually mark the limit of the ore (Fig.).

There are two varieties of pre-ore dykes. Both are quartz plagioclase porphyries, both have aplitic matrices. One set, leucocratic quartz plagioclase porphyry, that has a pinkish tan or rarely salmon pink matrix forms narrow dykes that commonly occur in swarms. The second and predominant set consists of biotite quartz plagioclase porphyry that has a green matrix and forms narrow to wide dykes.

Two varieties of post-ore dykes also occur. One set, leucocratic quartz plagioclase porphyry, forms narrow dykes and is similar to leucocratic pre-ore dykes. However, it is not veined or mineralized. The second set, lamprophyre, forms narrow dykes which are dark green and speckled with mafic phenocrysts. Based on staining and thin-section analysis, potash feldspar is the dominant feldspar in the lamprophyres. Thus they are biotite augite or hornblende augite vogesites. Lamprophyres are extensively altered to sericite, chlorite, and carbonate, and the latter also veins the rock.

Trends of Dykes

None of the dykes crop out but drilling and underground workings have shown that they strike north or southeast. Various level plans which have been drawn by Cominco geologists indicate that dips are steep. An individual dyke commonly varies in dip either side of vertical. Some dykes apparently bifurcate. No trends were determined for lamprophyre dykes but pre-ore and post-ore porphyries have parallel trends. Dykes probably occupy joints or subsidiary faults formed during movement on the nearby Lornex fault.

Structural Setting

The mineral deposit is west of the Lornex fault near its junction with the northeast-trending Lake and Highland Valley faults (Fig.). The existence of the Lornex fault is well documented immediately south of Quiltanton Lake and further south near the Lornex deposit where it offsets the Bethsaida-Bethlehem contact. The Highland Valley fault which occurs along Highland Valley east of the Lornex fault is inferred from drilling on Indian Reserve 13. The holes intersected a wedge of Tertiary sedimentary rocks bounded by steep slopes on its west and south sides. The Lake fault along Highland Valley west of the Lornex fault is inferred from drilling on ground west of Quiltanton Lake owned by Arlington Silver Mines Ltd. The drill holes cut Tertiary volcanic rocks in a basin which is bounded on its south side by a very steep slope.

Structural Data from Valley Copper Declines

Structural data from the underground workings are highlighted on Table 1 which is a synopsis of ~~(and illustrated on)~~ Figure . Characteristically, dominant faults comprise one south-southeast-striking set which dips steeply northeast and one subhorizontal set. Joints have a corresponding south-southeast-striking set as well as an east-southeast-striking set which dips steeply southwest in declines A and B and steeply northeast in decline C. Veins have south-southeast- and east-southeast-striking sets which are parallel to the predominant fault set and both joint sets.

Structural data from declines A, B and C were plotted on an equal area stereographic projection and contoured. Concentrations ~~(In declines A, B, and C the distribution)~~ of poles to joints and veins ~~very nearly~~ almost coincide (Fig.). Similarly in decline A and to a lesser extent in decline C, where only 51 faults are plotted, concentrations ~~the (distribution)~~ of poles to veins and faults nearly coincide. The explanation for these data is that veins occupy faults and joints.

As was mentioned previously, faults in the main set at Valley Copper strike south-southeast and dip 50 to 60 degrees toward the northeast. Presumably these faults are offshoots of and subparallel to the nearby Lornex fault. Thus the Lornex fault may also dip steeply northeast near Quiltanton Lake and the apparent change in strike south of the lake may be a topographic effect. Near Lornex, drilling suggests the Lornex fault has a steep westerly dip. No steeply dipping faults subparallel to the Lake fault are recorded from decline A and ~~oney~~ only a few occur in decline C. Hence the underground workings provide little evidence of a fault parallel to Highland Valley west of the Lornex fault.

A model is advanced to explain right lateral movement on the Lornex fault. In this model the maximum principal stress (σ_1) is subhorizontal and oriented northeast-southwest, the intermediate principal stress (σ_2) is steeply inclined, and the minimum principal stress (σ_3) is subhorizontal and oriented southeast-northwest. If right lateral movement on Lornex fault is responsible for many of the joints at Valley Copper, theoretically one would expect to find steeply dipping shear joints striking subparallel to and about 35 degrees northeastward of the Lornex fault and steeply dipping tension joints striking about ~~(110 degrees and)~~ 20 degrees northeastward of the fault in the $\sigma_1 - \sigma_2$ plane. [Insert sentence] Two sets of joints occur as predicted--these are a set subparallel to the Lornex fault (shear joints ?) and a set striking at azimuth ~~about~~ 110 degrees (later tension joints ?). The predicted secondary shear and tension joint sets were not recognized.

Subhorizontal faults and joints are apparently anomalous in the model. However, two possible explanations are:

(1) After the main period of faulting was complete the intermediate and minimum principal stresses interchanged. That is, the subhorizontal structures are small-scale late stage thrust faults and shear joints.

(2) Spreading of fragments in the Valley Copper shatter zone suggests high fluid pressures. If a convection cell were in operation during ore emplacement, the underground workings are in what was the upwelling zone because they are close to the quartz-rich ~~(ore zone)~~ center of the deposit. Thus the gently dipping structures may be tension faults and joints formed as convective flow waned and surged during vein and ore formation.

If the second possibility is correct, ~~it is possible that~~ the high fluid pressure may have initiated vertical movement on the Lornex fault during mineralization.

Summary

Omit

~~A model is proposed in which the Lornex fault was formed as a result of subhorizontal northeastward~~ or ~~(and) southwestward directed maximum principal stress (σ_1), steeply inclined intermediate principal stress (σ_2), and subhorizontal northwestward or southeastward directed minimum principal stress (σ_3). This resulted in right lateral (dextral) motion on the fault. The most abundant faults and joints at Valley Copper can be explained by this stress model but low angle joints and faults are attributed either to a later episode of small-scale thrusting or to fluxuations in pressure of upwelling fluids during~~

~~vein and ore formation~~ ¶ One aspect of this proposed model is that the Valley Copper deposit would post-date at least some right lateral movement on the Lornex fault.

Tertiary Sedimentation, Vulcanism, and Faulting

In the Tertiary basin bounded by the Lornex and Highland Valley faults slightly indurated sedimentary rocks predominate. The rocks form a wedge which thins rapidly toward the northeast (sections 2 and 3, Fig.) and is probably more than 1,000 feet thick near the junction of the faults (sections 2, 5, and 6, Fig.). The sedimentary rocks are immature siltstones and pebble conglomerates with local black, massive to laminated argillite layers and thin coaly layers. Bedding laminae are typically at 40 degrees to 85 degrees to the axes of vertical diamond drill holes, ie, ~~vertical axis of the core~~. ~~That is~~ dips commonly range from 5 to 50 ~~50 degrees to 5~~ degrees. However, dips between 25 degrees and 40 degrees predominate. The immature nature of the rocks and varying dips suggest they represent deltaic and lake bottom deposits. Many of the pebbles in the conglomerates were derived from a granitic terrain thus transport ~~transport~~ was probably from the west and south.

To the northeast, the sedimentary rocks thin rapidly and are apparently intertongued with a conglomerate containing fragments of volcanic rock and Bethlehem granodiorite. The conglomerate grades downward into unweathered Bethlehem granodiorite and is overlain by amygdaloidal dacitic andesite of the Kamloops Group. The flows are also inferred to be intertongued with the sedimentary rocks to the southwest. The volcanic source area is to the northeast (section 4, Fig.). In summary, the Tertiary basin was filled by clastic material eroded from granitic highlands to the south and west and by clastic and volcanic material from source areas to the northeast.

The Tertiary depositional area bounded by the Lake fault was filled by volcanic material. The volcanic deposits consist both of agglomerate and foliated porphyritic igneous rocks which may be dykes. ~~(Topography, outcrops)~~ Outcrops and drilling indicate that the deposits are thick near the fault and thin to the north and west. Drilling north and south of the Lake fault indicate a 75-degree minimum dip for the fault scarp which is the south boundary of the basin. Drill holes indicate that the biotite plagioclase porphyry dykes cut both the underlying granodiorite and the agglomerates. Most fragments in the agglomerates have the same composition as the dykes. The depositional basin probably contained one or more Tertiary volcanoes.

The Tertiary basins are bounded by the north-striking Lornex and easterly striking Lake and Highland Valley faults and result from block faulting in Highland Valley. As was previously discussed, dextral movement occurred along the Lornex fault before formation of the Valley Copper deposit. The Lake and Highland Valley faults were both active in Tertiary time but it is not clear whether they were initiated or simply rejuvenated at that time.

Summary

Several conclusions may be drawn about fault age relations and movements from the data:

(1) The Lornex fault was active before the Valley Copper deposit formed.

(2) Offset of the Bethsaida quartz monzonite-Bethlehem granodiorite contact indicates right lateral motion on the Lornex fault which post-dates consolidation of the Bethsaida phase.

(3) The Highland Valley fault is younger than the Bethlehem phase.

(4) The Lake fault is younger than the Bethsaida phase.

(5) Block faulting occurred (east side down, Lornex fault; northern side down, Lake and Highland Valley faults) prior to but probably not long before deposition of

Tertiary volcanic and sedimentary rocks. Fault scarp erosion probably accounts for landslide deposits and the immature nature of Tertiary deltaic and lake bottom (?) sediments south of Quiltanton Lake.

(6) The time of initiation of the Lake and Highland Valley faults is uncertain.

Alteration, Veining, and Mineralization

Introduction

At Valley Copper variations in grade are related to variations in intensity and type of veining and alteration in the host rock. Where veining is not extensive grade is low; where quartz veining is extensive grade is relatively low; but where quartz-sericite veining and alteration ~~is~~ are extensive grade is relatively high. The first condition is encountered at the gradational borders of the deposit, the second in the core of the deposit where poorly mineralized, relatively young quartz veins are abundant (Figs. and), and the third throughout the remainder of the orebody. In the core zone poorly mineralized quartz veins cut quartz-sericite zones and form an elongated dome with gradational contacts. As it is followed northwestward in longitudonal section (Fig.), the apex of the quartz-rich dome plunges gently at first and then steeply toward the northwest. The northeast flank dips northeast at about 40 degrees and the southwest flank is subvertical in transverse section (Fig.).

Argillic Alteration

Variation in the intensity of argillic alteration is illustrated on Figures ___ and for transverse and longitudonal sections through the orebody. In section 13 moderate to intense argillic alteration is most prominent along the gently northeast-dipping flank of the quartz-rich dome. Above and southwest of the core dome, intense argillic alteration forms a thin selvedge which approximately encloses the outer edge of the transitional contact of the dome. In section E, moderate to intense argillic alteration is most prominent in a gently northwest-plunging zone which extends from just above the contact of the transition zone to the edge of the orebody.

Feldspar in argillic alteration zones may be pale green, waxy green, emerald green, or chalky in shades of pale green to white. In the intensely altered chalky zones X-ray studies reveal kaolinite and sometimes illite with sericite and carbonate. Where alteration is less intense sericite with carbonate and sometimes chlorite predominate and X-ray diffraction photographs show no clay minerals. Primary potash feldspar was destroyed in at least some chalky alteration zones.

Biotite alteration seems to coincide approximately with argillic alteration but was not studied in detail. In areas of low to moderate argillic alteration biotite tends to be altered to chlorite; in areas of moderate to intense argillic alteration it tends to be altered to a mixture of sericite and carbonate. Sericite forms the body of the pseudomorph and ~~with~~ lensy carbonate plates lie in ~~along~~ the biotite cleavage planes.

Veining

Four main vein types are important. These are quartz sericite sulphide, quartz ± sericite ± sulphide, quartz potash feldspar ± sericite ± sulphide, and quartz ± sulphide. Those with sericite commonly carry higher values than those with no sericite.

Quartz sericite veining.--Most quartz sericite envelopes are centred by and presumably associated with quartz veins containing pods of sericite. Drill core containing quartz sericite zones but no associated quartz veins may simply have passed through a halo around a vein. Consequently, when the core was logged, quartz sericite alteration zones and quartz veins with sericite or quartz sericite halos were mapped as one entity and labelled quartz sericite veins.

The central quartz veins contain copper and to a lesser extent molybdenum sulphides as relatively late-stage crack or vug fillings (Plates and). In addition, sulphides form angular bodies between coarse-grained sericite crystals and line vugs in porous quartz sericite zones (Plate). Although there are many exceptions, bornite is generally more prominent than chalcopyrite in quartz sericite veins.

Quartz sericite veins vary from quartz veins with thin coarse-grained sericite selvedges to quartz veins with vuggy quartz sericite halos wider than the vein to vuggy quartz sericite zones with hairline or no apparent central quartz vein. Quartz sericite halos often contain inclusions of the host rock. Ocherous hematite is a common but not abundant coating on or filling between sericite plates. Vugs in the halos are often lined with quartz or carbonate crystals and contain copper or molybdenum sulphides. Occasionally, the copper sulphides seem to display crystal faces although these ~~they~~ may be molds of quartz crystal faces. Quartz sericite halos commonly grade outward into a zone rich in potash feldspar. The rind of potash feldspar is usually less than one-half inch wide.

The episode or more probably episodes of quartz sericite veining and alteration represent the main ore-forming stage. In part this probably reflects the state of evolution of the ore-forming fluid and in part the fact that numerous sites chemically favourable for deposition of metallic sulphides were present. It is likely that bornite predominating over chalcopyrite indicates a shortage of sulphur and reflects the state of evolution of the ore-forming fluid.

Quartz, Quartz ± Sericite, and Quartz Potash Feldspar ± Sericite Veining.-- At least two generations of quartz veins occur in the Valley Copper orebody. Earlier ones typically contain scattered pods, lenses, or selvedges of sericite. Copper mineralization is more abundant in these than in younger sericite-poor veins and much of the sulphide occurs with or near the sericite. Potash feldspar and carbonate are constituents of many quartz veins and potash feldspar may be abundant. Both hematite and pyrite occur in quartz veins but both are uncommon. Potash feldspar alteration is common adjacent to quartz veins and locally the host rock is flooded with salmon pink microcline. Copper sulphides commonly fill angular openings in quartz veins. Molybdenite is almost invariably smeared out along slip planes. In general, younger sericite-poor quartz veins contain more chalcopyrite than bornite.

As in the quartz sericite veins, sulphides have been deposited late, in favourable sites within the quartz veins. That is, veining produced physically and chemically appropriate sites into which sulphides were deposited. Concordantly, sulphide deposition probably reflects evolutionary changes in the composition of the ore-forming fluids.

Anhydrite-gypsum veining.--Gypsum veins are common below the so-called gypsum line (Figs. and) in the Valley Copper deposit. Commonly the gypsum is fibrous and white to orange but locally it forms large platy crystals or it may be massive. Gypsum veins often parallel or form borders on quartz veins but also cut both quartz and quartz sericite veins. Gypsum vein formation is apparently post-ore. However, tenuous evidence suggests gypsum veins are secondary, not late-stage primary veins. Indirect evidence is ~~probided~~ provided by anhydrite which is intimately intergrown with sericite and associated potash feldspar alteration near the bottom of at least one deep drill hole. That is, anhydrite is apparently the same age as and associated with sericitic and potassic alteration. More direct evidence is provided by quartz-gypsum veins and quartz-potash feldspar veins ~~with~~ in which gypsum ~~filling~~ fills angular interstices. In these instances, what is now gypsum was deposited with the quartz and quartz-potash feldspar veins. Gypsum may form late-stage primary veins but it is more likely in view of age relationships and the spatial relationships of gypsum and earlier quartz veins that gypsum veins are secondary. It is speculated that gypsum was formed at the expense of anhydrite which was deposited from the ore-forming fluids. No evidence was seen to suggest that gypsum veins ~~ever~~ existed above the gypsum line.

The position of the gypsum line was probably controlled by the composition of the ore-forming fluids and pressure-temperature conditions. One interpretation is that it represents the level at which the ore-forming fluid was so depleted in $CaSO_4$ because of anhydrite deposition lower in the orebody that deposition ceased. Subsequently, anhydrite in the upper part of the deposit was hydrated and most was reconstituted as gypsum veins. A second interpretation assumes fluids were moving in a convective cycle upward through what is now the quartz-rich core zone outward then downward and back into the core zone. In this instance composition of ore fluid rather than pressure and temperature must have controlled anhydrite deposition because the gypsum line is depressed toward higher pressure-temperature conditions in the core zone.

Ore Mineralogy

Chalcopyrite, bornite, and molybdenite are the typical ore minerals at Valley Copper. Common gangue minerals are quartz and sericite with ubiquitous but not abundant hematite and uncommon pyrite. Gypsum is a common accessory in the lower reaches of the deposit below the gypsum line. Lower still gypsum is joined by anhydrite. Secondary minerals associated with the veins are sericite, carbonate (siderite and calcite), clay minerals (kaolinite and illite), chlorite, and potash feldspar (microcline).

Petruk (1970) reported that chalcocite fills hairline cracks in bornite and ilmenite and rutile occur as a result of biotite alteration. He also identified gold and gudmundite (iron antimony sulphide).

In the thin oxidized capping of the deposit, iron oxide, malachite, coatings of black sooty chalcocite (?), and rarely native copper occur. Throughout the oxide zone unreplaced sulphides can be found and no supergene enrichment zone was recognized.

Chalcopyrite-Bornite Ratios

In section E (Fig.) it is seen that chalcopyrite equals or exceeds bornite in abundance along the northwest fringe of the ore and southeast of drill hole 68-5. In section 13 (Fig.) chalcopyrite equals or exceeds bornite on both the southwest and northeast flanks of the orebody as well as in and above the quartz-rich core zone. Chalcopyrite to bornite ratios from the centre to the edge of the deposit probably reflect chemical changes in the ore-forming fluid as it (~~migrated~~) was cycled. Thus there is subtle iron zonation with iron increasing relative to copper toward the borders of the deposit. In and above the core zone chalcopyrite enrichment is attributed to the abundance of relatively young quartz veins. As was remarked elsewhere they tend to have more chalcopyrite than bornite. It should be remembered that proportions here are qualitative; averaging the entire deposit would probably give more bornite than chalcopyrite.

Summary

It is evident from the structural data that the mineralized veins at Valley Copper occupy faults and joints which apparently formed in response to right lateral pre-ore movement on the Lornex fault. Therefore the first event leading up to mineralization was faulting which produced conduits subsequently used by the fluids which caused dilation and pervasive argillic alteration then quartz sericite sulphide and quartz ± sericite ± sulphide veining. Potassic alteration is associated with both quartz sericite and quartz veining. Gypsum which may be secondary after anhydrite and, in some deeper holes, anhydrite form veins below the gypsum line.

WORK DONE:

REFERENCES: B.C. Dept. of Mines & Pet. Res., K. E. Northcote, Geology and Geochronology of the Guichon Creek Batholith, Bull. 56, 1969; Minister of Mines, B.C., Ann. Rept., 1968, p. 181; B.C. Dept. of Mines & Pet. Res., G.E.M., 1969, p. 266; Allen, J. M., and Richardson, J., 1970, Geological Setting of the Valley Copper Orebody, paper delivered at C.I.M.M. Annual Meeting, April, 1970; Dept. of Energy, Mines, and Resources, Mines Branch, W. Petruk, Preliminary Mineralogical Study of the Copper Molybdenum Deposit of the Valley Copper Mines Limited in the Highland Valley Area in British Columbia, IR 70-71 (Industrial Confidential), 1970.

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VALLEY COPPER -- MOST PROMINENT STRUCTURAL TRENDS IN DECLINES

	FAULTS	JOINTS	VEINS
DECLINE A	173/64NE 000/16E --------- 018/54SE non-significant ? 004/90	169/68NE --------- 108/68SW ---------	161/64NE 034/15SE 104/71SW ---------
DECLINE B	No data	163/58NE 111/75SW 037/42SE 038/54NW --------- ---------	156/65NE 110/80SW --------- --------- 094/23SW } non-significant ? 100/42NE
DECLINE C	160/50NE 108/84SW --------- --------- 108/25SW 000/00	160/60NE 118/84SW 125/75NE 073/18SE --------- ---------	152/56NE 111/79SW 126/74NE 101/42SW 047/10SE

	~~GENERALIZED~~ FAULTS	~~GENERAL~~ JOINTS	~~GENERAL~~ VEINS	GENERAL ~~OVERALL~~ COMMENT
OVERALL TRENDS	One steep south-southeast set (NE dip) One subhorizontal set	One steep south-southeast set (NE dip) One steep east-southeast set (SW and NE dip)	One steep south-southeast set (NE dip) One steep east-southeast set (SW and NE dips)	Veins occupy, that is, are younger than, joints and faults. Post-mineralization movement is common.