Tom Schroeter

Valley Copper
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THE GEOLOGICAL SETTING OF THE VALLEY COPPER OREBODY

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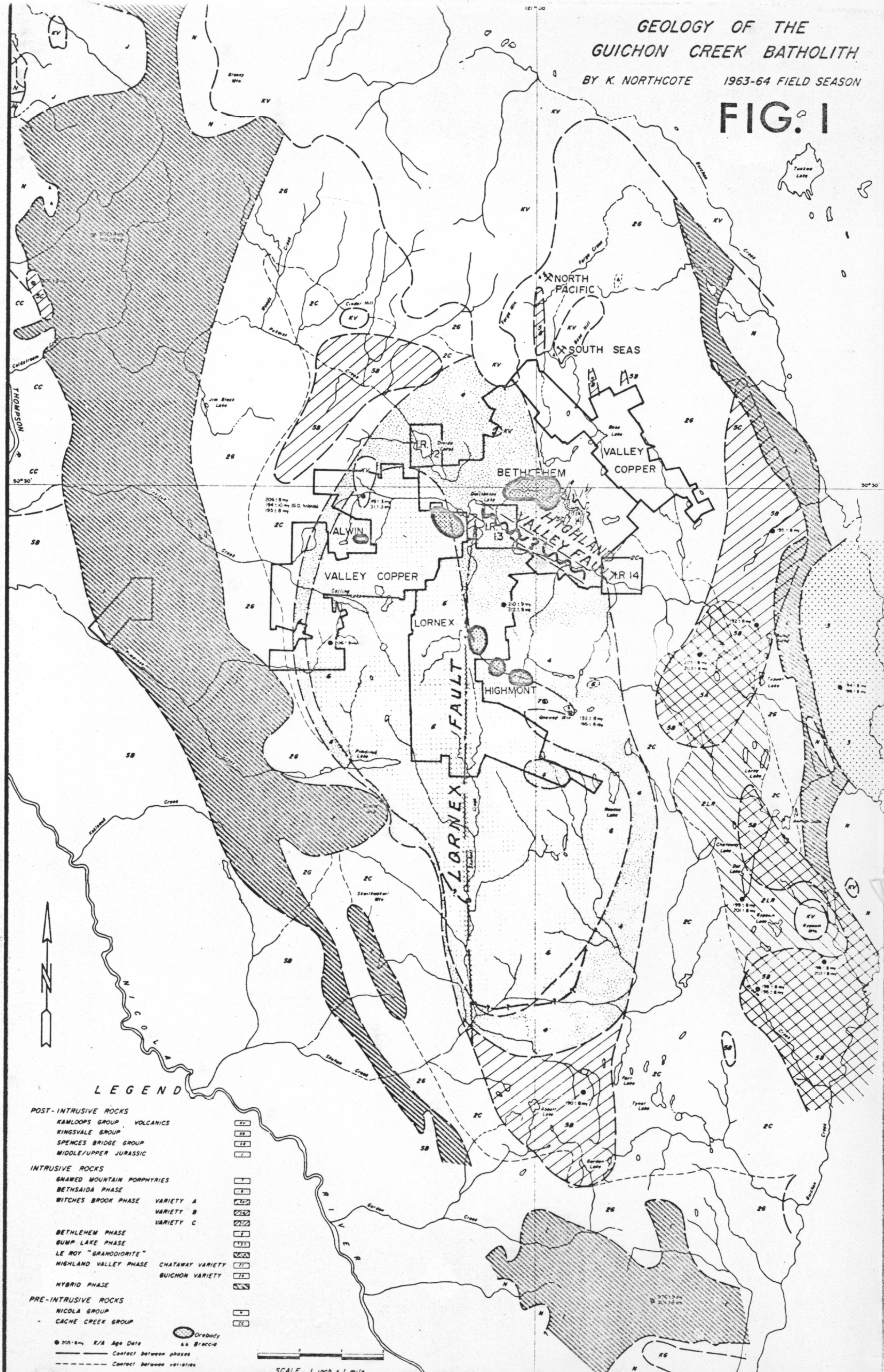

GEOLOGY OF THE GUICHON CREEK BATHOLITH
BY K. NORTHCOTE 1963-64 FIELD SEASON
FIG. I
NORTH PACIFIC
SOUTH SEAS
VALLEY COPPER
BETHLEHEM
I.R. 2
I.R. 13
I.R. 14
HIGHLAND VALLEY FAULT
ALWIN
VALLEY COPPER
LORNEX
HIGHMONT
LORNEX FAULT
THOMPSON
NICOLA RIVER
LEGEND
POST-INTRUSIVE ROCKS
KAMLOOPS GROUP VOLCANICS
KINGSVALE GROUP
SPENCES BRIDGE GROUP
MIDDLE/UPPER JURASSIC
INTRUSIVE ROCKS
GNAWED MOUNTAIN PORPHYRIES
BETHSAIDA PHASE
WITCHES BROOK PHASE VARIETY A
VARIETY B
VARIETY C
BETHLEHEM PHASE
BUMP LAKE PHASE
LE ROY "GRANODIORITE"
HIGHLAND VALLEY PHASE CHATAWAY VARIETY
GUICHON VARIETY
HYBRID PHASE
PRE-INTRUSIVE ROCKS
NICOLA GROUP
CACHE CREEK GROUP
Orebody
Breccia
K/A Age Date
Contact between phases
Contact between varieties
SCALE 1 inch = 1 mile

THE GEOLOGY OF THE VALLEY COPPER OREBODY

During the past five years, the Highland Valley area of British Columbia has been the site of two major copper discoveries, Valley Copper and Lornex. A third discovery, Highmont, may also prove to be of major importance. Taken with the existing producers, Bethlehem and Craigmont, these potential orebodies suggest that the Highland Valley area may become one of the major copper areas of the world.

The location of the major discoveries, current producers and more promising showings is shown on the accompanying sketch (Fig. I). All of these are within or at the contact of the Guichon batholith, a concentrically zoned body of quartz diorite composition emplaced about 200 million years ago in Upper Triassic time. The deposits and showings discovered to date have many features in common and all are genetically linked to magmatic processes in the Guichon batholith. The purpose of this paper is to comment on the discovery of one of them, Valley Copper, and to describe what is presently known about the deposit.

GEOLOGICAL SETTING

The Guichon batholith is a roughly oval body at least 24 miles long and up to 15 miles wide. Its long axis strikes 345°. The batholith is bounded on the east and west by major north trending faults and according to Carr these faults delimit an up-faulted block of Cache Creek and Nicola rocks into which the batholith has been intruded. The rocks of the batholith are overlain by four later groups consisting largely of volcanics ranging in age from Middle Jurassic to Eocene. The age of the batholith is on geological evidence limited to the interval between early Upper Triassic to Middle Jurassic.

Isotopic ages on rocks of the batholith, 55 of which have now been published, show a remarkable concordance. The average for all of these ages is 196 million $\pm$ 8 M.Y. and the spread is from 184 to 206 M.Y. Most of these ages were done by the K/A method and the possibility of Argon loss has to be considered, however, six Rb/Sr ages from the Craigmont mine agree very closely, i.e. 200 $\pm$ 2 M.Y. and this plus the lack of evidence of metamorphism which might have caused Argon loss shows that the ages are probably reliable. On the absolute time scale, this would place the time of consolidation of the Guichon rocks in the Upper Triassic.

The isotopic ages also show that there is no significant or systematic difference in age among the various phases of the intrusive. It would appear that all of the phases crystallized within a short interval and that multiple intrusion, if it did occur, must have been over a short period as well.

INTERNAL STRUCTURE OF THE BATHOLITH

The gross structural pattern in the batholith is shown,best by the distribution of intrusive phases. These phases are arranged in a concentric pattern around a central core of Bethsaida quartz monzonite. The Witches Brook phase displays cross-cutting relationships, but this rock type occurs only in dikes and relatively small irregular masses and since its distribution was probably controlled by local structure, it does not really disrupt the overall pattern.

The type and distribution of phases is shown on the accompanying figure. In all, there are seven distinct phases, two of which are subdivided into five varieties and a late porphyritic phase. There is no significant difference in the absolute ages of the phases, however, there is geological evidence that age increases from the core outward. The outer or hybrid phase, is the oldest and forms a shell up to five miles thick between the intruded rocks and the younger phases of the batholith. Its composition is generally quartz dioritic but this is variable and characteristically this phase contains partially assimilated blocks and fragments of the country rock. The contacts of the hybrid phase are generally gradational grading outward to Nicola or Cache Creek rocks and inward to the Guichon variety of the intrusive. The hybrid shell is much thicker on the western side of the batholith, i.e. 3 to 5 miles vs. ½ - 1 mile and this suggests that the whole batholith may have been tilted eastward by differential movement on the bounding faults.

The later phases are all granodiorites or quartz monzonites and distinction of them is based primarily on textural and mineralogical features and not on bulk compositional differences. There is, however, a decrease in specific gravity, i.e. from 2.80 to 2.64 from the hybrid to the Bethsaida phase that could reflect increasing differentiation. With the exception of the contaminated hybrid shell, the various phases are very similar and the differences among them probably resulted mostly from changing pressure and temperature conditions during intrusion.

Smaller structures within the batholith include faults, shears, breccia and shatter zones. Dikes and dike swarms, which are common, probably reflect another type of structure. The most common direction for linear structures is north-south and the majority of dikes follow this trend. The most notable of these structures is the Lornex fault which bisects the Bethsaida quartz monzonite. Faults and shear zones striking northeast are less common and a third set striking northwesterly, though not obvious, is important in localizing ore, e.g. Alwin, Valley Copper. Breccia zones such as those at Bethlehem, Trojan and on Gnawed Mountain may or may not be related to faulting, since the breccia types vary. However, the Trojan and Bethlehem breccias occur in areas where strong north-south faulting is common and a combination of suitable structural openings and access to volatile charged fluids is certainly suggested as a cause. Shatter zones much as those at Valley Copper, Krain and possibly Lornex occur within or adjacent to major faults and at least in the case of Valley Copper near the intersection of two major structures. The principal difference between the shatter zones and the breccias appears to be that in the shatter zones there was not sufficient space provided by stress release to permit the broken blocks to rotate.

MINERALIZATION IN THE BATHOLITH

Copper mineralization may occur anywhere in the batholith and in any of the various phases. The distribution of producing mines and better known prospects is shown in the accompanying figure. All of these lie close to a north-south line which bisects the batholith and the larger ones except for Craigmont are on or adjacent to a contact of the Bethlehem phase of the intrusive. This latter is suggestive of a genetic relationship with this phase, however, this is probably more apparent than real. All of these mines and prospects are structurally controlled and the mineralization in them is contained in open space fillings formed after the consolidation of the host rock. The significance of the Bethlehem phase and its contact is therefore limited to the influence each has had on the development of structures suitable for ore deposition. Similarly, the north-south zoning may reflect a concentration of deep seated north trending structures formed after differentiation had proceeded far enough to create a reservoir of copper bearing solutions. That this reservoir has been tapped by other structures is apparent from the wide distribution of copper within the batholith, however, structures large enough and continuous enough to contain sizeable orebodies appear at this time to be limited to the central zone.

The mineralization is quite similar from one mine or showing to another. Chalcopyrite is the most common copper mineral however, with the exception of Craigmont, the one producing mine (Bethlehem) and all of the potential producers contain bornite in amounts sufficient to determine the viability of the operation. Pyrite is a common associate of copper, but its amount varies considerably, e. g. at Bethlehem there is a heavy pyrite zone on the southwest side of the Jersey orebody while at Craigmont and Valley Copper pyrite is extremely scarce. The most common iron mineral in terms of occurrence is hematite. This mineral is ubiquitous in copper occurrences, but rarely does it occur in amounts greater than 3 percent, Craigmont being a notable exception. The widespread occurrence of hematite suggests that the mineralizing solutions had a relatively high Eh such as might be expected in a highly aqueous environment. What effect this may have had in the partition of Fe, S and Cu is unknown, but in many deposits it appears that in the competion for sulphur, Cu was favoured over iron and perhaps the oxidation state influenced this.
The source of sulphur has been the subject of two recent publications. Christmas, Baadsgaard, et al conclude from a study of S, C and O isotope ratios of Craigmont ore that the sulphur of the ore is of mantle origin and therefore from a deep source. M. P. Schau in a reply to this says that sulphur from assimilated Nicola basalts is just as likely a source since this sulphur would have mantle ratios too. As it now stands, the source of the sulphur is open to question, however the nature of the copper deposits and their relationship to deeply penetrating structures suggests that the copper and sulphur did come from some depth and could well be of mantle origin.

STRUCTURAL SYNTHESIS

The sequence of events leading to the discovery of the Valley Copper orebody started in 1964 with the formation of Valley Copper Mines Ltd. This company, at that time, held various groups totalling 425 claims. Evaluation of these groups began immediately and during 1964, 1965, and 1966 various kinds of exploration programs were carried out on all of them. By 1966, a considerable amount of information had been gained from this work and this was used along with published data to produce a geological compilation of the batholith area. To supplement this, a study of aerial photographs was made and this was combined with the known geology to provide a structural interpretation.

The Lornex discovery in 1966 served to draw attention to the Lornex fault and at about the same time new aerial photographs of the area became available. These photographs clearly show the southern extension of this fault for some eight miles, along Skuhost Creek valley. The northern extension beyond Lornex is obscured by steep topography but clearly if the fault is string straight for eight miles, its northern extension should be as well. Thus projection of the fault north through Divide Lake seemed reasonable. Intersection with an inferred structure under Highland Valley was more conjectural for there was not then and there is not now any direct evidence of faulting under Highland Valley. In any case, however, the area adjacent to the conjectured intersection of two large fault structures was considered to provide a worthwhile exploration target.

Another possibility suggested by the location of the Lornex orebody in or adjacent to the Lornex fault was that the orebody might have a displaced portion somewhere along the west side of the fault. At that time, neither the sense nor amount of movement along the

Lornex fault was known, however, the occurrence of copper mineralization on the Bethsaida claims suggested a relationship. If indeed the Lornex and Bethsaida mineralization were related, then left-hand movement of about 2 miles was indicated. Particularly suggestive of this was the low grade copper mineralization south of the Lornex orebody and in the southeastern part of the Bethsaida group as indicated by drilling in 1966. If these two areas of low grade mineralization were correlative, then the same spatial relationship could pertain on the Bethsaida group as did at Lornex. In this case, ore grade mineralization should be to the north or northeast.

This rather speculative interpretation needed further support and this was provided by the information compiled in 1966. This compilation in view of the possible importance of the Lornex fault was directed toward trying to find supporting evidence for the supposed left-hand movement of some 2 miles. It was found that the south contact of the Bethsaida quartz diorite had an apparent northward displacement on the west side of the Lornex fault. The amount of this displacement could not be measured accurately but was definitely of the same order as the distance between Lornex and the Bethsaida group.

This supporting evidence made the faulted offset hypothesis a good deal more tenable and suggested that the northeast quarter of the Bethsaida group would be a good exploration target. A second and supporting indicator was the possibility of a major fault intersection directly east of this same area under Divide Lake.

A number of factors have contributed to the discovery of the Valley Copper orebody. One of the most important of these was the realization early in the Valley Copper program that mineralization is always related to structure, particularly open space fillings. In the Guichon batholith there is little, if any, truly disseminated sulphides and with the exception of Craigmont, no replacement of host rock. Orebodies and showings, big or small, are invariably contained in breccias, shear zones, veins, shatter zones, etc. of obvious structural origin and the inference is clear that without the structurally prepared plumbing system there would be no mineralization. Also important is the distribution of copper mineralization within the batholith. Any of the major rock units may contain copper showings and in every case the mineralization is younger than the host rock. It thus becomes difficult to prove a genetic relationship to any rock unit and the importance of structure is further emphasized.

Thus the recognition of the possible significance of the Lornex fault and the Highland Valley fault zone was a very important element in the discovery of the Valley Copper orebody.

PERCUSSION DRILLING

Percussion drilling played a very important role in the discovery of Valley Copper and a few comments about the method follow.

In both 1967 and 1968, percussion drilling was done in the Bethsaida group. In both years, the purpose of this drilling was to test a broad area quickly and cheaply simply to see if copper mineralization was present. In each case, the percussion drill accomplished this purpose at about one-third the cost of diamond drilling.

Thus, for the same cost, three times as many holes can be drilled as with a diamond drill and herein lies the real virtue of the percussion drill. Most orebodies are irregular in shape and variable in grade. One hole drilled through an orebody may, because of geometry or grade distribution, miss the ore grade

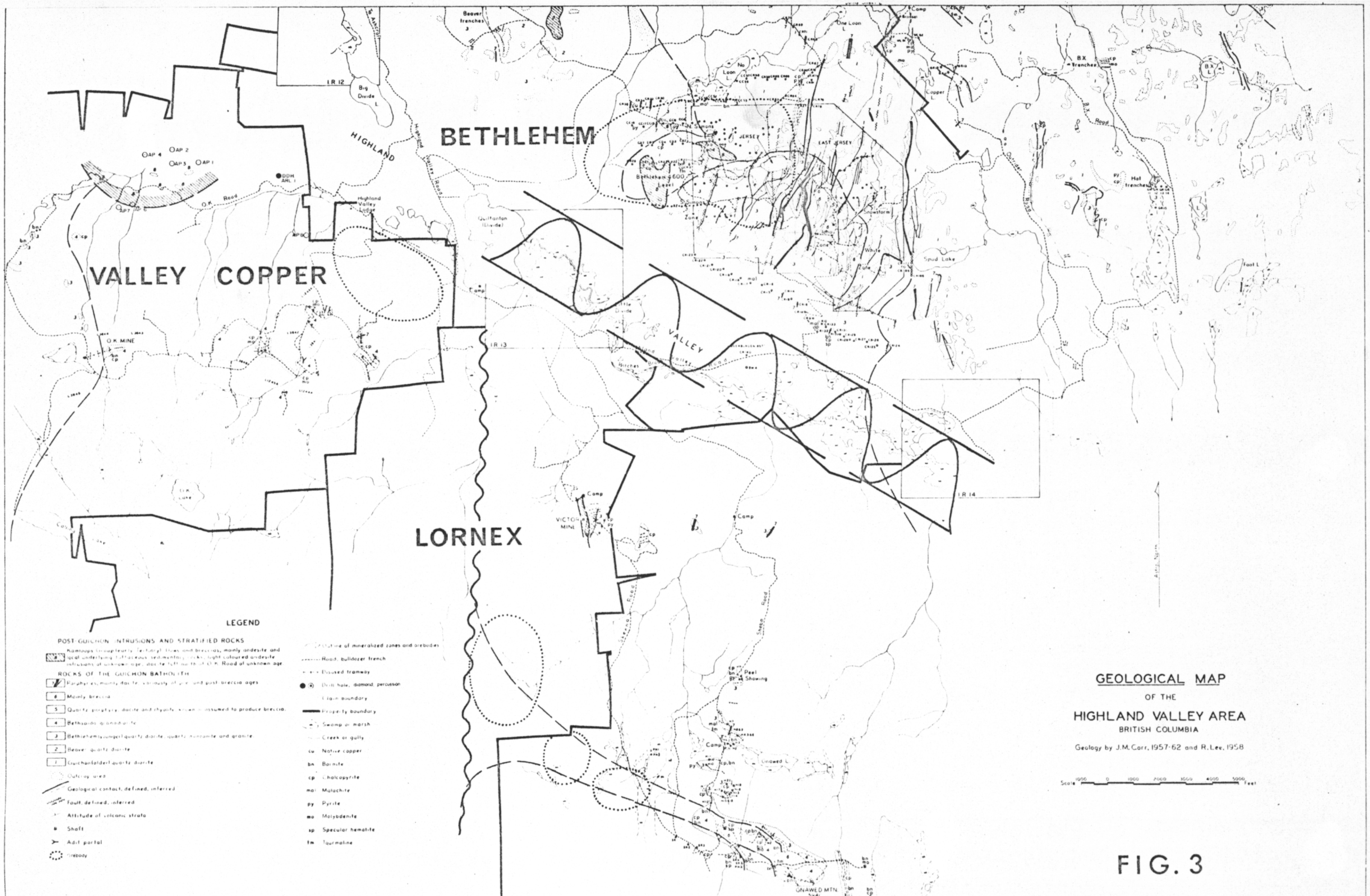

BETHLEHEM
VALLEY COPPER
LORNEX
HIGHLAND
VALLEY
Highland Valley Lodge
O.K. MINE
VICTOR MINE
Spud Lake
Big Divide L
Beaver trenches
BX trenches
Hal trenches
Peel Showing
GNAWED MTN. 5941
LEGEND
POST-GUICHON INTRUSIONS AND STRATIFIED ROCKS
ROCKS OF THE GUICHON BATHOLITH
6 Mainly breccia
1 Guichon(older) quartz diorite
Geological contact, defined, inferred
Fault, defined, inferred
Attitude of volcanic strata
Shaft
Adit portal
Outline of mineralized zones and orebodies
Road, bulldozer trench
Disused tramway
Drill hole, diamond, percussion
Property boundary
Swamp or marsh
Creek or gully
cu Native copper
bn Bornite
cp Chalcopyrite
mal Malachite
py Pyrite
mo Molybdenite
sp Specular hematite
tm Tourmaline
GEOLOGICAL MAP
OF THE
HIGHLAND VALLEY AREA
BRITISH COLUMBIA
Geology by J.M. Carr, 1957-62 and R. Lev, 1958

FIG. 3

section completely. Even two or more holes may do the same. The obvious solution is to drill a lot of holes and often this may be uneconomic with a diamond drill, but less likely to be so with percussion drilling. However, the depth limitation of 300 feet poses restrictions for the percussion drill.

THE OREBODY

The Valley Copper orebody is roughly oval in plan with its long axis striking about 310°. Its long dimension is at least 4,500 feet and the shorter 3,000 feet. The deepest hole yet drilled in the orebody was still in ore at 2,340 feet. The tonnage potential easily qualifies it as the largest orebody yet found in Highland Valley and work is still proceeding to actually delimit the area of mineralization.

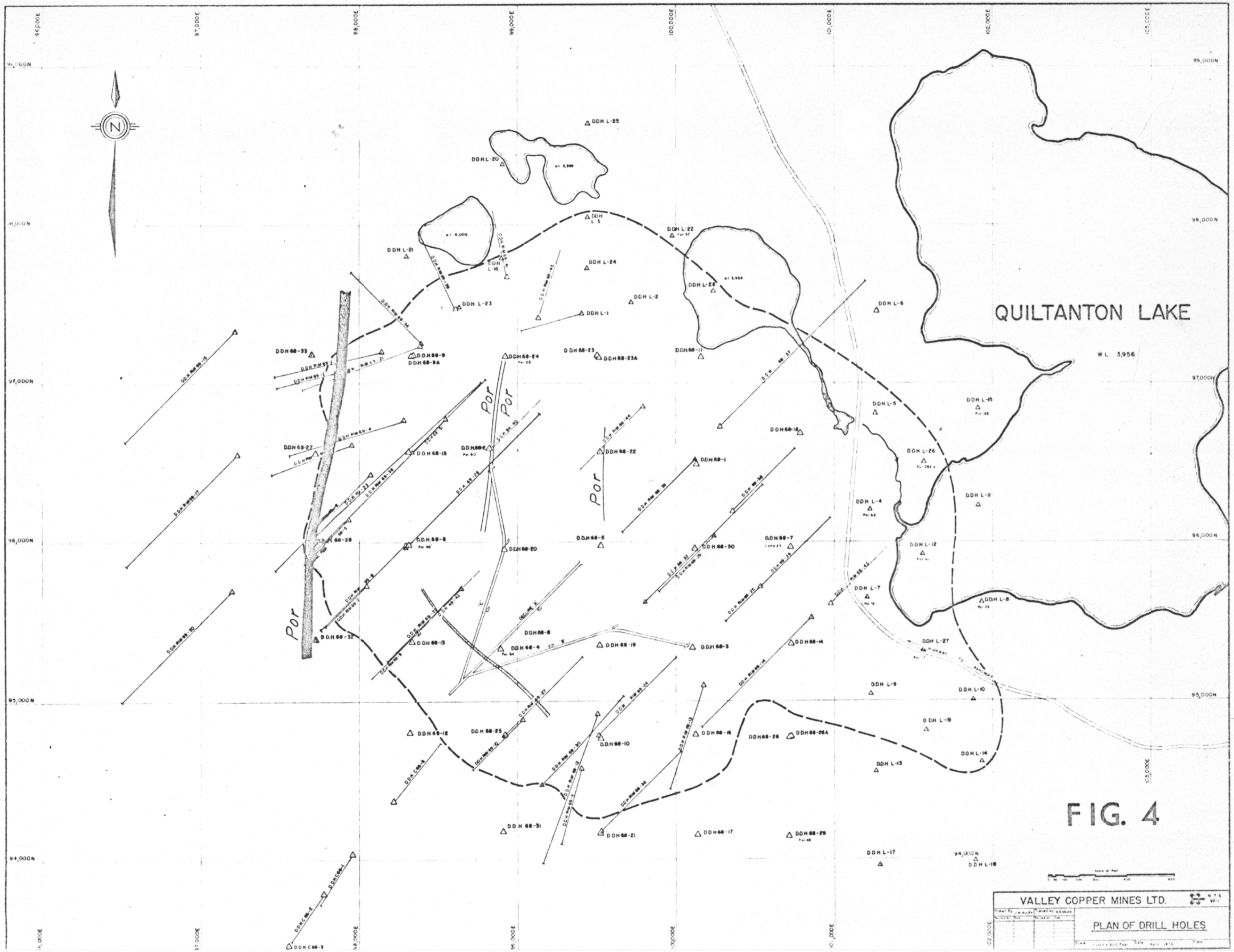
The geology of the orebody is quite simple for there is only one major rock type, the Bethsaida quartz monzonite. At least two typesof porphyry dikes and a variety of Lamprophyre dike cut the orebody, but these are generally narrow and do not bulk large in the geological picture. The geology does not, therefore, offer much insight into the genesis of the ore and geological controls, e. g. contacts, do not appear to have been important in localizing ore.

Structure on the other hand appears to have been a dominating influence. Almost all of the rock in the orebody has been strongly sheared and fractured and there seems ample evidence that the mineralizing and altering solutions were introduced along a structurally prepared system of openings. Two steeply dipping structural directions predominate, 290 - 310° and 340 - 360°.

It is along these directions that quartz veins, shears, faults and linear alteration zones are most commonly found. Other subsidiary systems occur and the patternof quartz veining and fracturing may change across the orebody, however, the two dominant directions are always present. It is probably no coincidence that of the two dominant directions, one (290^{o} - 310^{o}) is parallel to the Highland Valley fault zone and the other (340 - 360^{o}) is parallel to the Lornex fault. This also applies to the dike system. Both fault systems seem therefore to have had some influence on structural development. In addition, there is a set of flat quartz veins and shears which perhaps resulted from the interaction of the two fault systems.

The ore mineralogy is relatively simple. Two copper sulphides, bornite and chlcopyrite, are present and molybdenite, though ubiquitous, is scarce. Hematite in amounts to 2% is the most common iron mineral, magnetite occurs in rare small patches and pyrite at less than .5% is remarkable for its scarcity. The relative proportions of bornite and chalcopyrite vary within the orebody, but generally bornite predominates in a ratio of about two to one.

The alteration types associated with ore are of the classic kind occurring in prophyry copper deposits in other parts of the world. The most common alteration type is argillic which is pervasive throughout the deposit and appears to be early in the mineralizing sequence since it is cut by quartz veins, sericitic and potassic alteration. Argillic alteration is characterized by a chalky, slightly greenish appearance of the feldspars and by the alteration of the biotite to a pale green mixture of chlorite and sericite.


QUILTANTON LAKE
W.L. 3,956
Por
FIG. 4
VALLEY COPPER MINES LTD.
PLAN OF DRILL HOLES

Potassic alteration is next in the sequence and this is marked by the development of potash feldspar. This type of alteration, though widespread, is generally restricted to zones fifty to one hundred feet wide. Mineralization associated with the potassic alteration tends to be largely chalcopyrite.

Sericitic alteration shows the closest relationship to copper mineralization and it may occur in two distinct ways. Copper-bearing quartz veins almost always carry a selvage of coarse sericite. These veins may as they narrow become fine stringers of sericite, granular quartz and copper sulphides, dominantly bornite. Alternatively, sericite and granular quartz may occur in irregular zones up to 20 feet wide impregnated with bornite and chalcopyrite. In general, when sericite is present, copper sulphides are as well.

Silicification is a prominent feature of the orebody as shown by the great number of quartz veins and the presence of irregular siliceous patches. The amount of quartz observed is in excess of what might be expected from the remobilization of silica originally present in the fresh Bethsaida quartz monzonite and suggests that a good part of it must have been introduced with the mineralizing solutions. Several generations of quartz veins are present including a late barren type. This too might be construed as evidence supporting an epigenetic rather than syngenetic origin for the quartz. Propylitic alteration which commonly occurs on the periphery of porphyry copper deposits, is notable by its absence. Similarly, there is very little pyrite in the orebody and no evidence of a pyritic halo.

In summary, the Valley Copper orebody displays many of the characteristics ascribed to the better known porphyry copper deposits. The lack of a propylitic alteration zone and a pyrite halo probably reflect differences in fluid composition rather than in process and there seems to be little doubt in assigning the dposit to the prophyry copper class.

TESTING PROGRAM

Since May of 1969, a comprehensive testing program has been under way. This program was designed to bulk sample the orebody and to fill in gaps with additional surface and underground drilling.

The underground testing has consisted of driving three inclined headings into the orebody and sampling on a round by round basis. The underground headings were driven at -20% using rubber tired diesel equipment and in plan these headings form an arrowhead pointing southwest. The total footage driven was 4100 feet and the ends of the declines are 500 feet below the portal.

The size of the opening driven was 14' x 11' with an arched back. Each round was mucked, crushed and sampled separately. In order to provide a comparison with diamond drilling, two holes were drilled ahead of the face and the core from these matched to the round lengths to provide three separate samples. This comparison sampling will be done over the entire length of the declines.

Surface diamond drilling has been going on almost continuously since August, 1968, and to date some 90,000 feet have been drilled, almost all of it N.Q. size. Underground drilling started in July, 1969, as soon as working places were available. This program on completion will total 36,000 feet, all B. Q. size.

The testing program is now virtually completed and the information gained from it is currently being assessed. All of this information and the assessment of it will be incorporated into a feasibility study now in progress.

JMAllen/nc
April 8, 1970