THE RED-CHRIS PORPHYRY COPPER-GOLD DEPOSIT, NORTHWESTERN BRITISH COLUMBIA— A GEOCHEMICAL CASE HISTORY

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ABSTRACT

The Red-Chris deposit comprises two or more discrete zones of moderate to intense quartz vein stockworking carrying pyrite, chalocpyrite and rare bornite, with low but consistent gold values. The mineralized zones occur within an elongate, highly altered sub-alkalic monzonitic subvolcanic pluton of mid-Mesozoic age emplaced into volcanic and volcaniclastic rocks of the Upper Triassic Takla Group. Much of the mineralized system, including all of the area where reserves have been delineated, is covered by a thin (2–10 m) veneer of dark clay-rich till, containing rounded pebbles and cobbles of terrigenous clastic rocks of the Jurassic Bowser Lake Group. Lying above this till unit is a thin layer (50 cm average) of black organic soil, almost exclusively water saturated.

Stream sediment sampling yielded highly anomalous results where the mineralized pluton is dissected by deep stream gullies, but where little copper-gold mineralization has been exposed. Swampy drainages from the delineated reserve zones yielded silt samples with only low copper values. Conventional surface soil sampling showed a similar pattern, with high copper values where altered bedrock is exposed, and only very spotty anomalies over more strongly mineralized but till-covered areas. A limited programme of hand auger sampling, to a depth of approximately 1 m, gave results which were not better than those gained from surface sampling.

Sampling of till profiles exposed in the walls of bulldozer trenches suggests that the till has effectively blocked upward migration of metals from the bedrock surface. The till-bedrock interface is very sharp, and there seems to be no more than 30 cm upward migration of copper values. A comprehensive survey was undertaken using a hand-held gasoline powered drill to collect samples from the bedrock surface. Several hundred samples were collected, and the minus-10 mesh fraction was analyzed.

Two basic anomaly types are present, with values ranging up to well in excess of two orders of magnitude above background. The anomaly patterns correspond very well with the outlines of the two reserve zones. That over the Main or lower-grade dispersed zone is a large subcircular anomaly with relatively gently sloping sides, and the second, over the narrow, high-grade East zone is a narrow, very sharply defined linear anomaly. Neither anomaly shows any significant evidence of lateral migration.

INTRODUCTION

The Red-Chris porphyry copper-gold deposit, located near Ealue Lake in the Stinking River area of northwestern British Columbia (Figure 1) has been explored intermittently since 1956, with the bulk of the work in the period 1973–1976 (Forsythe, *et al.*, 1976). The deposit, estimated to contain about 41 million tonnes of material grading approximately 0.56% copper with low but significant gold values, is presently sub-economic. Copper mineralization was discovered on this property by conventional prospecting, and exploration has been guided largely by geology and geophysics. Most of the effort has been

FIGURE 1. Location map for the Red-Chris porphyry copper-gold deposit.

toward delineation of the deposit by percussion and diamond drilling, and intensive geochemical surveys were undertaken only later in the programme, in an attempt to outline further drill targets, and to solve surface geological problems.

This brief paper describes the various geochemical programmes which have been undertaken on the property. These are treated in logical sequence (i.e. stream sediment sampling followed by soil sampling followed by bedrock surface sampling) rather than in true chronological order. It should be emphasized that much of the geochemical work undertaken on this property was in the nature of orientation, to guide similar programmes on unproven but presumably similar properties in the general region. No extensive statistical studies of the data have been made; contour intervals on all geochemical plans have been chosen arbitrarily.

GEOLOGY

GEOLOGICAL SETTING

The Red-Chris deposit is contained within "an elongate, composite stock of altered hornblende monzonite" (Schink, 1977, p. i). This stock, one of several similar bodies in the general region, is considered to be a sub-volcanic intrusion related to a sequence of volcanic and volcaniclastic sedimentary rocks of Upper Triassic age and thus correlative with the widespread Stuhini and Takla Groups (Souther, 1971; Monger, 1977). The age of the stock is problematical; limited radiometric studies suggest that it must be at least as old as 195 Ma (million years), and may be slightly older (Schink, 1977, p. 8). There were at least two stages of intrusion, as large bodies of a so-called "late phase" monzonite can be seen to cut altered and mineralized main-phase rocks. Late-phase monzonite is always barren, is only weakly affected by hydrothermal alteration and is probably more widespread than presently mapped.

Figure 2 is a simplified geological map of the Red-Chris property, showing the position of the monzonite stock. To the southeast, Triassic rocks are in fault contact with well-bedded terrigenous clastic rocks of the Bowser Lake Group, here containing Callovian (Middle Jurassic) fossils (Schink, 1977, p. 15). The general geology of the Triassic rocks is reminiscent of that in several other regions of British Columbia, notably the Princeton to Kamloops belt (Nicola Group), the Quesnel Trough, the general Stiking River area, and elsewhere (Barr, *et al.*, 1976, Figure 1).

MINERALIZATION

Copper mineralization in the Red-Chris deposit consists of chalcopyrite and rare bornite in stockwork quartz veins, which locally become intensely developed, as in the high-grade "East Zone." The bulk of the mineralization is contained in the more dispersed "Main Zone." Both zones show a tendency to an antipathetic relationship between chalcopyrite and pyrite. Gold values are significant (in the range 0.4 to

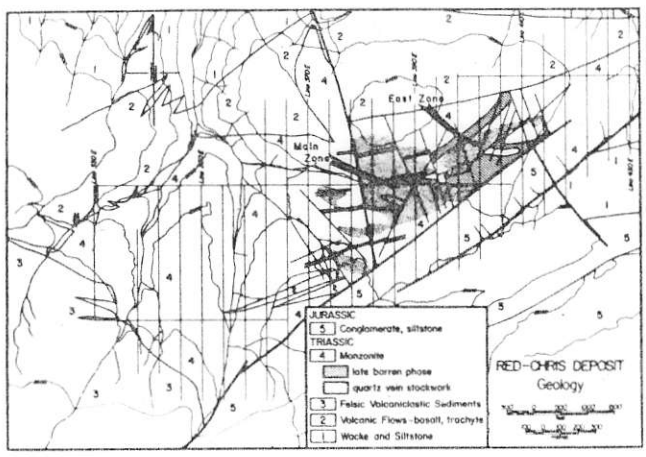

FIGURE 2. Simplified geological map of the Red-Chris property.

0.9 ppm), and molybdenum is present only as trace quantities of molybdenite.

The alteration assemblages present in the deposit are complex. Schink (1977) has outlined an early stage, "consisting of irregular zones of quartz-ankerite-kaolinite sericite-and quartz-sericite-ankerite-kaolinite alteration, and an extensive zone of quartz-sericite-pyrite alteration," followed by a later stage, "consisting of irregular zones of quartz-ankerite-kaolinite-sericite and quartz-sericite-ankerite-kaolinite alteration, and an extensive zone of quartz-sericite-pyrite alteration." This extensive quartz-sericite-pyrite assemblage is well exposed in the major north-flowing stream gullies lying to the west of the "Main Zone." Some limited areas of copper-bearing quartz vein stockwork also occur in this general region. The widespread pyrite mineralization gives rise to large and rather incoherent induced polarization anomalies.

The problem of classification of the deposit is a perplexing one. The gold content, coupled with the lack of molybdenum and taken in conjunction with the overall setting in a mixed alkalic and calc-alkalic volcanic sequence, means that the deposit resembles that of the "alkalic suite porphyry deposits" of Barr, *et al.* (1976), but the pluton is somewhat less alkalic than in most such deposits, and the intense quartz veining and the quartz-sericite-pyrite alteration is reminiscent of more normal calc-alkalic porphyry deposits.

SURFICIAL GEOLOGY

Much of the area underlain by the Red-Chris pluton, especially that covering the zones of copper mineralization, is mantled by a layer of till generally ranging in thickness from one to four metres, and locally reaching a thickness of ten metres. This till consists of dark sticky clay containing numerous pebbles and cobbles almost exclusively of Bowser Lake Group clastic sedimentary rocks. A few pebbles of Triassic rocks, especially altered intrusive material, are present in the basal portions of the till. The composition of the till, coupled with the topographic setting of the deposit, suggests that the surficial material represents a lodgment till deposited by an alpine glacier which swept northeastward across the Red-Chris plateau from high ground which lies to the southwest and which is underlain by Bowser Lake strata. No good evidence has been found for more than one till, although locally the basal portion contains abundant altered, rusty intrusive fragments. It is perhaps significant that the areas where this has been observed are immediately adjacent to major faults. Overlying the till is a thin layer (about 50 cm average) of fine, dark organic-rich soil which is locally water-saturated, producing boggy conditions. In many cases, there is a very weak development of iron staining in the till immediately beneath the soil layer.

In parts of the western portion of the sulphide system, especially on the sides of the larger gullies, much of the glacial veneer has been removed by erosion, leaving a very thin deposit of poorly-developed soil over actively decomposing rock. Large portions of such areas are underlain by a fine talus made up of small fragments of limonite-stained altered monzonite.

PRELIMINARY GEOCHEMISTRY

ANALYSES

Geochemical analyses were done for copper by atomic absorption spectrometry after digestion with hot solutions of HCl-HNO_3 (*Aqua Regia*).

STREAM SEDIMENT SAMPLING

The results of a programme of orientation stream sediment sampling are shown on Figure 3. The material sampled was active silt from flowing streams or seepages, and the minus-80 mesh fraction was analyzed for copper. The results show clearly that, whereas streams draining the actively eroding western portion of the pluton yielded silts with anomalously high copper values, the small stream which derives much of its flow from the area underlain by the two "ore-zones" yielded silts with relatively low copper contents. A few threshold values are present in small seepages derived from the mineralized zones, but

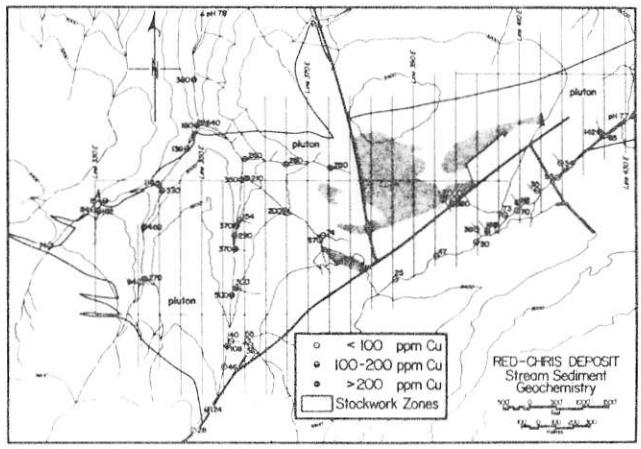

FIGURE 3. Map showing results of stream sediment sampling on the Red-Chris property.

these seepages would not likely have been sampled in a rapid regional programme, and in any case the values are only marginally interesting. The very high value (2,000 ppm) within the "Main Zone" stockwork area is from material contained in a minor drainage which is exposed at surface for only a few tens of metres, and which would certainly not have been sampled in a regional programme. The nearby high value (590 ppm) is from actively eroding material in a bulldozer trench. The pH of the waters from both the major streams were tested and found to be alkaline (7.7 and 7.8) (see Figure 3).

SOIL SAMPLING

In the course of early exploration of the prospect, at a time when it still comprised two separate properties, conventional soil sampling programmes were undertaken by both operators. Details of technique are not available to us, but we have assumed that so-called "B-horizon" material was sampled at depths certainly no greather than 30 cm, and that analyses were for total copper content, probably of the minus-80 mesh fraction. The results of these surveys are outlined on Figure 4. Reasonably coherent copper anomalies are present in soils from the western portion of the pluton, where altered monzonite with pyrite and sparse chalcopyrite is exposed at surface. There is no good explanation of why both the larger anomalies are restricted to the western sides of the gullies. In the area of the major copper-bearing stockwork zones, surface soils have for the most part only low copper contents. The two small anomalies outlined in the area between the "Main" and "East" zones were detected in Survey #2 but had not been found during Survey #1. The small anomalous zone to the east of the "East Zone" overlies an area where no significant copper mineralization has been found, despite the completion of several diamond and percussion drill holes.

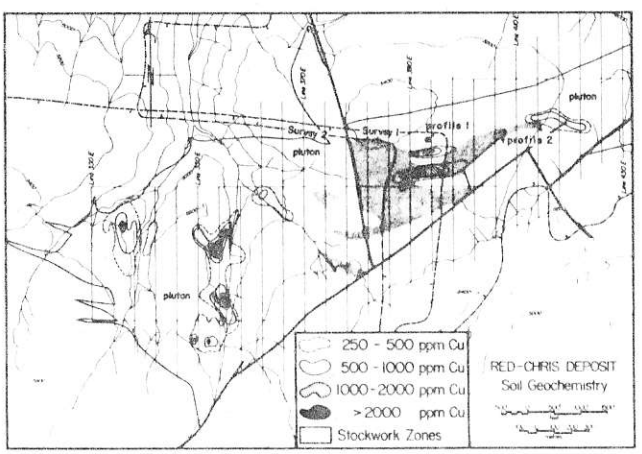

FIGURE 4. Map showing results of original soil sampling programmes on the Red and Chris properties.

HAND AUGER SAMPLING

A very limited programme of hand auger sampling, which recovered samples from about one metre depth, was undertaken for experimental purposes in an area known to be underlain by significant copper mineralization. The minus-80 mesh fraction of these samples were analyzed for copper. Figure 5 shows the results of this work, with the very spotty anomalies indicating that the technique is of questionable value in this area. Although there are several clearly anomalous samples, it is impossible to discern any coherent anomaly patterns, and such results could certainly not be used to choose drilling targets. The anomaly contours outlined on this drawing are those derived from the original soil sampling work, as shown on Figure 4.

BEDROCK SURFACE GEOCHEMISTRY

PROFILE SAMPLING

Several till profiles, as exposed in the walls of bulldozer trenches, were sampled in some detail. Figures 6 and 7 show the results of copper analyses on samples from two of these profiles. It is clearly evident that although there has been some upward

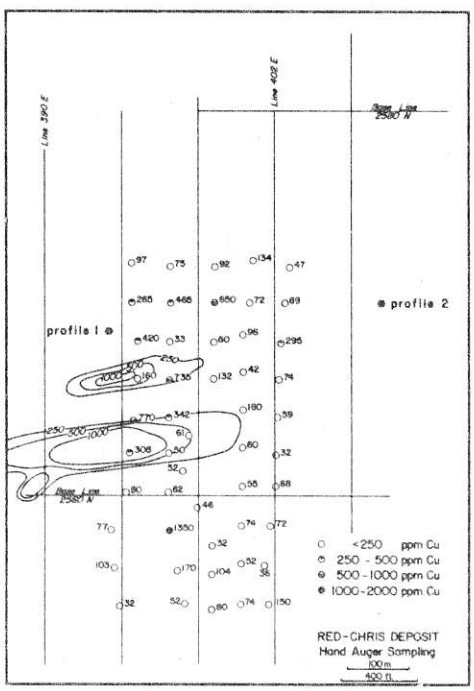

FIGURE 5. Sketch map showing results of hand auger sampling on the Red-Chris property. Sample depth is approximately 1 m.

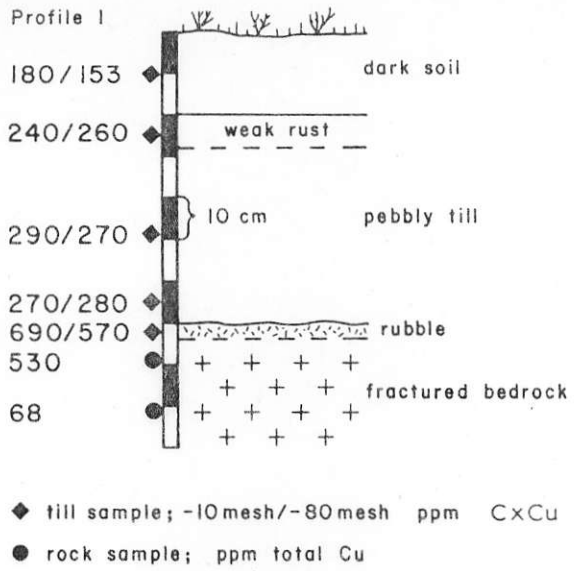

FIGURE 6. Sketch showing results of sampling till profile #1, northeast of the "Main Zone" on the Red-Chris property. CxCu = cold-extractible Cu.

movement of copper in the till, substantial thickness of clay-rich till with very low copper content may overlie bedrock with strong copper mineralization. Other profiles, not illustrated, show a similar pattern. In cases where the basal portion of the till is rich in intrusive fragments, copper contents are high near bedrock but tend to drop to very low values within 50 cm above the bottom of the more normal dark till which is devoid of intrusive fragments. There seems to be no marked increase in copper content in the weakly iron-stained uppermost portion of the till, below the soil layer. Unfortunately, we have no data to determine whether the mineralized till horizon rises in the section down-ice.

At a nearby property, with essentially identical bedrock geology and till conditions, a similar relationship has been documented. In one trenchwall profile, pebbly till lying immediately on well-mineralized bedrock contained greater than 20,000 ppm copper in the minus-80 mesh fraction and 13,000 ppm in the minus-10 mesh fraction. Immediately above this, only 20 cm higher in the section, the corresponding values had fallen to 138 and 92 ppm copper.

BEDROCK SURFACE SAMPLING TECHNIQUE

The bedrock surface sampling programme on the Red-Chris property employed a percussion drill of the Pionjar type, using a sampling method which has been well described by Gleeson and Cormier (1971), LaSalle, *et al.*, (1975), and others. Briefly, the

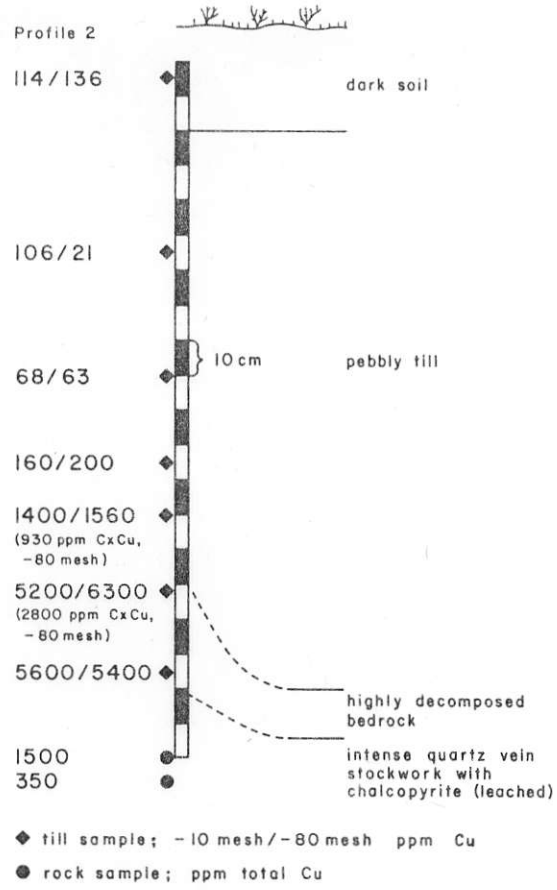

FIGURE 7. Sketch showing results of sampling till profile #2, within the "East Zone" on the Red-Chris property.

technique involves sounding the depth to bedrock with a pointed rod (or string of rods), and then driving a closed sampling device to the desired depth, in this case just short of the till-bedrock interface. The rods are then rotated to open the sampler, and the string is driven approximately 20 cm to fill the sampler. The rods are then retracted with a mechanical or hydraulic jack, depending on the ground conditions.

There are many problems encountered in using this sampling technique. Perhaps the most serious is the presence of boulders in the till; in some cases several attempts must be made to reach bedrock, and at some sites sampling proves impossible. Sampling expenses on this property were slightly below average for our experience in northwestern British Columbia; costs to recover a sample were of the order of $50.00.

Although this method of sampling basal till has been used extensively in eastern Canada (see, e.g., Ermengen, 1957; Gleeson and Cormier, 1971; Gleeson and Hornbrook, 1975; LaSalle, *et al.*, 1975; LaSalle, *et al.*, (1976), among others), it has not yet gained such popularity in the Cordilleran region. However, Gunton and Nichol (1974) reported on a

pioneering survey in southern British Columbia, and in recent years the system has shown signs of becoming fashionable in porphyry copper exploration in western Canada. The greatest promise of the technique in this connection lies in its potential ability to distinguish between geophysical anomalies (specifically induced polarization) caused by copper-bearing zones and those overlying barren pyrite systems, in areas of extensive cover.

RESULTS OF BEDROCK SURFACE SAMPLING

In the course of this survey on the Red-Chris property, several hundred samples were collected on cut lines 400 feet (122 m) or 200 feet (61 m) apart. Sample spacing varied, depending on the area, from 50 to 200 feet (15.2 to 61 m). Material was collected from the till-bedrock interface, and the -10 mesh fraction analyzed for copper. Larger chips, often representative of the bedrock, were separated and examined as an aid in geological mapping. Use of the -10 mesh fraction taken at the bedrock surface implies that the geochemical values reflect in a crude way the metal content of the underlying bedrock.

A synopsis of the results of this programme is shown by Figure 8. A large coherent anomaly lies over the dispersed "Main Zone" with some embayments which appear to reflect the distribution of bodies of "late-phase" monzonite or of monzonite lacking quartz vein stockwork. A much sharper confined linear anomaly overlies the narrow high-grade "East Zone." The eastward extension of this anomaly, which impinges on the end of a weak surface till anomaly outlined earlier, does not appear to overlie significant mineralization in the bedrock. This is one of the few places where one can reasonably postulate glacial dispersion of copper in the basal till. The very small anomaly south of the major boundary fault was drilled and found to be caused by mineralized boulders resting on barren Bowser Lake Group strata. Contour intervals on Figure 8 were chosen arbitrarily; sample results ranged from a general background below 250 ppm to several values in excess of 20,000 ppm total copper. Given this wide range of values, it was not considered necessary to examine the data in detail for subtle anomalies.

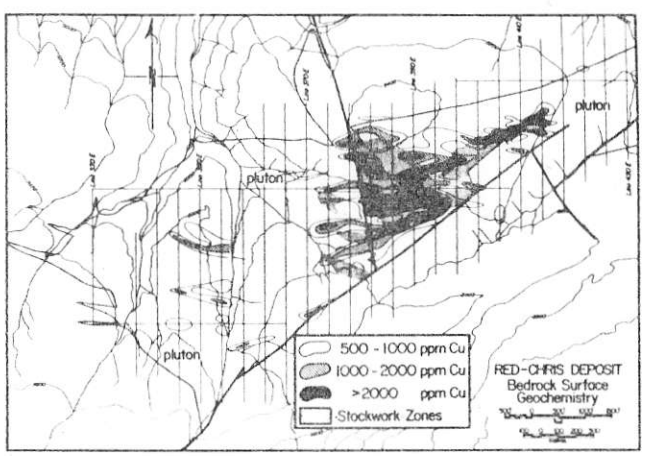

FIGURE 8. Map showing the results of the bedrock surface sampling programme on the Red-Chris property. Ice-direction roughly parallels the major northeast-trending fault.

CONCLUSIONS

Conventional stream sediment and soil surveys conducted on the Red-Chris property would not have focused attention on the copper-bearing quartz vein stockwork area.

The bedrock surface sampling technique, although very expensive, outlined the copper-bearing zones very effectively, and was especially useful in discriminating between induced polarization anomalies caused by pyrite and chalcopyrite portions of a large sulphide system.

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