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THE MINERALOGRAPHY OF THE
STRANGWARD COPPER PROPERTY
SOUTH TETSA RIVER B.C.

600155

BASED ON MEGASCOPIIC AND MICROSCOPIC
EXAMINATION OF ORE SPECIMENS FROM
THE PROPERTY

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ACKNOWLEDGMENTS

The theory on which most of the conclusions of this report are based was taken from the references listed at the end of this report.

I am further indebted to Professor R.M.Thompson, Tony Barker and Jack Gower of the University of British Columbia, Mineralogical Department for the instruction, and consideration discussions which made this report possible.

A special thanks is given to Morris M. Menzies for supplying the general information on the property from which the samples were taken. Furthermore, the descriptions of specimens to be found in this report are chiefly the work of Mr. Menzie^s, and I consider them a lesson on report writing.

ABSTRACT

A megascopic and microscopic examination of specimens taken from the Strangward Copper Prospect, ^{Tetsa River,} B.C., shows the presence of the following minerals in the mineralized regions:

Bornite
Chalcopyrite
Chalcocite
Covellite
Hematite
Limonite
Malachite
Azurite
Calcite
Quartz

A study of space relationships, textures, and minute fractures has led the writer to the conclusion that the primary minerals of this area were emplaced by two stages of mineralization. Chalcopyrite, calcite and quartz were deposited first, in fractures and brecciated zones during faulting of the country rock. The first minerals were followed by the simultaneous deposition of bornite and chalcocite.

Erosion and oxidation followed the deposition of the primary minerals. We have two main chemical actions involved; the oxidation and solution of copper, and the formation, in situ, of copper and iron minerals into oxidized compounds.

No orderly sequence of deposition has been suggested for the secondary minerals for it appears evident that once copper solutions have been formed the order of deposition depends entirely on the minerals which the solutions encounter.

Minerals which the writer believes to be secondary are; hematite, limonite, azurite, malachite, covellite, and chalcocite. Thus it appears that the chalcocite in the deposit may be primary or secondary. However, secondary chalcocite has formed in much larger amounts.

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Introduction

The property consists of 3 groups of claims recorded under the Strangward Partnership. Group 1 has 28 claims, 16 were staked on May 31, 1949, and 12 were staked on July 1, 1950. Groups No. 2 and No. 3 have 12 and 4 claims respectively, and were staked on August 15, 1950.

The discovery of these claims was made by the recorded owner, W.P. Strangward, during the summer of 1949. The following summer, 1950, an exploration party was sent to the area to start a geological map and to examine and sample various mineralized showings.

The persons involved in this first discovery stage were as follows:

W.P. Strangward, owner and discoverer,
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Cleveland, Ohio.

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R.M. Thompson, Geologist
Professor of Mineralogy
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M.M. Menzies, Geologist,
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Lloyd Bygrave, Surveyor
227 14th Street N.W.
Calgary, Alberta.

A.E. Callison and O. Collison, Suppliers,
Toad River Lodge,
Mile 421, Alaskan Highway

Herbert Fellers, packer,
Feller's Heights, B.C.

Albert Lo^rxanger, cook,
Lower Post, B.C.

Jim Nicolson, cook
Arras, B.C.

Location

Group No. 1 is 15 miles south of Summit Lake, B.C. which is at Mile 391 on the Alaskan Highway. These claims are on the north west slope of the Tetsa River valley. Group No. 2 is on the same side of the river as Group No. 1, but $2\frac{1}{2}$ miles upstream. The elevations of these two groups range from 4400 ft. to 7100 ft. (See figure 1).

Transportation

There is a good pack trail from Summit Lake into the area, over which a light pack train can complete the trip in one day. Aeroplane landings are feasible on South Tetsa Lake, a small lake near claim Group No. 2.

Topography and Water Supply

The area is cut by a series of mountain ranges which trend northwest. These ranges have rugged peaks reaching elevations of 7000 ft. and 8000 ft. The south slopes are covered with talus, and the north slopes are cliffs and escarpments. The area is drained by many small creeks, some of which form waterfalls as they pass through hanging valleys on their way to the Tetsa River. Some of these creeks dry up towards Fall, others, like the Tetsa River, are flowing till late Fall.

Timber

A forest fire during June, 1950, killed much valuable timber. The surviving wood, not over 30 ft. high, is chiefly white spruce, and does not grow above the 4300 ft. contour. Shrubs cover the unwooded areas in the valley, and form dense thickets along the creeks.

General Geology

The area is in the front range of the Rocky Mountains and is underlain by early Paleozoic, or late Precambrian, metamorphosed sediments. These sediments contact highly folded Mesozoic limestone along a northwest trending thrust fault 4 miles east of the claims. The folds of the

limestone rapidly give way to the gentle folds of the foothills farther east.

The area mapped is underlain by buff weathering, grey limestone which is overlain by the higher formations shown on the geological map and cross-section (see Index III) These sediments are gently folded into broad anticlines and synclines with northwest trending axes. A graphic formation, perhaps the key formation, has been squeezed into tight drag folds near fault zones.

The area is cut by two major, and several minor, faults. The displacement of these faults has not been determined, but they have a normal stratigraphic throw. Two sets of faults were mapped; the youngest^r set trending northwest, and the oldest^r set trending west.

Basic dykes occur in faults to the west of the mapped area. They are usually vertical but may undergo local changes where they crosscut other dykes. The age relation between various sets of dykes is not known because the intersections were not seen.

Economic Geology

Showings 1 to 4, all in No.1 group, are shown on the accompanying geological map. (See index II). No. 1 showing is 2500 ft. south of the summer camp site. No. 2

showing is on Pocker No. 1 claim, 1000 ft. southwest of the summer camp site. No. 3 showing is on the northeast boundary of Pocker No. 7 claim, 3500 ft. north west from the summer camp site. No. 4 showing is on Pocker No. 7 claim about 1700 ft. southwest from No. 3 showing.

Although No. 1 groups of claims was the area of chief interest during the summer of 1950, specimens from No. 2 were included with those received for microscopic examination.

A polished section was made for each specimen; then both specimen and polished section were numbered to correspond with the member of the sample from which they were taken. Thus, if we refer to sample, specimen or section, its source can be readily found on the geological map.

Minerals Identified:

Primary:

Bornite, Cu_5FeS_4

Chalcopyrite, Cu Fe S_2

Chalcocite, Cu_2S

Quartz, SiO_2

Calcite, Ca CO_3

Secondary

Hematite, Fe_2O_3

Limonite, $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$

Covellite, Cu S

Azurite, $2 \text{CuCO}_3 \cdot \text{Cu(OH)}_2$

Malachite, $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$

Chalcocite, Cu_2S

Method of determination

Quartz

Quartz was identified by such megascopic properties as; conchoidal fracture, hardness of 7, and vitreous luster. Prismatic crystals were seen when viewed through a microscope, and at least two good cross-sections (section 150) showed these prisms to be hexagonal.

Calcite

The perfect rhombohedral cleavage of calcite can be seen in one or two places on the hand specimens. The hardness is about 3.5. Identification was based chiefly, however, on the effervescence with a drop of cold nitric acid.

Malachite^{*} and Azurite

Malachite displayed such properties as: slender acicular crystals growing in tuffs, bright-green color, pale-green streak, and a hardness of 3.5 to 4.

The azurite is dull and earthy with a pale-blue streak and color.

Both these minerals effervesce in nitric acid, and both respond to the microchemical test for copper. The

^{*} An opaque form of malachite, intimately associated with quartzite, was first thought to be melaconite. However, an X-ray by Prof. R.M. Thompson proved the mineral to be malachite.

association of these minerals with each other, and other copper minerals, was also an aid ^{to} in their identification.

Hematite

Hematite showed dull maroon in intimate association with the brass yellow of chalcopyrite and the pinchbeck brown of bornite in the hand specimens. The identification was made, however, by viewing under a microscope. The following properties were used; color grey, hardness G, faint anisotropism, red powder when scratched, and negative to all reagents. The microchemical test for iron was difficult to obtain without interference from the intimately associated malachite..

Limonite

The yellow limonitic stains characteristic of weathered copper deposits were on all the hand specimens. Under the microscope the limonite was isotropic and showed a yellow powder when scratched. This mineral showed intimate association with other oxides in the replacement phenomena observed throughout the sections.

Covellite

The presence of covellite was not discovered until the examination of polished sections began. Such diagnostic properties as indigo-blue color, hardness of B, strong anisotropism, and polarization colors of white, yellow, and

fiery orange, were seen. The perfect basal cleavage could be seen in almost every case where the mineral was observed. KCN stains black. This mineral occurs in minute scales replacing other copper sulphides.

Chalcocite

Although there is both primary and secondary chalcocite in the specimens, the mineral is anisotropic wherever it is observed. Other identifying properties were, the blue-grey color, and the hardness of B. HNO_3 effervesces vigorously, stains blue, and brings out etch cleavage and grain boundaries KCN stains black and corrodes. Cu is precipitated in microchemical tests.

Bornite

The bornite is brittle and massive. It is pinch-beck brown on a fresh surface, has a metallic lustre, and readily tarnishes to a peacock purple. Under a microscope the mineral is isotropic, pinkish brown, and has a hardness of B. HNO_3 effervesces and etches to a brick-like pattern. Microchemical tests showed the presence of Cu and Fe.

Chalcopyrite

The examination of chalcopyrite disclosed the following properties; brass yellow color, high polish, C. hardness, brittleness, weak anisotropism, and a negative reaction to HgCl_2 ; KOH, KCN, HCl, Fe Cl_3 and HNO_3 .

This mineral can be easily scratched with a needle, giving a powder. Microchemical tests showed the presence of Cu and Fe.

Description of Hand Specimens and Polished Sections

Specimen 150

One surface of the specimen is bounded by a one third inch laminae of black quartzite, fragments of which occur throughout the vein in random orientation. The gangue is composed of white granular vein quartz generally lacking ~~in~~ well developed crystal faces. Small vugs, however, occur in the specimen and poorly developed quartz crystals are found in them.

Malachite fills fractures in the black quartzite, forms films around grains of vein quartz, and occurs in fibrous masses. Limonite caps the specimens and occurs in vugs and interstices between the quartz grains.

Section 150

The dark color of the brecciated gangue is a result of the intimate association between the quartzite and malachite. The quartz crystals have been brecciated but have not undergone any alteration. There are small scattered showings of hematite and limonite which have a tendency to associate with the malachite in the spaces between the quartz particles.

Specimen 151

The specimen contains a vein, less than one inch in width, that has been mineralized by chalcopyrite. The chalcopyrite has undergone extensive alteration and is cut by a fine network of fractures filled with secondary minerals.

Section 151

The chalcopyrite appears to have been fractured by a continuation of movement in the country rock. The chalcopyrite is being vigorously replaced, and in several areas the replacement has reached the advanced stages leaving only remnants of chalcopyrite in a sea of oxides and secondary sulphides. On close examination of the ramifying veinlets of oxides and sulphides in the chalcopyrite, some suggestion of arrangement can be detected in what appears at first to be just a jumble of copper and iron minerals. (See diagram 1)

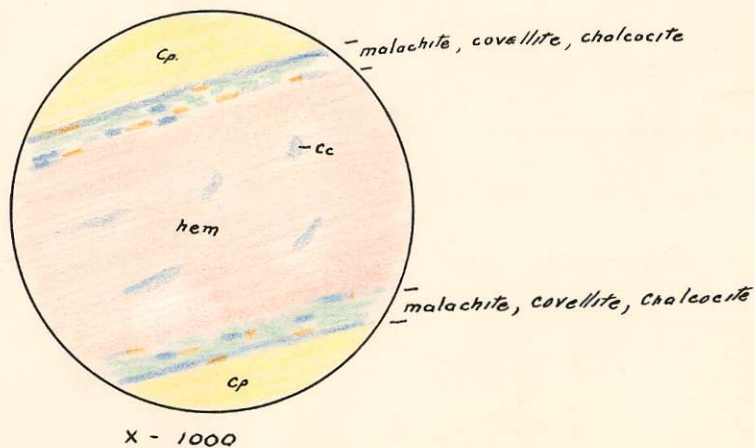


Diagram 1.

Specimen 152

Primary sulphides occurring in the specimen are chalcopyrite and bornite with chalcopyrite forming about two thirds of the combined volume. Limonite is present as a coating and occupies fractures in the wall rock. Malachite stain covers a thin crust of vein quartz on one of the specimen fragments.

Section 152

Bornite and chalcopyrite are the chief ore minerals, with chalcopyrite in larger quantities. The two show smooth contacts between grains. Both minerals form equigranular textures. And, though both minerals are fractured, with chalcopyrite having suffered the most.

Anisotropic, grey, chalcocite grains, 10 microns by 125 microns, form a lattice pattern along the (111) planes of the bornite grains. Covellite is selectively replacing bornite at the grain boundaries and along minute fractures.

The boundaries between chalcocite and bornite are smooth, and there is in general, an even distribution of chalcocite through the bornite. Where the lath~~s~~ of chalcocite intersect each other they have a tendency to pinch out. (See figure ² 1).

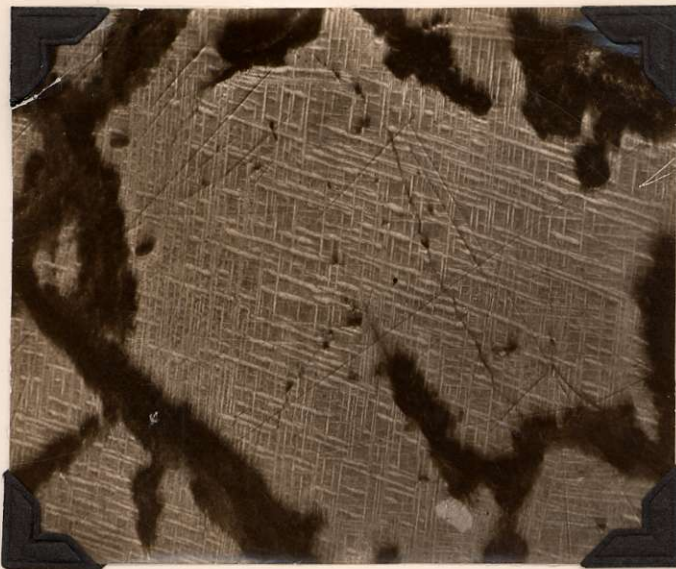


Fig. ²/₃. The lattice intergrowth of chalcocite (light grey) and bornite (medium grey) resulting from the unmixing of a solid solution.

Specimen 153

This specimen has a high specific gravity and contains a few grains of milky vein quartz. The primary sulphide portion consists mainly of bornite, with chalcopyrite as a minor constituent. Both are extensively altered to secondary sulphides. Malachite occurs in fractures and stains the specimens. Limonite is also present.

Section 153

The chief minerals of the section are bornite and covellite in a quartz-carbonate breccia. The covellite has extensively replaced the bornite along grain boundaries and in fine ramifying veinlets. Calcite has been extensively

replaced by malachite. The malachite is in streamlets through the section as though it had flowed in to fill existing spaces.

Specimen 154

This specimen has an earthy brown color and is stained with malachite, azurite and limonite. Iron oxide, possibly hematite, forms the largest percentage of the specimen. Examination by hand lens disclosed the presence of bornite and chalcopyrite; with bornite being the more abundant.

Section 154

The section shows vigorous replacement of bornite by chalcocite in fractures and around grain boundaries. Malachite, ~~malacconite~~, hematite, and limonite are scattered through the section in relatively large amounts so that the ratio of sulphides to oxides is small.

Specimen 169

Chalcopyrite is the only primary sulphide detected but much of it has been altered to chalcocite and iron oxides. Some replacement of the quartzite seems to have occurred making the boundaries between the host rock and the mineralization irregular and indistinct. Remnants of the rock are also found within the sulphide-oxide mass.

The specimen is coated with malachite and limonite.

Section 169 (a and b)

Replacement has reached the later stages resulting in numerous chalcopyrite isolations surrounded by chalcocite and oxides. Brecciated quartzite and fractured chalcopyrite indicate that the chalcopyrite was introduced by fissure filling during movement in the country rock.

Paragenesis

Movement in the earth's crust caused fractures in the quartzite host, and the formation of channels for mineralizing solutions. Quartz, calcite, and chalcopyrite were deposited before or during this fracturing of the host rock, a fact made clear by the highly brecciated nature of these minerals. While faulting continued, chalcocite and bornite were deposited. This later group of minerals is much less fractured than the first group. Although chalcocite is slightly sectile and would not fracture as readily as its associates, the bornite is brittle and would fail as readily as the quartz or calcite.

In the case of bornite and chalcocite there is good evidence of exsolution, thus simultaneous deposition. The connected lattice-work to be seen in section 152 is interpreted as an ex-solution texture. There is, in general, an even distribution of the chalcocite through the bornite. The ex-solution bodies show no widening at the contacts with one another. And, the replacement of bornite at the grain

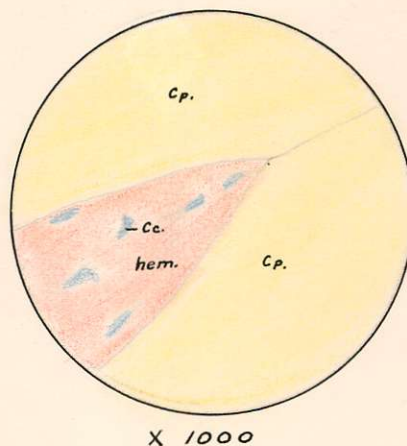
boundaries is by covellite.

We might also add that the compositions and crystal structures of the two minerals are such that a solid solution is feasible. Bornite and cubic chalcocite have mutual (III) S-planes and (III) Cu-planes, and the atomic spacing here differs by only 3%.^{*} The facts that chalcocite is anisotropic and that blue chalcocite is absent suggest slow cooling. If the rate of cooling is equal to, or less than, the rate of diffusion then it is conceivable that the bornite and chalcocite separate completely and the chalcocite reverts to its orthorhombic form. This reverting of the chalcocite would put an upper limit of 105° C for the temperature of formation of the chalcocite and bornite.

Thus, the order of deposition for the primary minerals appears to be: quartz, calcite, and chalcopyrite, followed by bornite and chalcocite together, all being deposited during fracturing of the quartzite host.

An explanation of the deposition of the secondary minerals is suggested in examining the space relations of the oxides and secondary sulphides present in the diagram of section 151. We have two main chemical actions involved; the oxidation and solution of copper, and the formation, in situ, of copper and iron minerals into oxidized compounds.

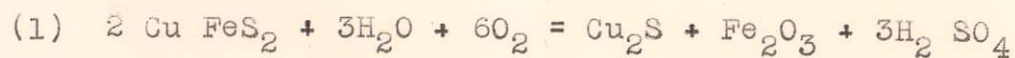
* Edwards, A.B., Textures of the Ore Minerals, 1947, P (77-78)



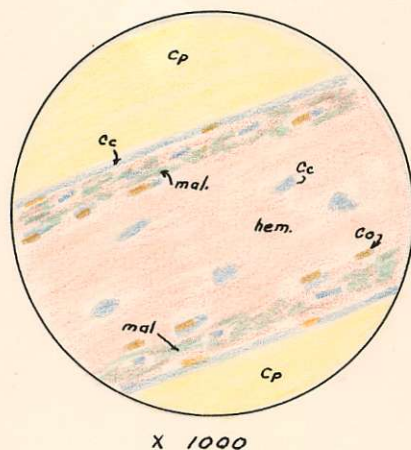
Dia. 2. The space relation of primary and secondary minerals

The points of the veinlets are a mixture of chalcocite and hematite (see diagram 2). Such a mixture of minerals suggests that they are simultaneously replacing the chalcopyrite host. The replacement was probably due to the presence of descending surface waters carrying oxygen.

An indication of the reaction is given in the following equation:



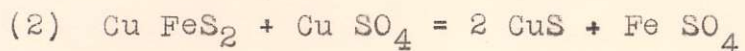
In a wider portion of the veinlet we see the intrusion of secondary veinlets (see diagram 3).



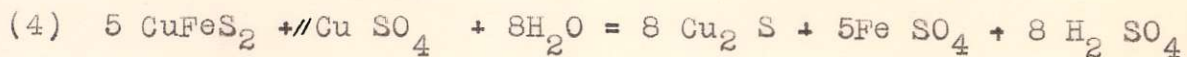
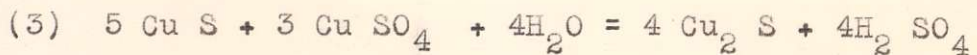
Dia. 3. The space relation of primary and secondary minerals

This space relation suggests the following general trend:

Descending copper solutions facilitated the replacement of chalcopyrite by covellite



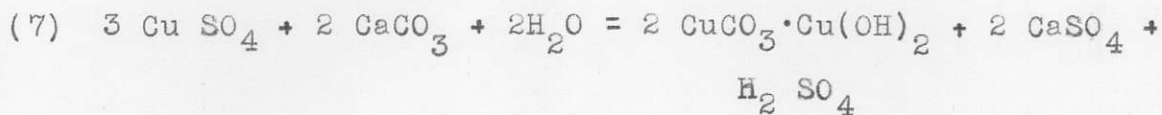
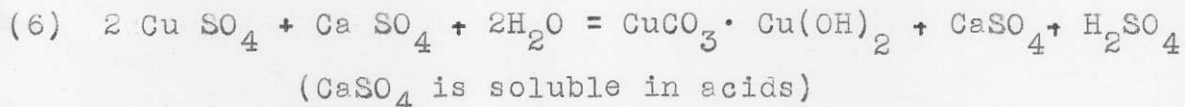
Then, with an increase in the concentration of the copper solutions chalcocite began replacing covellite and chalcopyrite



The replacement of bornite by covellite, seen in section 153, may also be due to the migration downward of soluble Cu SO_4 . The reaction indicated here is as follows:



When the copper solutions encounter the calcite, malachite and azurite will form and equations (6) and (7) indicate the general trend.



Oxidation and enrichment of the primary sulphides has begun but does not appear to have advanced very far. There are two possible explanations for this poor advance. The first is the small amount of pyrite in the area.¹ Intensity of activity depends on the presence of available sulphur. Thus disulphides yielding free sulphur on ~~turning~~ ^{becoming} ~~over to~~ a sulphate will yield something else in addition to the sulphate of the metal.

The second explanation follows from the first. If the pyrite is not present in large amounts, then the deposit has not had sufficient time to enrich to any great extent when depending on the sulphides that are present for free sulphur. That is, the period of erosion and oxidation, that follows the deposition of primary sulphides, has not been long enough to permit extensive enrichment of this type of

1. Pyrite has been reported as present around Pocker No.8 and would explain the more intense enrichment seen in sec. 169.

mineralization.

To give an orderly sequence of deposition of all the minerals is impossible, for once the copper has gone into solution the minerals deposited depend on the minerals which the solutions encounter. For this reason, the minerals are grouped as primary sulphides, secondary sulphides, and secondary oxides. (See table 1).

Table 1

Primary Sulphides	Secondary Sulphides	Secondary Oxides
Bornite	Covellite	Hematite
Chalcopyrite	Chalcocite	Limonite
Chalcocite		Azurite
		Malachite

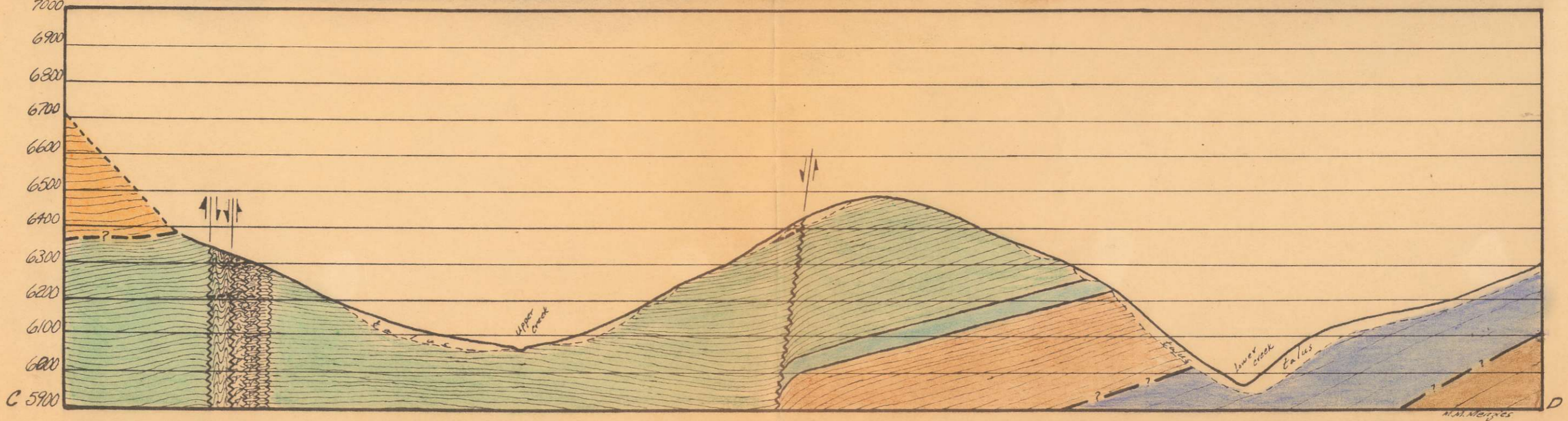
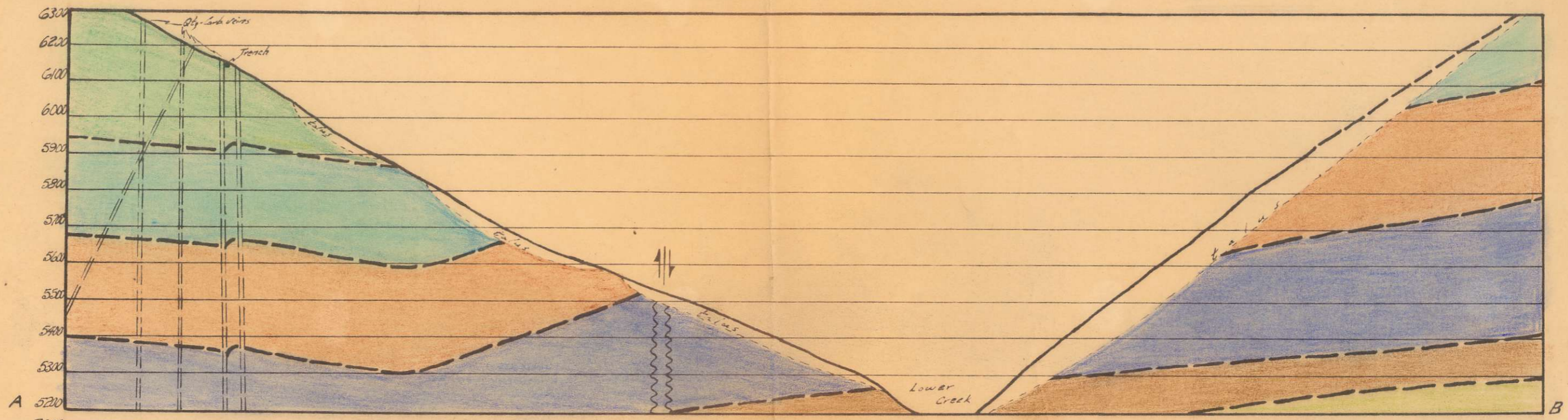
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McKinstry, Mining Geology (P. 150)

✓ Edwards, A.B., Textures of the Ore Minerals, 1947, P (77-78)

APPENDIX II



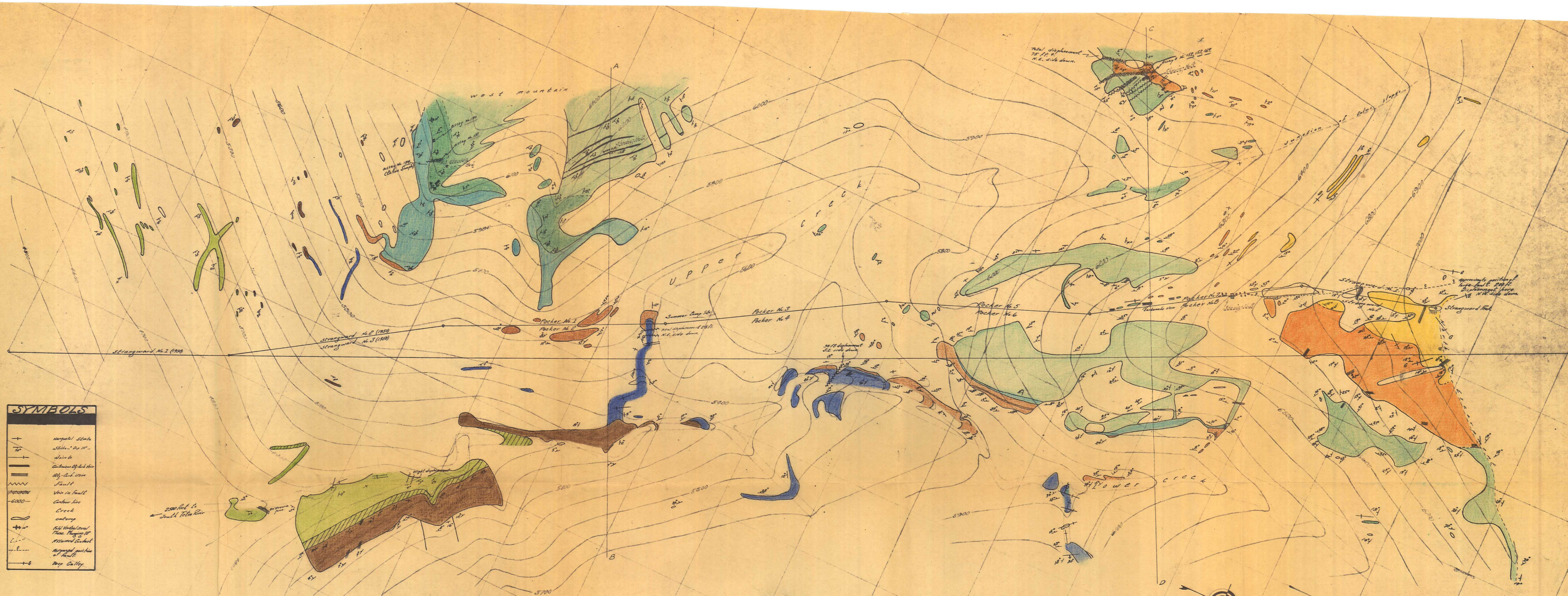
N.M. Merges

APPENDIX III

Thickness in ft.	Description of Members
400 to 500	Similar to A2. Several hundred feet thick.
200 to 300	Yellowish weathering dark limestone. Weathered surface unusually rough. Crags weathering out limestone. The weathered surface has by particularly convoluted appearance due to very fine laminations of quartzite and thin shales.
500 to 700	Crystalline quartzite. They are generally thin bedded but some beds are 3 feet thick.
100 to 150	Very thin bedded crystalline quartzite. The sublimation was made only on West Mountain.
300 to 500	White quartzite similar to A2. The fabrics vary greatly along the strike and are cut at regular intervals by shales and shaly limestone and soft weathering quartzite with irregular shales. No real changes in way of weathering, which is very much quartzite.
250	White quartzite with no visible bedding.
150 to 300	Buff weathering limestone and quartzite, bed from 2 to 7 feet thick.
50	That bedded white quartzite.
400	Gray limestone with several layers of thick shales which quartzite.
Bottom	Gray limestone, but weathering. Bedges 1000 feet thick.

7000' Maximum Thickness 2000'-3000' ft.

SYMBOLS	
+	Vertical shaft
—	Shale "do" "do"
—	Thin ls
—	Carboniferous ls
—	Self-lith. ls
—	Fault
—	Thin ls fault
—	Carboniferous
—	Creek
—	outcrop
+	Old Vertical Level
+	Plane. Pegging 10'
+	Assumed level
+	Assumed position of fault
+	Deep Gully



STRANGWARD COPPER PROPERTY
SOUTH TETSA RIVER B.C.
 Scale 1 inch = 300 feet
 Contour Interval 100 feet
 Mapped & Drawn by
 M.M. Menzies