Title Queen Charlottes 802191

Author ASB

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A. METALLIC MINERAL DEPOSITS

I. Metasomatic Iron-Copper Deposits

Nature

Metasomatic iron-copper deposits are composed of magnetite and chalcopyrite in a range of relative proportions usually with pyrite or pyrrhotite and associated with a partial or complete envelope of skarn. They form a distinct type, characteristic of Vancouver, Texada, and Queen Charlotte Islands, which are united by similar stratigraphic setting, structure, form, and mineralogy. The description that follows is based on Queen Charlotte Island occurrences but might with few changes be applied to them all. Many of the common features have been noted from the earliest studies, McConnell ( ) and Young and Uglow ( ), but recent studies have noted these features with increasing precision as a result of much greater detailed knowledge of the deposits gained from extensive drilling and development and of the regional geology (Bacon, 1952).

The significant deposits and the great majority of the lesser deposits have the following features:

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1. At or within a few hundred feet of the contact of the massive limestone member of the Kunga Formation with altered sodic basalts of the Karmutsen Formation.

2. Near (within 500 feet) of a plutonic body.

3. Pre-ore diorite porphyry bodies present.

4. Post-ore dykes abundant.

5. Skarn envelope or partial envelope present--composed of garnet, epidote, tremolite, pyroxene, and chlorite.

6. Pre-ore faulting present.

7. Evidence of brecciation common.

8. Massive bodies of magnetite ~~and/~~or OR MAGNETITE, chalcopyrite, ~~with~~ pyrite ± PYRRHOTITE IN VARIABLE PROPORTIONS ~~and pyrite~~ with variabl~~e~~y sharp to gradational boundaries.

9. Shape of the orebodies an interplay of a number of forms concordant or discordant to bedding.

   (a) Tabular-lensoid or lensoid swarm conformable with bedding.

   (b) Tabular discordant to bedding.

   (c) Pipe-like discordant to bedding.

Orebodies may combine these shapes in varying degrees but concordant lensoid shapes are commonest.

These features are shown on Table which is a check list for all the important deposits and a selected few others. The location of the deposits are shown on Figure , the mineral resource map. Inspection of the table will show how relatively uniform this group of deposits are. Some small massive magnetite bodies or larger disseminated bodies occur in the Karmutsen Formation basalts or minor limestones in this formation, or may occur remote from plutonic rocks, but none of these ones have been considered by pragmatic prospectors sufficiently large to be worthy of continuing ownership. All the significant deposits are in the preferred setting. In addition the larger deposits seem to all have indications of pre-ore porphyry, faulting, and brecciation--and normally abundant post-ore dykes. The skarn envelope is commonly better developed in the basalts or diorite porphyry than in limestone, both in regard to completeness and size. In a few deposits in limestone skarn minerals are limited to the immediate vicinity of the magnetite, or even the interstices.

The mineralogy of skarn and ore is also relatively uniform. Skarn formed from limestone is commonly composed of fairly coarse mid-brown garnet of andradite-grossularite series. In other rocks garnet is commonly only developed in the most intense skarns and is commonly either fine or of irregular grain of more variable colour. Skarns formed from Karmutsen rocks are dominantly green rocks of chlorite, actinolite, epidote, and minor anthopyllite. Skarns formed of porphyries are lighter green—epidote, garnet, actinolite rocks. In both Karmutsen and porphyries remnants of the original texture are common. Minor quartz calcite and magnetite are present in almost all skarns. The ore itself is formed of a low titanium magnetite with scattered sulphides—chalcopyrite, pyrite, or pyrrhotite, with rare high iron black sphalerite. The proportions of sulphide to oxide may be reversed--normally in such a case the ore is replacing limestone. Magnetite may be fine to coarse grained & is commonly coarser where replacing limestone. Replacement of volcanic rocks, prophyry, or diorite is on the average not as complete as of limestone for inclusions of skarn or partly skarned rock of all sizes occur and the boundaries are generally gradational. Ore replacing limestone also commonly has small areas of coarse calcite the boundaries of which invariably have the coarsest well-crystallized magnetite so that the calcite appears like a vug filling.

like a vug filling. Scattered or massive garnet may occur within ore in limestone but rarely epidote, amphibole, or chlorite. Sulphides occur as smooth blebs or streaks, and also as irregular filling of interstices and as veinlets with clear quartz. Copper and zinc sulphides are commonest in limestone or orebodies replacing limestone, pyrite, or pyrrhotite in orebodies replacing igneous rocks.

Origin

The origin of the metasomatic iron-copper deposits of the coastal islands has received considerable attention but mostly through detailed field and microscopic study (Swanson, 1925; Jeffery, 196 ; Stevenson and Jeffery, 1964; Sutherland Brown, 1963). Geochemical and thermodynamic and theoretical aspects have had less attention and are clearly still needed (Sangster, 1964; Eastwood, 1965). A general consensus has been reached about the sources and general means although the mechanism is not outlined with either detail or confidence.

The nature of the deposits seriously limits the possible origins. A glance at the mineral resources map is enough to re-affirm that the basic setting is not accidental. These deposits are all close to plutons which intrude the Karmutsen Formation and deposition has generally occurred at or near the basalt-limestone contact. The Karmutsen sodic basalts are abnormally high in iron as well as soda, with total iron oxides about 13 per cent (see Chem analyses pp.). The plutons not only intrude the Karmutsen Formation offering an opportunity for assimilation but were seemingly generated by differential melting and mobilization of the Karmutsen Formation (see Plutonic Rx pp. Tectonics. pp.). Therefore there is an available source of iron that spatial data suggest it is the actual source.

The physical conduit system for the metalization is believed to be more nearly akin to hydrothermal processes than was believed in early studies concerned with skarns developed exclusively at intrusive contacts. Most significant deposits are definitely associated with either mineralized pre-ore faults or breccia pipes. Most of the larger deposits are also associated with pre-ore irregular diorite porphyry bodies which are more or less confined to the vicinity of the orebodies. These provide a great contrast in physical properties to either the limestone or chloritic basalts and behave brittly. Brecciation results on deformation and a permeable, reactive environment results. Recent underground development at Texada Mines, Texada Island, reveals the lower conduit system and the structural relations of porphyry, limestone, volcanics, breccia, intrusive rocks, and skarn orebodies. The orebodies form an upwardly branching system that follows a zone at the contact of the intrusive rocks in which irregular porphyry bodies and breccia are important. Where the system reaches the gently dipping limestone, both porphyry and orebodies blossom out. The whole system appears to have been a breccia pipe before it was largely replaced by skarn and magnetite (Sutherland Brown, 1964). Similarly the Kingfisher orebodies at Empire on Vancouver Island are pipes of circular cross-section which bifurcate upward and are locallized along a pre-ore fault (Jeffery, 1960).

The chemical mechanism for the transfer of the iron, alumina, and silica into the ore zone and other materials out is not as obvious. The actual transfer of materials in a metasomatic deposit is large and in replacement of limestone is very obvious. Replacement of baslt and porphyry involve more complicated transfers, such as the net increase in CaO in the skarn zone formed from porphyry, diorite or basalt in contrast to a decrease in limestone. This was suggested by the writer (1967) & demonstrated for the Prescott orebody of Texada Mines by Sangster (1964, p. 173). On considering the origin of colloform magnetite from the Kingfisher ore pipes replacing limestone, Stevenson and Jeffery (1964) conclude that rapid deposition occurred from a gel that approximates the chlorided solutions proposed by Holser and Schneer (1961). A complete review of these aspects is beyond the scope of this bulletin and has recently been well done by Sangster who concludes (1964, p. 134):

"Skarnification, which took place in the temperature range 700-550°C, generally preceded the main stage of magnetite deposition. Conformity to Gibbs Phase Rule and non-appearance of incompatible phases is strong evidence that equilibrium was attained during skarnification. Neutralization of iron chlorite solutions by calcite resulted in precipitation of magnetite in the temperature range 400-550°C. Ore fluids, originally one phase, probably developed into a two-phase system at lower temperatures. These fluids increased in pH by reaction with calcite until they reached at least 7.8, the minimum stability pH of calcite. Magnetite first filled cavities in skarn and brecciated volcanic rocks; then diffusion into, and replacement of, volcanic rocks took place. Where the volume of host rock dissolved exceeded the volume of metasome deposited, cavities were formed, some of which were later filled by magnetite or by post-ore calcite and/or quartz."

Title Jib

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Jib
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The Jib iron ore deposit is situated at Bluejay Cove on southeastern Burnaby Island. The major part of the deposit is just offshore. The property is held by Burnaby Iron Mines Limited, a company formed in 1963 and owned jointly by Mastodon-Highland Bell Mines Limited and Leitch Gold Mines Limited. The property consists of ~~57~~ 47 located claims which cover much of the southwestern peninsula of Burnaby Island south of Poole Point and extending across Skincuttle Inlet to Skincuttle Island of the Copper Islands.

The Jib iron ore deposit does not outcrop but cuperiferous skarns related to it were first investigated in 1862-63 by Francis Poole. The small adit and shaft near tidewater dating from this period can be seen on the bay south of the main deposit. Some further work was carried out on these copper-rich skarns on the present property both at Poole's original showing and further to the southeast during the period 1910-16. The history of the discovery of the iron deposit is as follows: In 1961 Denison Mines Limited had an aeromagnetic survey flown of the area from Burnaby to Kunghit Island in which the requisite geology was known to occur. A significant magnetic anomaly was discovered over the present deposit and claims located. However these were allowed to lapse without much further testing, and in the fall of 1962 were relocated by Highland-Bell. Drilling started in January 1963 and continued to September. Eighteen AX holes were drilled in fans from the shore with the longest holes nearly 1,000 feet long and a total of 12,208 feet altogether. This preliminary drilling established 2.5 million tons of 50 per cent iron ore and an additional 1.5 million tons of probable ore. In 1965 drilling recommenced (in May and continued until September); five new holes were drilled and ~~five~~ six deepened for a total of ~~6,805~~ 6735 feet.

Geology

The Jib is a typical metasomatic magnetite deposit in the typical setting. The geology is illustrated by Figure , a plan of the shoreline and Figure , which is a semi-longitudinal vertical cross-section on the western fringes of the orebodies. The stratified succession includes Karmutsen Formation and Kunga Formation massive grey limestone and flaggy black limestone members. All these rocks have characteristics normal for the units as described on pages to . The Karmutsen Formation is here formed of massive amygdaloidal basalt flows that are fairly well chloritized. As mentioned below, sills within the limestone are very similar and hence doubt may occur regarding identification of specific areas as belonging to one or the other. The grey limestone is shown by the drilling to have a total thickness of about 775 feet. Only the basal 100 feet of the flaggy black limestone is encountered on the showings or in the drill holes. The palaeontological control of one horizon of these rocks is precise for, although the collections from the massive limestone are indeterminate, collections on the property from two localities 20 feet above the base of the flaggy black limestone indicate an upper Karnian age probably correlatable with the _Tropites welleri_ Zone (_see_ p.). Both limestone units are bleached and recrystallized in part. The massive grey limestone has a pronounced bedding cleavage in the main bay whereas the flaggy limestone exhibits boudinage of the more massive beds at the northern outcrop area. The stratified rocks are intruded by dykes and sills and by the Burnaby batholith. This body is composed chiefly of melanocratic quartz monzonite. A sheared, skarnified contact of Karmutsen greenstone and the batholith is exposed in the little bay north of the showings. Highly altered granitoid rocks were penetrated in diamond-drill hole S-7 at 871 feet that may be the main body or possibly a dyke from it. The dykes and sills consist of three groups. The earliest are basaltic greenstones in all respects very similar to the Karmutsen flows. These rocks also occur within the Kunga massive limestone throughout the area surrounding Skincuttle Inlet. They resemble the Karmutsen flows lithologically and structurally are mostly quite conformable but they also occur as dykes, can be seen to have minor cross-cutting relationships with beds, and occur in varying stratigraphic positions in different areas. They probably are penecontemporaneous with deposition of the limestone and represent the last pulse of Karmutsen volcanism. The volcanic area south of the main bay is such a sill as can be seen best in section (Fig.). The second group of dykes are diorite porphyries similar to ones at other major metasomatic deposits. Their relationships at the Jib are not well known for they do not occur on the surface. They are skarnified and may be replaced by magnetite. At other properties they pre-date the main plutonic body and probably represent an early phase. The third group are late basalt to andesites that are post-ore and have a complicated relationship to the faulting--seeming largely to post-date major faulting but may be cut by late movement. Many are completely undeformed and have crudely developed columnar jointing normal to the walls. None are very large.

The structure of Skincuttle Inlet is relatively simple: Gently dipping panels which trend east to northeast and dip northward are cut into a mosaic pattern by steep block faults. The structure near the Jib is similar with some complications. Beds generally strike north 45 degrees east and dip from 10 degrees to at most 25 degrees northwestward. There is, however, a gentle, minor anticline-syncline pair in the vicinity of the main bay with axes trending west and plunging west 10 to 20 degrees (see Fig.). Additional complexities are the cleavage in the grey limestone and boudinage and small recumbent folds in the flaggy limestone. The axes of recumbent folds and boudins are oriented north 65 degrees east and indicate a net movement of the upper beds southward. The bedding cleavage may well result from the intrusion of the subjacent greenstone sill. The boudinage and recumbent folds might also result from dilation pressures on the intrusion of greenstone sills, but the orientation of axes is nearly normal to the contact of the Burnaby batholith so that it may well result from an outward thrust at a high level during emplacement of this body.

Three well-defined block faults near the Jib are oriented north 45 degrees east, north 75 degrees west, and north 30 degrees west. The largest is the fault oriented north 45 degrees east which apparently dropped the southeast block 1,100 feet. The other two definite faults have some striae indicating late horizontal movement but the main stratigraphic indications are of normal movement of 50 feet to 150 feet with the north and northeast blocks down. Two other important faults are believed to exist but are relatively poorly known or defined. One parallels the contact with the batholith (around north 60 degrees west) which is highly sheared and slightly skarned on the shore. Parallel to this minor shears occur in the greenstone ~~along the shore~~. The other fault is known only from drill holes and has a similar orientation (north 55 degrees west) and may in fact be the same fault. It appears to be a steep fault that drops the northeast block 100 to 150 feet. Precise information on the relative ages of faulting is lacking. Most faults appear to be pre-ore in part (because skarn and magnetite are emplaced along the fault lines) but most have also been subject to post-ore movement, offsetting even some of the late basalt dykes.

Orebodies

Exploration has not yet fully tested the magnetic anomalies on the Jib group. Some anomalies offshore have not been drilled at all and one of the more important has been penetrated by only one hole. Hence analysis and conclusions regarding the orebodies are preliminary.

The mineralogy of the ore and skarn is typical of the Queen Charlotte Island metasomatic deposits, with slight variations. On the whole the ore is fairly pure magnetite, but every gradation occurs to skarn with trace amounts of magnetite. Hematite occurs in some skarns in preference to magnetite. Sulphides are quite erratic and are chiefly pyrite, rarely chalcopyrite or pyrrhotite, and very rarely sphalerite. The average tenor of sulphur in ore is only 0.2 per cent; of copper, 0.02 per cent; of TiO_2, 0.08 per cent; and of P, 0.05 per cent. Skarn minerals are variably developed. Some skarns are nearly pure light brown garnetite, and in others epidote, actinolite, pyroxene, or chlorite may be dominant but seldom without much of the other skarn minerals. Quartz and calcite are common accessory minerals but are never dominant.

The Jib has two distinct groups of orebodies, one at the base of the limestone called the underlime orebody and the other within the massive limestone but concentrated about greenstone sills. The underlime deposit is on the whole a conformable body replacing the uppermost part of the Karmutsen Formation and to a lesser extent the basal Kunga limestone. Figure shows the known extent and thickness of this body. It has a crest more than 40 feet thick elongated in a north 10 degrees west orientation. At the southern part in diamond-drill hole S-22 the body is very much thicker and penetrates well up into the limestone. This may represent a vertical pipe or conduit and may connect underlime with the upper bodies. Very nearly everywhere the magnetite orebody is separated from adjacent greenstone or limestone by a thin sheath of skarn and in general the underlime deposit is slightly less pure than the upper bodies, containing more skarn minerals.

The upper orebodies are less regular than the underlime but are generally higher grade and commonly considerably thicker. Figure B shows an interpretation based on the drilling and magnetic anomalies of the cumulative thickness of the upper bodies. By comparison with the sections (Fig.) it can be seen that only the thickest sections are in continuous ore--toward the fringes they tend to fray out into two or more bodies separated by skarn, greenstone, or limestone. Skarn is a common transitional rock between ore and greenstone or limestone but it does not form such a continuous sheath or envelope as it does in the underlime deposit. It is clear from the sections that the orebodies replace the greenstone sills, particularly the contacts of the sills. Essentially one can say, no greenstone sill, no ore. Other factors must also be important but not all are clear. The thicker sections seem to be related areally to some of the faults, particularly the main fault through the ore zone (north 55 degrees west).

Reserves

As a result of the 1963 drilling the company announced reserves of 2.5 million tons of reasonably assured ore and 1.5 million tons of possible ore. In a short article by the engineering staff of the company after the 1965 drilling (Western Miner, p. 97) 7 million tons of ore grading 50 per cent soluble iron was said to be a cautious estimate.

[References: Minister of Mines, B.C., Ann. Repts., 1962, pp. 13-14; 1963, pp. 18-2
Western Miner, October, 1965, p. 97.]