SIMILKAMEEN MINING COMPANY LIMITED
P.O. BOX 520
PRINCETON, BRITISH COLUMBIA
CANADA

GEOLOGY OF THE INGERBELLE AND COPPER MOUNTAIN DEPOSITS

These deposits are located ten miles south of the village of Princeton in southern British Columbia, and 166 miles by road east of Vancouver. The Hope-Princeton Highway crosses the Ingerbelle orebody, while Copper Mountain lies about a mile to the east on the opposite side of the Similkameen River valley.

Mineralization was first discovered at Copper Mountain 80 years ago, with prospecting and development being carried out during the early 1900's. Production by the Granby Mining Company in the period from 1925 to 1957 amounted to 35 million tons of ore averaging slightly more than 1% Cu, nearly all of which came from underground mining.

In 1966 Newmont acquired a group of claims opposite Copper Mountain, and exploration and development work carried out over the next three years proved up the Ingerbelle orebody. During this time, drilling by Granby was adding to their known reserves of open pit ore, and in December 1967, Newmont purchased their Copper Mountain property. Both are now held by Newmont's wholly-owned subsidiary, Similkameen Mining Company Limited.

Ore reserves recoverable by open pit mining are estimated at 76 million tons of 0.53% Cu. Of this amount a little more than half are in the Ingerbelle orebody and the remainder are in two Copper Mountain orebodies, designated Pits 1 and 2. The grades of all three deposits are close to the 0.53% average. The stripping ratio at Ingerbelle is 2.6 tons of waste to

1 ton of ore, but is less at Copper Mountain, so that the overall ratio is 2.2 to 1. A possible third open pit at Copper Mountain is the area of the old underground mine. The Ingerbelle orebody will be mined first at a rate of 15,000 tons per day, then mining operations will shift to Copper Mountain. Pit preparation and mill construction are now well advanced, with commencement of production expected in mid-1972.

GENERAL GEOLOGY

The Nicola Group of Triassic volcanic rocks occur in a belt from the U. S. border northwards to Kamloops Lake. The Nicola is covered in places by Cretaceous and Tertiary formations, and in the Princeton area it is bounded by younger granitic intrusions.

Copper mineralization is found in many places within the Nicola Group and in rocks that have intruded the Nicola, namely:

(a) the Guichon Batholith with the Highland Valley deposits, and the Craigmont mine near its southern end,
(b) the Copper Mountain Intrusions.

The Ingerbelle and Copper Mountain orebodies lie within a 14,000 by 3,500 foot belt of Nicola rocks. These rocks are composed of andesitic tuffs and agglomerates, lesser amounts of flows, and some lensy siltstone layers. It has not been possible to construct a detailed stratigraphic column for this area but, nevertheless, the siltstone and fine-grained bedded tuff have been separated. The west end of this belt is in fault contact with other Nicola rocks including flows, agglomerates, and argillites. The volcanic belt is bounded on the south by the concentricelly zoned Copper Mountain stock consisting of diorite, monzonite, and pegmatitic syenite. Other bodies of undifferentiated diorite are the Voigt stock and the Smelter Lake stock just north of the main area.

Bounding the volcanics on the north is the complex Lost Horse Intrusive ranging in composition from syenite to diorite with fine grained and porphyritic phases. Small masses of the intrusive occur in the volcanics and partially assimilated volcanic blocks exist within the intrusive. Contacts

are everywhere irregular and generally obscure due to alteration. The only phase of it that can readily be separated in mapping consists of distinct post-mineral dykes. All of these intrusions have been dated at about 195 million years, which is Upper Triassic. The Nicola Group is also known to be Upper Triassic, indicating a relatively short interval between volcanism and emplacement of the intrusions.

A series of post-ore felsite dykes occur at Copper Mountain. They are quartz and feldspar porphyries of late Cretaceous or early Tertiary in age.

Capping some of the higher ground in the area are Tertiary lavas and agglomerates of the Princeton Group. A small trough of Tertiary conglomerate covers parts of the Pit 1 and 2 orebodies.

STRUCTURAL GEOLOGY

In an area with such an intrusive history, it could be expected that the volcanic rocks caught between various intrusions would suffer considerable deformation. Due to the lack of a good through-going marker bed, the folding and faulting puzzle is only partially solved.

Observations made on the various bedded units show the gentle to moderate dips prevail, and that folding probably presents an uneven, undulating pattern. Fold axes, in the few places where they can be postulated, trend in a northwest-southeast direction approximately parallel to the intrusive contacts.

Extensive faulting has taken place, with several periods of movement being indicated from pre-mineralization through to Tertiary time. The faults may be classified into the following categories:

(1) E-W faults. The Gully Fault is an important structure that slices through the Ingerbelle orebody. At Pit 2 certain E-W faults and crushed zones could be early structures also.

(2) NW-SE faults - The Main Fault at Copper Mountain had considerable influence on the location of ore and also appears to have had an extended history.

(3) NE-SW faults, forming a series of "breaks" through the area, also influenced ore location and were involved in the structural adjustments along the Main Fault.

(4) The N-S Boundary Fault has been traced for 7 miles and has been shown by drilling to dip 60°W. It is important because it cuts off the belt of Nicola rocks containing copper mineralization. The rocks to the west of this fault are virtually barren, they have a higher proportion of sedimentary units, and they exhibit only low-grade metamorphism. They bear little resemblance to the intruded, highly-altered and mineralized volcanics to the east.

In addition to numerous faults, the volcanic rocks have also been extensively fractured. Detailed study at Ingerbelle has shown the fractures to be mainly steeply dipping with random orientation. Preferred trends are present locally but rarely persist over larger areas. It is evident that these rocks were thoroughly shattered prior to alteration and mineralization.

Fracturing at Copper Mountain has long been recognized as an important ore control. The "ore fractures" in the mine area strike northeasterly at right angles to the stock contact and dip steeply northwest. The larger fractures may carry considerable K-feldspar, biotite and coarse chalcopyrite-bornite, while the finer ones may carry only a film of sulphides. In the hard fine-grained tuffs these parallel fractures may be quite numerous, but in the more granular volcanics and intrusives they are not as plentiful and are more irregular.

Breccias occur to a minor degree at several localities within the Lost Horse Intrusive complex. They are characterized by a dark matrix containing magnetite and usually a little chalcopyrite-pyrite.

The lower bedded unit which was the host for the important Contact orebodies at Copper Mountain, is folded down against the Copper Mountain stock. The Pit 1 orebody lies adjacent to the stock and is centered on the Main Fault. Pit 2 lies on a highly altered and irregular contact zone with the Lost Horse Intrusive, and includes a small breccia pipe at the north side.

A north-south section through the Ingerbelle orebody, from the Copper Mountain stock on the south to the Lost Horse Intrusive on the north shows that the bedded siltstone is nearly flat-lying on this section, and that numerous dykes and irregular masses of Lost Horse intrude the volcanics.

MINERALIZATION

The Ingerbelle mineralized zone is crudely L-shaped. The southwest arm is about 1,000 feet wide and tails off to a narrow erratic zone of low-grade mineralization. Narrowing as it wraps around the point of the L, the zone broadens to a width of 1,500 feet as it trends southeast to the Similkameen River. A 900 foot width of Nicola volcanics lying between the orebody and the Copper Mountain stock is practically devoid of copper. On the northwest side mineralization terminates abruptly against highly altered volcanics, but small patches of it are scattered through the less altered volcanics further to the north and east.

The Ingerbelle orebody can be divided into 3 zones. The southwest zone measures 800' by 900' at its top and decreases to 250' by 700' at a depth of 650 feet. The top of the ore terminates against the bedded siltstone band at a depth of 100 to 200 feet and only weak mineralization was exposed in trenches in this area.

The north zone includes all of the ore lying north of the Gully Fault, and has maximum dimensions of 1700' by 900'. The top of this zone contains some of the better mineralization found during the early exploration, but again the bulk of the ore lies 200' to 700' below surface.

The southeast zone lies south of the Gully Fault and is the lowest grade portion of the Ingerbelle orebody. It may represent the downward continuation of the North zone, indicating a normal displacement on the Gully Fault of 700 feet. However, exploration has not been carried deep enough to determine if the North zone definitely terminates against the fault. The southeast zone is largely overburden-covered and its potential was not recognized until after we had been working on the property for a year.

In summary, it can be said that the overall shape of the Ingerbelle

ore zones is crudely pipe-like in some areas and lens-like in others. However, an important feature of this orebody is the very irregular distribution of copper mineralization within these zones. Although much of the orebody has been drilled off at a 100 foot spacing, it is often difficult to correlate individual ore intersections from one hole to another. An analysis of all the diamond drill holes within the orebody was made using the criteria of 30 feet for a minimum ore length and 0.30% cutoff. This showed that the average ore intersection was 72 feet long and the average grade was 0.69% Cu. Waste sections between the ore average 0.15% Cu, and after determining bench grades and allowing for lateral dilution, the average grade expected in mining is reduced to 0.53% Cu. Ore boundaries are usually sharp, with little marginal material noted in drill core samples.

Mineralogy of this ore is relatively simple. Chalcopyrite and pyrite are the dominant sulphides, but the ratio can change abruptly from predominantly chalcopyrite to predominantly pyrite. Total sulphide content of the ore varies from 2 to 5%, but some of the more pyritic material on the fringe carries 10 to 12% sulphides. Pyrrhotite occurs in the southeast zone. The whole area from the Copper Mountain stock to the north edge of the orebody is geophysically anomalous, with the highest chargeabilities occurring over the heavier pyrite-pyrrhotite on the south sides of the ore zones.

Sulphide mineralization at Ingerbelle occurs largely as fine disseminations, accompanied by fine discontinuous fracture-fillings and some coarser blebs. Sulphide veins up to several inches thick are rare. The host rocks are mainly altered tuffs and agglomerates. Massive andesite, although mineralized, is less favourable for ore-grade material. Less than 10% of the ore is in small masses of monzonite or diorite.

At Pit 2, more of the sulphides are in fracture-fillings and coarser veins. At Pit 1 the bulk of the ore is very finely disseminated pyrite-chalcopyrite in a massive coarse tuff.

ALTERATION

Alteration of the volcanic rocks and the Lost Horse Intrusive varies from moderate to extreme.

In general, the finer-grained tuffs and siltstones have been "hornfelsed" with the recrystallization of the feldspar, development of biotite, and some secondary pyroxene (at least along the contact of the Copper Mountain stock). The other volcanic rocks consist essentially of augite and plagioclase, and their alteration products.

At Ingerbelle the most prominent alteration associated with copper mineralization is a pale greenish bleaching of the dark volcanics. This alteration involves a conversion of andesine plagioclase to albite, together with the formation of considerable epidote and lesser amounts of chlorite, scapolite, calcite, and occasionally hornblende. The recrystallization has converted the host into a hard, tough rock with many of the original fractures healed together.

Potash feldspathization is very minor at Ingerbelle, despite the occurrence of large amounts of pink-coloured alteration, mainly at the north side of the orebody. Albite is the chief mineral affected by this pink colouration, and staining techniques have shown that actual K-feldspathization is limited to late-stage fracture-coatings.

Pink feldspathization is also intense in some areas at Copper Mountain, but here a major part of it is potash feldspathization. Ingerbelle ore contains only 1-1/2 to 2% potash versus 5% at Pit 2. However, without being able to rely on colour in field mapping, the extent of K-feldspathization in the whole area of the Lost Horse Intrusive and the volcanic belt is not well known. A rock geochemistry study now in progress will give us much more analytical data on this area.

A little secondary biotite is noticeable in the altered volcanics and intrusives of the Ingerbelle area. Coarse biotite is found in many of the pegmatitic ore fractures at Copper Mountain, where it is at the centre of the vein and may be intergrown with bornite or chalcopyrite. The age of this latter biotite has been shown to be virtually the same as that in the intrusives.

Argillic alteration of the feldspar on a substantial scale is evident adjacent to some of the major faults and felsite dykes, and occurs

to a minor degree throughout many of the mineralized zones. However mineralization is usually weak or absent in zones of heaviest argillic alteration. Sericite, which is nowhere obvious in hand specimen, accounts for some of the feldspar alteration at Copper Mountain but appears to be absent at Ingerbelle.

Scapolite is a unique alteration mineral at Ingerbelle, occurring as steep networks of narrow veins and as minor replacements through much of the adjoining rock. It is most common along the heavily altered northwest side of the orebody and occurs sparingly elsewhere through the mineralized zone. It is rarely recognized at Copper Mountain.

Quartz is significantly absent from most of the rocks in the area, but traces of it have been seen in thin section. It is occasionally seen at Ingerbelle as a minor constituent in the scapolite-albite veins.

Magnetite of secondary origin occurs in a variety of forms. Blebs and veinlets sometimes carrying a little pyrite or rarely chalcopyrite, are found over the whole Ingerbelle-Copper Mountain area but are not common. Local concentrations are known within the Lost Horse Intrusive, sometimes with associated copper. Magnetite is usually absent from the bleached volcanics and is totally absent in the most intensely altered rocks.

MINERAL ZONING

Mineral zoning in and around these deposits can only be crudely defined but the following points are of interest. Chalcopyrite is the only copper-bearing mineral at Ingerbelle, and is the predominant one at Pits 1 and 2. Only a trace of bornite is found at Pit 2 but appreciable amounts were mined along the contact of the Copper Mountain stock. At Ingerbelle, pyrite concentrations occur outside the south and west sides of the orebody, but not near the more intensely altered northwest and northeast sides. At Copper Mountain, small amounts of pyrite and chalcopyrite are found all through the volcanics but cannot be described as haloes.

Further away from the orebodies, widespread but weak occurrences of chalcopyrite-pyrite-magnetite are found in the Lost Horse complex and its volcanic inclusions. Small but better-grade deposits of chalcopyrite-hematite are associated with a shear in the Voigt stock. The Copper Mountain stock carries much less sulphide than the Lost Horse intrusions, and it usually occurs as chalcopyrite-bornite pods or fracture-coatings associated with the K-feldspathization.

Even further out from the ore deposits traces of chalcopyrite in the Nicola volcanics have an affinity for pyrrhotite rather than pyrite.

Molybdenite, in sub-economic quantities, is most prevalent in the heavily-altered north end of the Ingerbelle orebody, much less common to the south, and very rare at Copper Mountain.

Gold, recoverable with copper, is highest at Ingerbelle, somewhat less at Pit 2, and lowest at Pit 1. Silver shows an inverse relationship to gold, being highest at Pit 1 and the underground mine. A small credit per ton of ore is anticipated for gold and silver.

ORE GENESIS

It is believed that these copper deposits are related spatially and genetically to the Copper Mountain Intrusions. However, all of the information now available suggests that the Lost Horse Intrusive complex has had a much more important part in the formation of these deposits than has previously been recognized.

Zoning at Ingerbelle appears to be in a direction outward from the Lost Horse complex rather than from the Copper Mountain stock. The heavily-altered Gully Fault zone, which appears to have been a channelway for mineralization, dips 70° towards the Lost Horse.

At Copper Mountain, the Pit 2 deposit lies on the indistinct contact zone with the Lost Horse, and has no alteration or mineralization tie-ins with the Pit 1 deposit 1,000 feet to the southwest. The importance of faulting and fracturing as ore controls for those deposits close to the Copper Mountain

stock has already been mentioned. The stock itself shows little sign of the fracturing, alteration and mineralization found in the adjacent volcanics, and it probably acted as a barrier to mineralizing fluids rising along the various openings.

The orebodies terminate on the east approximately where the Lost Horse complex and the Copper Mountain stock diverge. The apparent absence of orebodies around the east and south sides of the stock can perhaps be related to the absence of Lost Horse rocks in those areas.

It could be argued that the source of the copper might be the volcanic rocks that have undergone extensive assimilation and alteration by the Lost Horse Intrusions. However, the amount of metasomatic replacement that the volcanics have undergone is still speculative at this stage.

These deposits are not readily classified into commonly accepted systems. However, they appear to lie closer to pyrometasomatic deposits than to typical porphyry coppers. Their relationship to intrusives, the possibly extensive metasomatic replacements, the evidence of pneumatolytic activity, the formation and redistribution of magnetite, and the irregular distribution of mineralization are all characteristic of pyrometasometism.

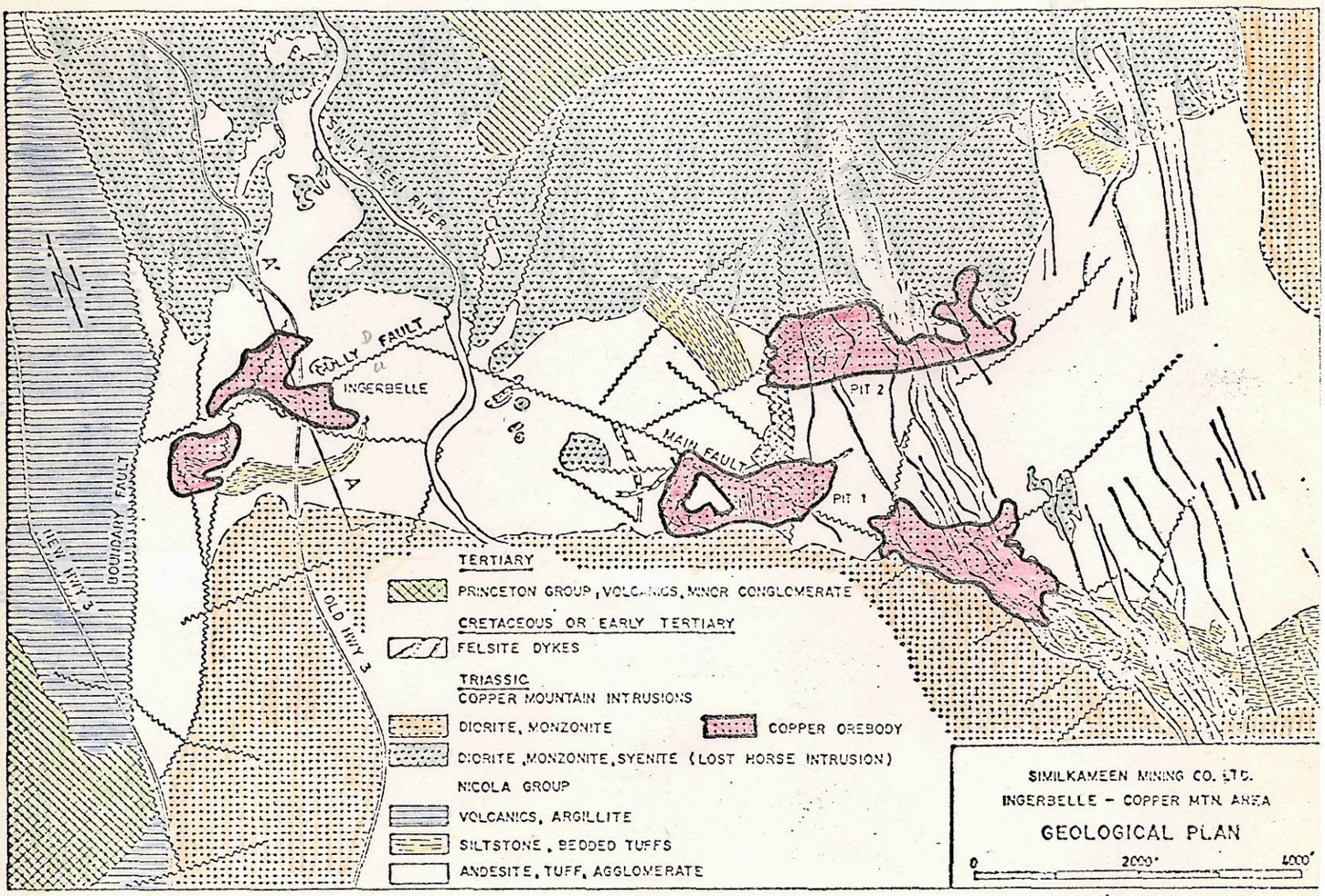
GENERAL

Because of the erratic nature of the chalcopyrite mineralization some 89 miles of drilling (63% diamond drilling) plus extensive earlier drilling by Granby at Copper Mountain, was done prior to a production decision making this probably one of the most thoroughly drilled open pit properties in the world. One mile of adit workings were driven at Ingerbelle to obtain good exposures, provide drilling sites, and a source of bulk samples for metallurgical testing.

Considerable computer work was done in attempting to assess the ore content but final ore reserves were basically founded on the manual polygon concept.

ACKNOWLEDGEMENTS

This summary is based on a paper given by T. N. Macauley at the C.I.M.M. meeting, October, 1971, based on his comprehensive geological report of the property.


SIMILKAMEEN RIVER
BOUNDARY FAULT
NEW HWY 3
OLD HWY 3
FULLY FAULT
INGERBELLE
MAIN FAULT
PIT 1
PIT 2
TERTIARY
PRINCETON GROUP, VOLCANICS, MINOR CONGLOMERATE
CRETACEOUS OR EARLY TERTIARY
FELSITE DYKES
TRIASSIC
COPPER MOUNTAIN INTRUSIONS
DIORITE, MONZONITE
COPPER OREBODY
DIORITE, MONZONITE, SYENITE (LOST HORSE INTRUSION)
NICOLA GROUP
VOLCANICS, ARGILLITE
SILTSTONE, BEDDED TUFFS
ANDESITE, TUFF, AGGLOMERATE
SIMILKAMEEN MINING CO. LTD.
INGERBELLE - COPPER MTN. AREA
GEOLOGICAL PLAN
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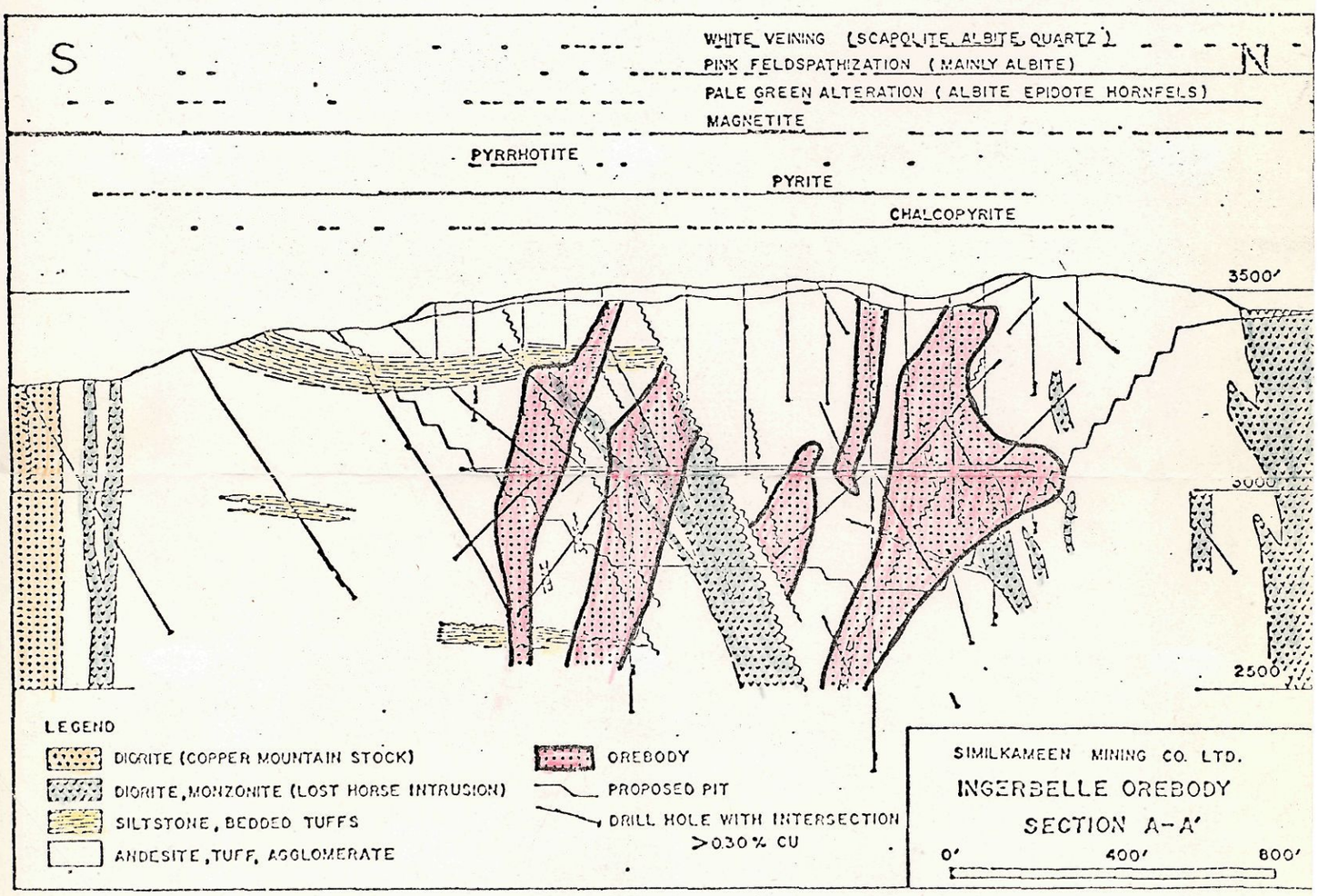
2000'
4000'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N
WHITE VEINING (SCAPOLITE, ALBITE, QUARTZ)
PINK FELDSPATHIZATION (MAINLY ALBITE)
PALE GREEN ALTERATION (ALBITE EPIDOTE HORNFELS)
MAGNETITE
PYRRHOTITE
PYRITE
CHALCOPYRITE
3500'
2500'
LEGEND
DIORITE (COPPER MOUNTAIN STOCK)
DIORITE, MONZONITE (LOST HORSE INTRUSION)
SILTSTONE, BEDDED TUFFS
ANDESITE, TUFF, AGGLOMERATE
OREBODY
PROPOSED PIT
DRILL HOLE WITH INTERSECTION >0.30% CU
SIMILKAMEEN MINING CO. LTD.
INGERBELLE OREBODY
SECTION A-A'
0'
400'
800'