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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 70-49

PRELIMINARY REPORT ON THE COPPER DEPOSITS, COPPERMINE RIVER AREA, DISTRICT OF MACKENZIE

E. D. Kindle

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ABSTRACT

Most copper deposits in the Coppermine River area are either syngenetic or epigenetic. Fourteen classes of deposits are described briefly and certain conclusions drawn concerning the origin of the lode copper deposits.

PRELIMINARY REPORT ON THE COPPER DEPOSITS, COPPERMINE RIVER AREA, DISTRICT OF MACKENZIE

INTRODUCTION

Geological Outline

The Coppermine River area embraces a late Precambrian belt of sedimentary and volcanic rocks mapped as the Coppermine River Series by Craig, Davison, Fraser, Fulton, Heywood and Irvine (1960). These rocks reach southerly from the village of Coppermine on Coronation Gulf for 50 miles and extend 108 miles west of and for 40 miles east of the Coppermine River. Baragar (1967) refers to the Coppermine River Group as being at least 12,000 feet thick and comprised of a lower 8,000-foot-thick volcanic zone made up largely of basalt flows and an upper volcanic and sedimentary zone about 4,000 feet thick composed of basaltic flows and interbedded red hematitic sandstones and shales. A succession of thin bedded light grey, quartzites, arkoses, siltstones and shales overlie the Coppermine River Group apparently unconformably. The basaltic flows and associated sediments form a belt about 20 miles wide along the Coppermine River but this belt thins westerly from the river and is only 12 miles wide between 35 and 85 miles west of Sandstone Rapids. In good rock exposures on the south side of September Mountains and north of Dismal Lakes, the basalt flows overlie conformably the Hornby Bay Group, a thick series of stromatolite-bearing dolomitic limestones and dolostones that grade down into mudstones, siltstones, sandstones and quartzites.

All of the above rocks have northerly dips. The basalt flows commonly dip about 5 degrees north but northerly dips of 12 degrees are found, and in some places the flows are flat lying and even gently domed. The sedimentary rocks along the river have average dips of 2 or 3 degrees northerly. The basalts and intercalated sedimentary rocks are cut by a series of prominent faults that normally strike either northwest, about north or northeasterly.

The Coppermine River Group rocks are cut by dykes and sills of diabase and gabbro. A diorite dyke that strikes southerly across Willow Creek about a mile or more east of Willow Lake is said to be 10 miles long.

Hornby Bay strata apparently rest unconformably on massive and gneissic granitic rocks south of Dismal Lakes and Kendall River but east from the big bend in Coppermine River the Hornby Bay Group rests unconformably on Yellowknife Group strata, consisting mostly of greywacke, slates, phyllites, conglomerates and derived schists. And a little farther northeast they rest unconformably on Epworth Formation sedimentary rocks that include greywacke, slates, argillites, phyllites, quartzites, sandstones, dolomite (stromatolites in some), conglomerates and some dacite.

The northerly tip of the Muskox Complex, a north-striking mass of dunite, peridotite, pyroxenite and gabbro, which is nearly 4 miles wide and

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32 miles long, lies only a mile east of the most southerly outcropping of the Coppermine River basalt belt, 10 miles southeast of the big bend of Coppermine River.

The basalt flows commonly exhibit a ridge and trough topography as a result of differential erosion between the massive portions of the flows and the softer amygdaloidal flow top zones and this makes it possible to make a rough count of the presence of at least 70 separate flows, through examination of the air photographs of the area northeast of Lower Dismal Lake. But the actual number of flows is greater as a pair of thin flows appears in some places as a single thick flow on the photographs presently available (1 mile to 1 inch). Baragar (1969, p. 5) states that 130 flows may be counted in the Bornite Mountains.

A typical basalt flow consists of a dull red, scoriaceous, amygdaloidal, in places fragmental flow top 10 to 20 feet thick underlain by about 100 feet of massive, grey to purple, brown or dark green basalt which contains only scattered amygdules that are commonly spaced from 2 to 6 inches apart, whereas in the flow top zones the amygdules are more generally about a quarter inch apart. The amygdules are for the most part composed of either calcite, quartz, epidote, chlorite, and pink sanidine, or various mixtures of these minerals. Native copper and/or chalcocite is commonly found within the amygdules as small grains or as thin linings of the walls of the amygdules. The native copper within amygdules seen by the writer, was always in the amygdules that are scattered through the massive main mass of the basalt flows. Native copper flakes, specks and grains occur alone and also in some flows associated with small amounts of disseminated chalcocite within the massive parts of the flows. The native copper is present in small amounts in the majority of the flows but in varying amounts for each flow. The copper content of many of the basalt flows ranges from about 0.01 to 0.5 per cent copper.

The basalts contain an average of from 1 to 5 per cent of magnetite and ilmenite and the magnetic properties of these minerals may cause errors in Brunton compass readings of about 8.5 degrees on the average according to W.A. Robertson (1969) who has studied this feature. Some anomalously high magnetic intensities which he found were considered as likely due to local lightning strikes.

Extensive geophysical prospecting has been done in the area in expectation of finding great tonnages of high grade ore, but these hopes have not been realized. A number of magnetic high anomalies have been drilled with negative results. Magnetic readings taken over flow top zones should theoretically always be lower than readings over the thick massive parts of the basalt flows as the magnetite in the flow tops was oxidized to nonmagnetic hematite when the flow was originally formed. Magnetic low anomalies in outcrop areas of massive basalt are likely to be significant in pointing to zones of low magnetite content and hence a possible veined structure or fault zone. Several geophysical instrument operators (assessment reports, 1969) have reported failure to get readings indicating presence of orebodies even though their instruments stood directly above vein-lodes containing 5 to 15 per cent chalcocite.

Geochemical surveys have been carried out by about a dozen mining companies in the Coppermine River area, numbers of geochemical anomalies have been found and several have been drilled with negative results. Geochemical surveys were ruled out by some mining companies as those in charge of exploration felt that these surveys would be unrealistic where copper is so widespread in the basalts and drift cover. In one instance a soil anomaly was found lacking in an area where copper-bearing float was plentiful and where the drift is underlain by sedimentary rocks.

During the 1969 field season W.R.A. Baragar and J.A. Donaldson undertook geological mapping of N.T.S. quadrangles 86 N and 86 O for the Geological Survey of Canada, and some preliminary geochemical field work was also done by E.H. Hornbrook and R.J. Allan.

Acknowledgments

The writer wishes to acknowledge assistance extended in the field by officers of Coppermine River Limited and Hearne Coppermine Explorations Limited; with particular thanks to geologists M. Watt, R.S. Hindson, P.H. Taylor, T. Horsely, N.J. Byrne, R.W. Seasor, John Graham, J. Inkster and Dr. R.A. Blais. The resident geologists at Yellowknife, Dr. R.I. Thorpe in 1968 of the Geological Survey of Canada, and Dr. J.A. Kelly in 1969 on behalf of the Indian Affairs and Northern Development Department, were very helpful in supplying needed information, claim maps, etc. Dr. R.V. Kirkham assisted with the field work during the 1969 field season. Mr. A.D. Oliver of Indian Affairs and Northern Development supplied much information.

TYPES OF DEPOSITS

Most of the copper deposits present in the Coppermine River area may be classified as belonging in either the syngenetic or in the epigenetic class of mineral deposits as listed in Table I. These are primary classes of mineral deposits in that they formed during the original ore-forming and rock-forming period. The syngenetic ore minerals formed contemporaneously with the enclosing rock in which they occur; the epigenetic ore minerals formed later than the enclosing country rock. The secondary deposits are those that formed as a result of erosion and disintegration of the original older rocks and minerals.

Table I

PRIMARY

SYNGENETIC DEPOSITS

Sedimentary and igneous copper lodes

1. Disseminations of copper sulphides and native copper in sedimentary rocks.
2. Disseminations of native copper in basalt flows.
3. Disseminations of chalcocite in diabase dykes.
4. Disseminations of copper sulphides in diorite dykes.

EPIGENETIC DEPOSITS

Copper-bearing cavity fillings

5. Fault-fissure veins, and vein-lodes, in basalt flows.
6. Fault-breccia lodes and shear vein-lodes in basalt flows.

Impregnation copper lodes

7. Amygdaloid impregnations in basalt flow tops.
8. Shear zone impregnations in basalt.

Replacement copper lodes

9. Sandstone beds replaced by chalcocite adjoining a fault.
10. Carbonatized zone copper-lodes.
11. Sandstone-dyke-copper-lode.
12. Chert beds replaced by chalcocite.

SECONDARY

13. Supergene native copper plates and nuggets.
14. Alluvial detrital deposits containing native copper.

Brief descriptions of the different types of deposits listed above are presented below in order to acquaint the reader with a rough assessment of the economic possibilities, and as a guide for further prospecting.

Disseminations of Copper Sulphides and Native Copper in Sedimentary Rocks

Chalcopyrite, bornite and chalcocite occur as fine disseminations in easterly-trending bluffs of sandstone, quartzite, siltstones, silty pebble conglomerates and dark mudstones on the Bud 942-947 claims (G. Lelievers, owner) about 6 miles west of Coppermine River and 3 miles north of Husky Creek. The copper minerals appear to be most plentiful in a zone that lies between 10 and 40 feet stratigraphically below a gently northerly-dipping diabase sill over 100 feet thick. This mineralized zone lies a short distance above an unconformity between the grey to brown copper-bearing sedimentary rocks and underlying red to rusty sandstones and shales. Copper concentrations in these sedimentary beds generally average less than 0.4 per cent copper but some thin horizons may contain up to 0.6 per cent copper.

Copper was found 6 miles farther east at the same stratigraphic horizon as described above in two holes drilled on the south side of the east-flowing part of Coppermine River 3 miles southwest of Escape Rapids. These holes drilled by Coppermine River Limited during the summer of 1969 are about 650 feet apart and roughly 1,500 feet south of the river on claim ESC 38. In general it was found that pyrite, chalcocite and chalcopyrite are disseminated in grey to greenish glauconitic sandstones that are intercalated with black shales and which lie a short distance above reddish sandstones; these are locally separated by a basalt flow 25 feet thick. The mineralized section of sandstones and shales is from 30 to 35 feet thick and the copper content would probably average close to 0.4 per cent.

An interesting feature in the drilled holes is the presence of fine particles of native copper which is restricted in the easterly hole to a 5 1/2-foot-thick band of interbedded coarse sandstone and black sandy shale at a depth of about 130 feet and 6 feet above the basalt flow that rests on the red sandstones. Some coarse native copper blebs were also found in the other hole 650 feet farther west at about the same horizon but confined to a band of coarse sandstone only 4.5 inches thick and 5 feet above the basalt.

Disseminations of Native Copper in Basalt Flows

Native copper occurs as thin flakes, as grains, as spots and specks, as splashes and rarely as paper thin leaves the size of a penny within some grey to green basalt flows of massive appearance. A high proportion of the scattered amygdules found within the massive parts of these same flows also contain native copper. In most cases the copper is present as thin linings coating the walls of the former gas vesicles or is present as grains of native copper enveloped within quartz-sanidine-calcite amygdules. Most geologists who have visited the area contend that this copper originated with the flow, that these were flows particularly rich in copper and that the copper has migrated but little since consolidation of the flow. The native copper within the amygdules necessarily migrated to its present position through the enveloping massive basalt along with the calcite, sanidine and quartz that forms the amygdules but lateral and vertical movement of the copper may well have been a matter of only a few centimetres; this would be insufficient to change the class of the deposit to epigenetic rather than syngenetic.

The writer tested only 2 samples of this type of basalt. One sample collected 1/4 mile south of the west end of Hope Lake contained 0.3 per cent copper. Another sample collected on a basalt ridge 9 miles farther northwest contained 0.50 per cent copper. A sample from the Alf group (north of main vein) was not assayed but a visual estimate placed its native copper content as better than 0.5 per cent.

Disseminated native copper occurs in basalt bluffs 30 feet high on the KAT claims (Bracemac Mines Limited) and according to a company report (1968) a sample of this material assayed 1.32 per cent copper.

Disseminations of Chalcocite in Diabase Dykes

A north-striking diabase dyke 30 to 60 feet wide that intrudes the basalt flows on the Vic group (Canadore Mining and Development Corporation) contains disseminated chalcocite. Drilling and sampling of a 1,200-foot-long section of the dyke by the owners, indicated an average grade of 0.463 per cent copper across a true width of 35.7 feet. Narrow zones of copper-enriched diabase were also found adjoining small fault fissures. Frost shattered blocks of another diabase dyke that intrudes basalt flows on the A.C. group (Conwest Exploration Co. Ltd.) also contain disseminated chalcocite. A typical sample of this mineralized diabase, collected by the writer, contained 0.50 per cent copper (spectrochemical analysis). The copper content of these dykes is tentatively considered to have been emplaced with the parent dyke magma.

Support for a theory of widespread mineralization in sills or dykes of diabase is given by O'Neill (1924) in his Canadian Arctic Expedition Report. In the Bathurst Inlet area he found "a considerable amount of chalcopyrite and some chalcocite disseminated through some of the large sills or dykes of diabase which traverse the region". A grab sample of one such occurrence, on a small island just northeast of Algak was found by analysis to contain 1.18 per cent copper. Similar sulphide occurrences are displayed all along the ridge of diabase passing through Hanerotit Island about 16 miles eastward of Cape Barrow, and in other places.

Disseminations of Copper Sulphides in Diorite Dykes

A diorite dyke that crosses Willow Creek about a mile east of Willow Lake is well exposed at intervals for 5 miles along a north-northwest course from the creek and probably extends south of the creek. This dyke was examined by the writer in 3 places and was found to range from 80 feet to 125 feet in width. In each instance the rock was found to be of medium grain and to contain sparse disseminations of pyrite, chalcopyrite, and chalcocite. A spectrochemical analysis made on a sample of the diorite dyke collected about a mile north of the east end of Big Lake, showed a copper content of 0.1 per cent.

Fault-Fissure Veins and Vein-Lodes in Basalt Flows

Most of the fault-fissure veins are formed of quartz or calcite or dolomite or mixtures of these three minerals. Barite gangue was noted in 2 places; (1) associated with quartz and chalcocite a mile northwest of the Bornite Lamb property and (2) in veins near the north end of Tundra Lake. Small amounts of datolite and prehnite are found in a few quartz veins. Most of the above kinds of veins hold variable amounts of chalcocite, bornite and chalcopyrite and the copper content of these veins generally ranges from about 1 to 3 per cent copper, and some very rich shoots of ore are also found. Copper sulphide veins, formed predominantly of massive chalcocite and bornite and generally associated with some quartz, are present in a good many of the veins of quartz and carbonate. The sulphides veins are generally found to be short, narrow, and lenticular and in some cases are numerous enough to be of economic importance. A lenticular bornite lens known as the Copper Lamb bornite vein is the largest of this type found to date and its existence has been known for many years. This vein is located a mile northwest of Bornite Lake. It averages 47 per cent copper across a width of 12 feet at its widest point but is less than 200 feet long and is reported to pinch 20 feet below surface. It occurs along a strong quartz vein, along which other sulphide lenses might be found when more exploration is undertaken. Several of the copper-bearing quartz and carbonate veins are over a mile long but none of them has been tested for depth persistence of their copper mineralization (the Copper Lamb and Jack 13 veins were cut by only a few shallow drillholes). Silver content of the sulphide veins appears negligible judging from 6 fire assays for silver recently completed by the Mines Branch (Jan. 1970). The silver content of the 6 samples tested ranged from 1.10 to 2.67 ounces a ton.

Some small narrow chalcopyrite-bearing quartz and carbonate veins have been found in the dolomites that underlie the Coppermine River basalts but none found to date is of economic importance.

The Lloyd quartz vein is one of those that may eventually be of economic interest and a short description follows. The Lloyd vein is well exposed on the Lloyd 5 claim in 5 open-cuts and in natural exposures for a length of 500 feet starting at a point 250 feet northeast of the most northerly bay of Lloyd Lake. The vein strikes N40°E and has a vertical attitude. In the open cuts the vein ranges from 2 to 8 feet wide and the quartz gangue contains from 2 to 3 per cent or more of chalcocite. In one trench there is a lens of solid chalcocite 6 inches wide. Vugs lined with idiomorphic quartz crystals occur in several places but this type of quartz is mostly barren. The Lloyd vein is open to the northeast and it probably continues much farther to the southwest in an area largely drift covered. A mineralized quartz vein that outcrops on the east side of a small bay of Lloyd Lake and again in marshy ground on a peninsula 200 feet farther west, on the north shore, at a distance of 2,700 feet southwest of the showings described above, may be the same vein as it is directly on strike and if so the overall traced length of the Lloyd vein would be about 3,600 feet. At the lakeside showings the vein ranges 2 to 3 feet wide and the quartz holds chalcocite, bornite and some chalcopyrite, with a total copper content of at least 2 per cent. Some prehnite and minor carbonate are present in the quartz gangue. About 1,100 feet northeast of this lakeside showing there are loose blocks of quartz in the drift, that contain 3 or 4 per cent of copper sulphides. A 4-foot-wide malachite-stained shear zone that also strikes N40°E outcrops 100 feet north of the area of quartz blocks float, suggesting that there may be an *en echelon* pattern here and 2 overlapping parallel veins may be present rather than one.

Fault-Breccia Lodes and Shear Vein Lodes in Basalt Flows

Fault-breccia zones, sheeted, shattered and sheared zones within the basalt flows form the structural framework of the more important copper deposits in this area. These controlling structures are all closely related and they change from one to the other along major fault zones. In a typical deposit the copper sulphides and quartz and carbonate gangue minerals fill the open spaces and act as a cement that binds the angular fragments of the fault brecciated basalt zones together. The mineralizing process was invariably accompanied by some replacement of the wall-rocks and fragmented basalt.

Chalcocite is the dominant copper sulphide found in this class of deposit but some bornite is generally present and chalcopyrite is sometimes seen in very small amounts. The gangue minerals, present in varying amount, include quartz, white calcite, buff-coloured carbonate (dolomite), pink sanidine and rarely some barite. Small grains of anthraxolite are also found in the mineralized lodes, mostly as replacements of basalt, also in quartz veins, and more rarely as amygdule fillings. The anthraxolite grains are mostly in the form of small, soft, jet black grains 1/4 to 3/8 inch in diameter. The anthraxolite has well developed conchoidal fracture and is not radioactive.

The DOT 47 (Coppermine River Limited) copper deposit is the largest found to date in the area and furnishes a good example of a mineral deposit that occurs along a brecciated, shattered, and sheared zone, in this case along the major northeasterly striking Teshierpi fault zone. It is reported to be a vertically dipping tabular orebody about 1,400 feet long and 35 feet wide, but widening in places along successive gently dipping flow tops. One hole shows a depth of 600 feet. Late in 1968 the ore reserves were reported to be 4.16 million tons grading 2.96 per cent copper, allowing for 10 per cent dilution during mining.

The June deposit (Bernack Coppermine Exploration Limited) is another that occurs along a brecciated fault zone. It ranges in width from 3 to 15 feet in surface exposures, and is well mineralized with chalcocite for about 700 feet in the surface outcrops. Drilling (1969) has indicated that mineralization extends to a depth of over 300 feet. Ore tonnage outlined by the 1969 drilling is reported (Craig and Kelly, 1970) as 1,000,000 tons of 2.5 per cent copper.

A fractured brecciated zone known as the Dick No. 1 lode (Pickle Crow Gold Mines Limited) is another that shows good length and mineralization. It is 3 miles south of Willow Lake, strikes north towards the west end of the lake and has been traced by diamond drilling and through scattered outcrops and float for about 3,200 feet. A breccia zone of basalt fragments is cemented by stringers, veinlets and masses of quartz, calcite and chalcocite. According to C.P. Jenny (1954) the structure was drilled along a strike length of 1,100 feet and to a depth of 100 feet. The average width of the lode was estimated to be 10 feet and indicated ore was 90,000 tons of 8.78 per cent copper.

The Vera vein-lode (Consolidated Proprietary Mines Holdings Limited) is another chalcocite-bearing sheared and fractured zone that commands interest as it can be followed for 4,000 feet along its northeasterly strike (though much of it is concealed by drift cover) and in many places it appears to contain from 2 to 5 per cent of chalcocite over widths of 6 or more feet. In a cliff face toward the north end of this lode a branch vein-lode 4 feet wide that lies 100 feet east of the main lode contains 2 to 3 per cent of chalcocite.

The Pickle Crow vein-lode that lies north of Burnt Creek and about 2 miles north of the Vera is another deposit of the brecciated fault and shear zone type. It ranges from 6 to 30 feet wide and is readily traceable by opencuts and frost heaved float for over 1,000 feet in a northeasterly direction. In a rock cut towards its southwest end the lode is 6 feet wide; 2 feet is well mineralized, a visual estimate suggested a possible chalcocite content of over 20 per cent. A zone 4 feet wide in a rock cut about 1,000 feet farther northeast contains about 5 per cent of chalcocite. The full width of the lode is not exposed in this vicinity.

The CU vein-lodes (Quadrate Explorations Limited) which are located on the ridge a mile east of the Vera lode, are likewise sheared and brecciated fault zones containing appreciable chalcocite. Three separate lodes are present each of which exceeds 1,500 feet in length and 8 feet in average width. The northerly-striking No. 3 lode which was partially drilled in 1969 returned a weighted average grade of 3.74 per cent copper across a true width of 8.1 feet for a length of 525 feet (drill intersections about 100 feet below surface).

The Dot 210 shear-vein-lode lies a mile northeast of the No. 47 deposit, on Coppermine River Limited ground, and occurs along a branch of the Teschierpi fault system. It strikes northeasterly and can be followed through scattered outcrops for an overall length of 4,000 feet. It is a mineralized sheared zone that changes in places to a mineralized sheeted, braided fractured zone that ranges up to 30 feet in width. One or more chalcocite-bearing lenticular quartz veins that occur along this structure have average widths of about 12 inches but these shear quartz veins range in some places up to 3 feet in width. Along its more northerly exposures the sheared and sheeted basalt and shear quartz veins were seen to contain in general about 1 per cent of chalcocite across widths of up to 18 feet but this could be an underestimate. For 400 feet along its strike on either side of Dot Creek the sheared zone displays a braided branching outline and in many places contains up to 4 per cent of chalcocite. Along one sector 30 feet northeast of Dot Creek the lode is 25 feet wide and a chip sample collected across this width by the writer, assayed, 3 per cent copper. Another sample collected 140 feet farther southwest across a width of 7 feet, assays 5 per cent copper. Other sections of ore grade may occur in drift covered areas northeast of Dot Creek.

Amygdaloidal Impregnations in Basalt Flow Tops

Chalcocite fillings of gas vesicles in the vesicular upper parts of basalt flows form what are known as amygdaloid copper deposits. In general the gas vesicles of the basalt flow top zones have become filled with one or more of the following minerals - calcite, quartz, pink sanidine, chlorite and epidote and these filled cavities are called amygdules. Where chalcocite amygdules are present, the basalt wall-rocks are commonly found to have been replaced in part at least by chalcocite.

Amygdaloid copper deposits in this area are of economic interest only in the vicinity of and immediately adjoining vertical or steeply dipping mineralized, brecciated, fractured, sheared or fissured zones. Wherever steeply dipping or vertical fractures or brecciated zones etc. are mineralized, then the immediately adjoining flow top zones are suspect places to look for chalcocite deposition and enrichment. An example of good copper grades in this type of ore at the No. 47 deposit (Coppermine River Limited) was given recently in a drill results report for vertical hole S-122 located 50 feet off the southeast boundary of the main lode. The results were: 13 feet starting at 93 feet down assayed 10.46 per cent copper; 12 feet starting at 143 feet down assayed 2.16 per cent copper; 42 feet starting at 160 feet down assayed 1.59 per cent and 11 feet starting at 210 feet down assayed 5.96 per cent copper.

Malachite Lake gets its name from malachite-stained blocks of amygdaloidal basalt heavily impregnated with chalcocite, which litter the northwest shore of the lake. These blocks of ore are believed to have come from the bottom of the lake and were moved to their present position by northwesterly moving glacial ice.

Shear Zone Impregnations in Basalt

Many of the sheeted, brecciated, braided and shattered zones in the basalts change in places to shear zones in which there have been minute displacements along closely spaced fractures or cleavage planes with production of schistose zones. Some of the schist zones have been impregnated with varying amounts of chalcocite and some replacement and alteration of the sheared basalt has also taken place. The Dot 210 shear-vein-lode, already described above may be used as an example of a chalcocite-bearing shear zone that changes in places to a sheeted braided fracture zone. Much smaller shear zones that are also impregnated with small amounts of chalcocite are known to abound in the area, and many of them probably contain from 1 to 5 per cent chalcocite.

Sandstone Beds Replaced by Chalcocite Adjoining a Fault

Flat lying to gently northerly-dipping grey and greenish grey glauconitic sandstones, siltstones and shales that outcrop on the east side of Coppermine River 19 miles southwest of the mouth of Coppermine River are impregnated and replaced by chalcocite for 50 feet laterally on either side of a strong fault that strikes N60°E. Some chalcocite nodules occur in the sandstones near the fault fissure and malachite and azurite stains are prominent along the cliff walls in the 100-foot-wide zone centred along the fault. This mineralized belt probably continues northeasterly from the river for as far as the strength of the fault is maintained in that direction. The copper-stained sandstones probably contain between 0.3 and 1.0 per cent copper in the cliff exposures.

Chalcocite-rich nodules occur over a length of 500 feet or more in a 4-foot-thick band of greenish grey glauconitic sandstones that outcrop a few feet above the rushing waters of Coppermine River, where the latter flows easterly about 20 miles southwest of Coppermine, N.W.T. (on claim ESC 63). The nodules contain pyrite and hematite as well as chalcocite. They range from 0.1 to 3 inches thick and some are up to 4 inches long. Most of them are lenticular and some are spherical. The nodules are most plentiful in a 40-foot-long and 4-foot-thick zone where some crumpled or slump structures are present in the sandstone. This zone lies only a few feet west of a northeasterly-striking fault fissure that is calcite-filled and ranges from 1 inch to 6 inches wide. The sandstones on the east side of the fault contain scattered cobbles several inches in diameter in one place, and it may be that these were dropped from floating ice; this would tie in with an ice push origin for the crumpled beds noted above.

Some thin chalcocite-rich layers occur in the greenish grey sandstone beds that overlie the copper nodule zone at the base of vertical bluffs about 75 feet high. A sample of the mineralized sandstone collected by the writer (1968) 15 feet west of the fault contained 0.5 per cent copper. All of the exposed copper-bearing beds at this site occur within 50 feet of the northeast-striking fault and so it appears probable that the copper-bearing solutions were introduced along the fault, pyrite nodules near the fault were replaced by chalcocite and certain favourable laminae in the sandstones near the fault were replaced by chalcocite.

According to R.S. Hindson (pers. comm.) pyritic nodule beds occur at several locations a few miles farther north along the river and he has observed that the pyritic nodules are replaced by chalcocite only within a zone 25 feet wide adjacent to fault fissures.

Carbonatized Shear Zone - Copper Lode

The Dot 20 or Circle Lake No. 3 carbonatized shear zone is 600 feet north of the north bay of Circle Lake about 2 miles northwest of the No. 47, lode on ground owned by Coppermine River Limited. Judging from scattered surface exposures the deposit is at least 60 feet wide and 250 feet long but is open at both ends. The outcrops are formed of highly carbonatized amygdaloidal flow top basalt that is of a pale grey to white colour, with considerable green malachite stain. The carbonate mass carries between 1 and 4 per cent chalcocite and from 0.5 to 1 per cent pyrite. The ore is veined by tiny veinlets of red feldspar and of quartz. In its surface expression this deposit is part of a flow top and it probably represents a flared out or locally expanded part of what may be a narrower underlying mineralized zone, one with a steep or vertical attitude, but one which might be expected to flare out at other successive underlying flow top intersections. The lateral widening of the copper deposits along successive buried flow tops, at their intersections with vertical copper lode structures has been demonstrated as a proven feature in this area through diamond drilling evidence at the No. 47 lode. A central, deeply penetrating fissured, brecciated, and, or sheared zone seems to be indicated at the Dot 20 lode as openings were formed sufficiently deep to tap and conduct the hydrothermal calcium-rich solutions that were circulated to form the carbonatized zone. This deposit contains higher copper values in its surface outcrops than are found in surface ore outcrops at the No. 47 lode.

Sandstone Dyke - Copper Lode

The Cal 3 deposit is a sandstone dyke-copper lode that is situated on the northeast side of a small lake about 1 1/2 miles west of Cliff Lake in ground owned by Hearne Coppermine Limited. The sandstone dyke ranges from 5 to 7 feet in width and is well exposed for a length of 250 feet. Its strike is N70°E and the dip is vertical. The overall length of the dyke is about 600 feet; it abuts on the east against a fault which strikes about N27°W, and on the west it abuts against a fault that strikes N30°W. The westerly part of the dyke is concealed beneath a small lake and the latter mentioned fault follows the northwest side of this lake which is about 200 feet wide. The sandstone dyke is a clastic filling of a tension fissure and the sand filling may have been partially consolidated as it entered the fissure, judging from its partly fragmented nature, or it may have been lightly shattered after emplacement and consolidation. The sandstone is replaced by pods, grains, small masses and veinlets of chalcocite. In one pit several pockets of chalcocite up to 2 inches in diameter were noted. The dyke probably contains an average over all content of between 1 and 3 per cent of chalcocite. Amygdaloidal basalts form the wall-rocks in the close to the lode surface exposures.

The presence of chalcocite in the dyke suggests the presence of possible mineralization along the bounding northwesterly striking major faults which are largely drift covered. Some ore was noted along the fault scarp 1,000 feet northwest of the small lake.

Chert Beds Replaced by Chalcocite

At the south boundary of the CU group (Quadrate Explorations Limited) 2 1/2 miles southwest of the mouth of Burnt Creek some angular blocks of rich copper float ore up to 2 feet in diameter are clustered together in an oval area about 12 feet long. This material consists of brecciated reddish brown chert of which the fragmented material shows very little dislocation and the fragments of which are both cemented together by chalcocite and are in part replaced by chalcocite so that the resulting chert breccia contains about 10 per cent chalcocite and its spectacular appearance is enhanced by the presence of thin films of malachite. The chert horizon in which these copper minerals occur is intercalated with the basalt flows and so may be expected to dip gently north. Judging from the size of the ore boulders, the chert horizon is probably at least 3 feet thick and it may be much thicker, possibly even 10 or 15 feet thick. As malachite-stained red chert fragments occur in frost boils 200 feet south of the 12-foot-long area of float ore, it is probable that the chert bed is locally only lightly drift covered. The brittle nature of the chert horizon and its ready susceptibility to fracturing and replacement by chalcocite make it a possible carrier of widespread copper mineralization. This theory could be tested by drilling a number of short holes. It may be mineralized only in the vicinity of faults. Brecciation of the chert bed may have developed through fracturing by internal expansive chemical cracking. Chemical brecciation may occur according to Sawkins (1969) when cherts are invaded by alkali-rich hydrothermal solutions.

Another mineralized red chert horizon occurs on the Kil claims (Donalda Mines Limited) about 2 miles east of the mouth of Burnt Creek and just west of a small lake. This chert horizon can be seen in only a few places where it is overlain on the west side of a drift area by a massive grey basalt flow. The chert is lightly fractured and is replaced by irregular-shaped veinlets, spots and pods of chalcocite, all of which appear to adjoin minute fractures in the chert. Specimens collected at this locality all contained pods of chalcocite partially altered to native copper.

Supergene Native Copper Plates and Nuggets

Native copper as slabs, sheets, thin leaves and kidney-shaped masses are found in places along chalcocite-rich calcite and quartz veins where the chalcocite has been reduced, possibly by ferrous oxide and sulphuric acid to the native copper form as indicated in the following equation:

$$Cu_2S + Fe_2O_3 + 5H_2SO_4 = 2Cu + 6FeSO_4 + 5H_2O$$

Glaciation has removed the most favourable zones for occurrence of these native copper remnants and as Indians and Eskimos have searched the region for several centuries to find native copper with which to forge their hunting implements, the present day finding of native copper in large masses constitutes an unusual event.

Alluvial Detrital Deposits Containing Native Copper

It is probable that native copper slabs and nuggets have accumulated along the bedrock floors of some of the streams in the Coppermine River area and are now concealed beneath a mantle of alluvial sand, gravel and boulders. But it is unlikely that a placer mining venture to search for such accumulations would ever be financially rewarding.

ORIGIN OF THE COPPER

Most of the Coppermine River basalt flows contain small amounts of copper, and this natural copper content is considered to have been the prime supplier of the copper in those lode deposits that are found along most of the fissured, sheeted, brecciated and sheared zones. That copper was deposited along the major vertical and steeply inclined openings could be attributed in large part to the volume concentration of solutions moving along these channels and partly as a result of the mingling of vertically moving waters with lateral moving groundwater solutions that moved in along the amygdaloidal flow top zones. But there is no doubt but that hydrothermal solutions were also involved and that a deep seated magma chamber supplied both energy and vein forming solutions and probably also some of the copper. Surface evidence of the presence of a deeply buried copper-bearing igneous melt is seen in the copper-bearing diabase dykes and copper-bearing diorite dykes that cut the Coppermine River Group. A copper-bearing quartz vein that occurs along one wall of the largest diorite dyke indicates that the mineralizing period was long as it followed in part the latest period of igneous activity.

The great size and diversity of some of the vein deposits in the basalts are contributing evidence of deposition by hydrothermal solutions. Veins up to 75 feet wide are found that are composed of up to 95 per cent quartz, others are composed of up to 95 per cent calcite and a few are formed largely of dolomite. The vein-forming solutions from which these were deposited must have come up along conduits that were fed from deep seated and different parent sources. Some of these veins are barren while others contain appreciable copper that may have originated at the same source as the vein gangue.

Wall-rock alteration is well developed along many of the lode deposits and is further evidence of the past presence of hydrothermal solutions. The feldspars have been altered to chlorite, epidote, and carbonate and these minerals are widely distributed as amygdule fillings. There is an abundance of pink orthoclase feldspar (sanidine) replacing the basalts along most of the sheared and brecciated zones and it occurs as amygdule fillings.

CONCLUSIONS

An understanding of the different types of copper deposits (as outlined above) that are found in the Coppermine area, will be useful guidance for both prospectors and developers who are planning to carry on exploration in this region. There are probably hundreds of fault and fissure lineaments (visible in air photographs) in the area, that are largely hidden in drift-filled depressions, and many of which are probably mineralized but have never been exposed to view. A lot of drilling and or pick and shovel or bulldozer trenching will be required to prospect for possible well mineralized readily accessible parts of these structures. Geophysical work may find the breaks beneath the soil cover but evidence to date suggests that geophysical instruments are of little use in determining the presence or absence of chalcocite ores of the 2 to 10 per cent copper category in the presence of magnetite-rich basalt.

The writer believes that further very rich copper ores (the 10 per cent copper variety) may be found but only in limited amounts. The high tonnage copper lodes still being sought will probably be of around the 2 to 4 per cent copper tenor.

The recognition that hydrothermal solutions are in part at least responsible for the presence of the copper lodes in the basalts lends hope to the possibility that ore shoots may be found in future years to occur at greater depth than presently known, particularly along zones of profound faulting. It also means that copper deposits may be looked for in the older rocks south and east of the Coppermine River basalts.

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