Copper Deposits in the Nicola Rocks, Craigmont Mine

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IT is not the intent of this presentation to review the geology of the Craigmont Mine in detail but rather to outline the controls on the deposit and the conditions attending its discovery in the hope that the information presented will assist in the search for a similar deposit elsewhere in the Nicola rocks. The local areal geology and mine geology will be reviewed briefly, the ore body controls summarized, and the history and exploration problems reviewed.

Local Areal Geology

The main feature of the local geology of the Promontory Hill section of the Merritt area is the contact of the Jurassic Guichon quartz diorite and diorite batholith on the north with the Upper Triassic Nicola rocks to the south. This contact strikes approximately east-west. The strike of the Nicola rocks ranges from east-west to S 60° W so that the Nicola rocks are truncated at an acute angle against the batholith. The general dip of the Nicola rocks is steep to the south. The Guichon batholith at its southern edge is composed of diorite with an attendant fringe of dioritized Nicola rocks.

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The Nicola rocks on Promontory Hill comprise andesitic flows, vitric and lithic tuff, greywacke and limestone. The limestone beds seldom exceed 100′ in thickness, except when thickened by drag folding, but are believed to be continuous on strike for several miles and on dip for at least several thousands of feet. So far no correlations have been made to suggest that the several limestone beds could be repetitions of one or more folded limestone beds, although this is entirely possible.

Correlation of mine geology with the geology of the less altered rocks on Promontory Hill is complicated by the presence of a capping of Kingvale volcanics that covers the contact and much of the Nicola rocks for a mile to the west of the mine.

Craigmont Mine Geology

The Craigmont ore body can be described as a pyro-metasomatic replacement of a folded impure limestone bed, typified by heavy chloritization of the limestone. The copper-iron mineralization is closely associated with this chloritization, and to a much lesser degree with the garnet-epidote skarn alteration that appears to be a fringe alteration around the ore bodies. Lens-shaped pre-mineral diorite dykes and irregular andesite dykes within the ore zone have been mineralized to a small degree.

Ore minerals are the copper iron sulphide, chalcopyrite, which comprises almost all the copper mineralization, and the iron oxides, magnetite and hematite which occur in about equal quantities. There are no precious metals and almost no pyrite which makes the deposit rather unique.

northwestward partly along the Fraser River (White, 1959, p. 83). A north-trending graben adjoins the Guichon batholith near Ashcroft, in which Middle Jurassic shales and conglomerates accumulated; another extends northwestward to join the Fraser graben near Lillooet and received Lower Cretaceous volcanic rocks; and several other grabens are marked by Cretaceous and early Tertiary deposits. Still others are thought to exist, but are hard to trace beneath Tertiary lavas or where earlier volcanic or sedimentary strata are missing from them. Together the grabens form an intersecting and branching system of faults, many of which were active over a long period of time. This activity was expressed, not only by sedimentation and volcanism, but also by igneous intrusion. The later intrusions vary in size from dykes to stocks and may range widely in age. Although some cut Lower Cretaceous rocks, none are yet proved to be Tertiary. Whereas the earlier batholiths were chiefly of granodiorite, quartz diorite, and more basic rocks, the later intrusions are frequently more alkaline and approach granite and syenite in composition. Mafic intrusions of small size also occur, and are of picrite-basalt near Kamloops and of pyroxenite at the Canam mine. Porphyritic textures are general and many small intrusions are chilled to felsite and porphyry.

Porphyry intrusion is confined to zones of relative tension. The porphyry complex of Highland Valley occupies a northerly trending zone, in which a large stock and a series of dykes were emplaced and produced explosion breccias. The zone is central in the Guichon batholith and may have resulted from tensional stresses connected with movements of grabens around or within the batholith. Porphyries and explosion breccias are also found near the Iron Mask batholith and the Copper Mountain stock, where graben faults may likewise occur.

The structural history of the grabens is undoubtedly complex. Recurrent movement on the major faults caused folding and subsidiary faulting which even affect the early Tertiary rocks. Within the grabens the folding is mostly lengthwise and gently plunging. Where steep or transverse folds occur, they probably indicate strike-slip movement of the fault system. At the Canam mine a fold plunges almost vertically to a known depth of 1,600 feet and is located near a main graben fault. At Premontory Hills near the Craigmont mine, a thick and varied Nicola succession is partly upturned and warped near the Guichon batholith. The limestone beds show steep minor drag-folding and brecciation, indicating strike-slip movement between adjacent beds, and the steep regional warping probably resulted from relative movement of the batholith margin and major faults to the south. At the Nickel Plate mine, Billingsley and Hume describe intense crumpling of similar rocks due to movements on enclosing faults. Thus wherever Nicola or younger rocks are severely deformed, the influence of adjacent faults should perhaps be suspected.

All the known orebodies in the area appear to be associated directly or indirectly with major faults, which are part of a regional system about which we know far too little. Existing maps indicate that this system is radial and, like many other good things, originates south of the line (Fig. 2). Grabens extend fanwise from the Columbia basalt plateau, and branch and diverge to form the framework in which our ore deposits are found. A better understanding of this system is essential to efficient prospecting and the finding of new ore deposits, and can be expected through continued geological work.

There is a gradation in magnetite-hematite distribution from high magnetite content in the eastern end closest to the batholith to high hematite content in the western end. The chalcopyrite is distributed in close association with both iron oxides but appear richest where there is roughly an equal mixture of these two oxides.

The wall rocks of the favourable limestone bed are greywacke and the whole assemblage has been folded in pre-mineral times into large gently plunging isoclinal drag folds and to a lesser degree on the limbs that connect successive folds. To date two of these major structures have been outlined. Recently some evidence has been gathered that suggests that steeply plunging secondary drag folds may be superimposed on the gently plunging main folds, thereby increasing the thickness of the favourable rocks and providing a further localizing control on mineralization.

To date this one mineralized limestone horizon has been explored for 3600′ along strike, with mineable mineralization encountered for 2800′ of that length, and for 1800′ of vertical extent. Two major ore bodies have been discovered, one in each of the major folds. Ore widths range up to 220′ in the upper ore body and 300′ in the lower ore body.

Ore Controls

While present geological interpretations of structure and ore control are based on considerable evidence the interpretations should not be accepted dogmatically as the interpretations will probably be subjected to some modification as more evidence becomes available during the life of the mine. With this qualification the following ore controls may be applied to the Craigmont ore body:

1. Proximity to the batholith is a prime control. The Guichon batholith is considered to be the source of the hydrothermal solutions responsible for the alteration and mineralization of the limestone. Westward, where the divergence in strike of the Nicola rocks and of the contact causes an increasing separation between the limestone and the batholith at any one elevation, the alteration and mineralization decrease to the point where large masses of recrystallized but otherwise unaltered limestone occur. There may be an optimum range of separation of the limestone from the batholith contact which may reoccur along strike or dip, if the batholith surface is irregular.

The second prime control is the impure limestone host rock. A small percentage of the mineralization replaces diorite and andesite or occurs as fracture fillings in the wall rocks but the bulk of the mineralization is contained in the altered impure limestone. Grade of ore decreases abruptly at the limestone-greywacke wall contact. In most of the ore zone the original host rock is unrecognizable through the massive alteration and replacement, but the ever-present calcite and the occurrence of unreplaced limestone is evidence that the host rock was originally an impure limestone. Judging from less altered rocks to the west, the limestone was originally a thin bedded, somewhat argillaceous limestone with some thin cherty bands. It is not dolomitic.

The third ore localizing control is the drag folding structure in the impure limestone. Mineralization is best developed where the drag folding has thickened and possibly dilated the limestone beds.

Cross faulting and strike faulting may have some definite control on the size and location of portions of the ore bodies but unfortunately the magnitude of this effect has not been established. However, faulting does not appear to be as important as the above mentioned controls.

History of Discovery

The foregoing is an interpretation of the controlling geology of the Craigmont mine. The following discussion is a review of the factors contributing to the discovery of Craigmont.

First, it should be pointed out that the Craigmont ore body was completely covered by a variable thickness of overburden and was capped at its western end by the young Kingsvale volcanics. The nearest older rock outcrops were those of the Guichon batholith 1500′ to the north. There was no indication of Nicola rocks occuring beneath the overburden between the Kingsvale roeks to the south and the batholith to the north. This fact is brought out to illustrate the need for thorongh examination of any area covered by overburden or covered by what may prove to be a thin capping of younger rocks.

The key Craigmont claims were staked in 1954. Exploration work in 1956 and early 1957 comprised geochemical and magnetometer surveying and trenching on old showings on the batholith. Compass deflections were noted over what later proved to be the ore body during line cutting for the geochemical survey. A reconnaisance magnetometer survey in early 1957 indicated a strong anomaly over the ore body and another smaller anomaly to the north in the vicinity of weak copper showings in a road cut.. Two diamond drill holes on the north anomaly gave only negative results but the first hole on the main anomaly produced encouraging mineralization that led to the drilling of four more holes, culminating in the drilling of hole No. 7 which intersected 520′ of 2.22% copper.

The subsequent history of Craigmont since the drilling of hole No. 7 is one of adequate financing and thorough exploration and development with which you are all familiar. The discovery of the lower ore body at Craigmont in early 1960 was a result of progressive exploration by underground drilling of a narrow band of ore that was connected westward and downward with the major lower orebody.

Adjacent Showings

The other mineral showings in the immediate Craigmont area did not provide any clues that a large ore body was nearby. All these showings were in the diorite and consist of fracture fillings or disseminated replacements of chalcopyrite and magnetite. The number and location of these showings, however, does indicate a concentration of mineralization along the contact and such a distribution elsewhere could indicate the presence of a favourable contact situation. Some of these showings had attendant magnetic anomalies that could be misleading but luckily most of them could be stripped of overburden to expose the cause of the anomaly.

Exploration Criteria

Using the Craigmont deposit as an example it is possible to postulate the desirable criteria for search for a similar deposit. First an area must be selected around an intrusive body within the recognized copper belt where there is a probability of limestone of the Nicola series being in close proximity to the intrusive body. Areas of overburden or young volcanics should receive careful consideration on the possibility that they would be underlain by favourable rocks. Careful surface mapping may reveal favourable rocks and structures that could be projected to the vicinity of the intrusive contact. The cautious use of geophysics may provide some immediate exploration targets. It should be remembered that although the magnetic survey indicated the Craigmont ore body there is mixed hematite-chalcopyrite ore at the west end that is non-magnetic and this type of mineralization alone could be missed by the magnetometer. Geophysical methods dependent on conductivity give poor responses on Craigmont ore because the total sulphide content is low and well disseminated.

Careful attention to rock alterations during surface mapping or core logging may provide clues on the proximity to mineralization. Garnet epidote skarn developed in the limey rocks and silicification of the non-limey rocks is evidence of hydrothermal activity that could have produced an ore body nearby. Since chloritization is closely associated with mineralization at Craigmont this type of alteration should be considered an encouraging sign.

Once favourable geology has been determined an extensive program may be required to exhaust the possibilities or to find the desired ere body. It is unlikely that future ore bodies will be easily discovered and therefore well conducted long-range programs are required if other ore bodies are to be found in the Nicola rocks.