XX CONGRESO GEOLÓGICO INTERNACIONAL



# SYMPOSIUM SOBRE YACIMIENTOS DE MANGANESO

Tomo III. AMERICA DEL NORTE

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## MANGANESE OCCURRENCES IN BRITISH COLUMBIA

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# MANGANESE OCCURRENCES IN BRITISH COLUMBIA

By Hartley Sargent. *

## CHAPTER I

### SUMMARY AND GENERALITIES CONCERNING MANGANESE OCCURRENCES

#### *Summary*

Manganese occurs in British Columbia as silicates, rhodonite and manganese garnet; as carbonates — rhodochrosite, manganosiderite, and manganese-bearing ankerite; and as oxides. The oxides include wad occurring in unconsolidated material, black oxides more or less mixed with silicates and other rock minerals, coating and to a degree replacing silicates, carbonates, and host rock, and filling veins and veinlets within the zone of weathering. Manganese in undetermined form occurs in some deposits of magnetite and some deposits of limonite.

Production has been almost entirely of wad from a deposit in unconsolidated material, on Kaslo Creek, and of ore from a bedrock deposit, in the Cowichan Lake area. The combined production including a shipment of 35 tons from a third deposit amounts to less than 2,500 tons.

Generalities Concerning Manganese Occurrences: Accumulations of black oxide are found only in the zone of weathering. The areas where most of them occur have been glaciated; the accumulations must therefore have been formed in the last few thousand years. The recent glaciation and continuing rapid erosion favour neither weathering *in situ* nor the accumulation of secondary products, and black oxide rarely extends below a depth of 2 or 3 feet.

The larger bedrock accumulations are obviously related to silicates (rhodonite and manganese garnet) and to a much lesser extent to carbonates, in rocks that are mainly cherty tuffaceous sediments, of which the ages have been given as: "Permian and older", 'Carboniferous and Permian", and "Triassic and older". It may be more than a coincidence that red siliceous rocks, described as chert, quartzite and jasper are mentioned in the descriptions of all the larger occurrences.

Manganese-bearing siderite is an important gangue mineral in many veins and replacement deposits in British Columbia, and rhodochrosite is an important constituent of veins in one locality. The veins and replacement deposits

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are considered to be of Jurassic or post-Jurassic age, the veins containing rhodochrosite being of Tertiary age.

Ankerite with varying manganese content is found widely in one area, as porphyroblasts, disseminated grains, streaks and narrow veinlets, in Lower Paleozoic rocks of the Cariboo group. Veins containing manganese-bearing ankerite are found in the same rocks. The mineralization in the veins is thought to be post-Jurassic, and the ankerite in the rocks of the area is thought to be in part introduced by the veins (Holland, 1954, pp. 24, 92).

In 1932 data on manganese deposits then known in British Columbia were brought together in "Manganese Deposits of Canada" by G. Hanson (1932). That volume includes descriptions of ten deposits and tabular reference is made to eight other occurrences in British Columbia.

Some thirty occurrences are now known; additional geological descriptions have become available, and deposits near Cowichan Lake have been mapped and described more fully.

The occurrences considered include several accumulations of black oxide limited to patches a few square feet in area; they also include manganese minerals noted as important constituents of veins explored or worked for other minerals.

## CHAPTER II

### GEOGRAPHIC DISTRIBUTION OF MANGANESE DEPOSITS

The more extensive deposits of wad in unconsolidated material investigated in British Columbia are: a few miles west of Kaslo (1)*, at Nazko (2), near Birch Island (3) some 65 miles northerly from Kamloops, and near Owen Lake (4) midway between Prince Rupert and Prince George.

Bedrock accumulations of black oxide have been investigated in six localities: in a belt trending northwesterly on the northern side of Cowichan Lake, Vancouver Island (5), on Saltspring Island (6) in rocks of the same series as those in the Cowichan Lake belt, a few miles northwesterly from Olalla (7) in southern central British Columbia, near Arrowhead (8) northwest of the Slocan area, near Clinton (9), and on the eastern side of the Fraser River some 18 miles southwesterly from Williams Lake (10).

Veins or lodes containing manganiferous siderite are known about 100 miles easterly from Vancouver in the Summit Camp (11), and in the Slocan area. Veins containing rhodochrosite occur near Owen Lake

* Numbers in brackets correspond with numbers beside solid dots on Figure 1, indicating the approximate localities of manganese deposits.

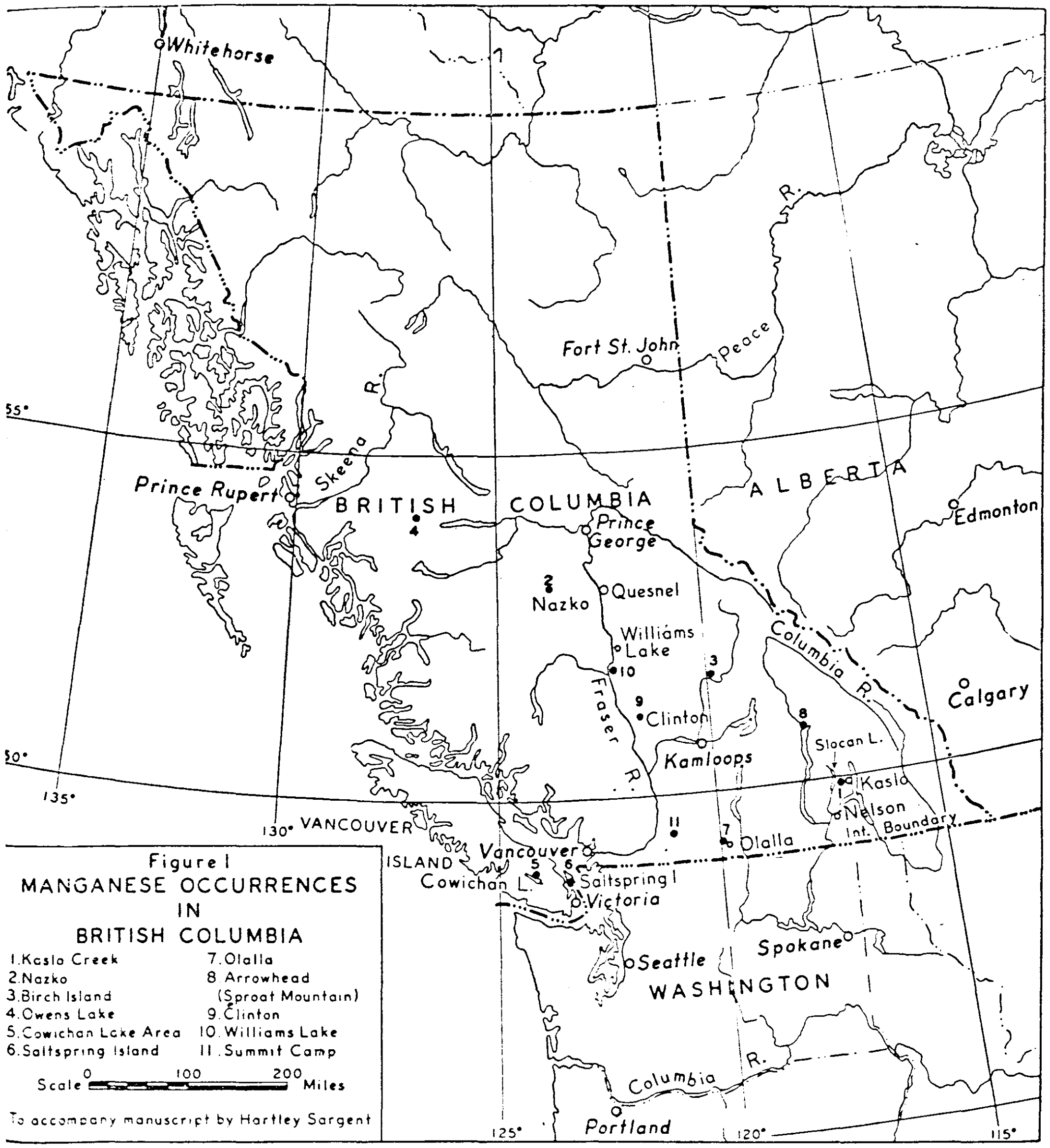
Figure I
MANGANESE OCCURRENCES
IN
BRITISH COLUMBIA
1.Kaslo Creek
2.Nazko
3.Birch Island
4.Owens Lake
5.Cowichan Lake Area
6.Saltspring Island
7.Olalla
8.Arrowhead
(Sproat Mountain)
9.Clinton
10.Williams Lake
11.Summit Camp
Scale 0 100 200 Miles
To accompany manuscript by Hartley Sargent
Whitehorse
Fort St. John
Peace
R.
Skeena
R.
Prince Rupert
BRITISH COLUMBIA
ALBERTA
Edmonton
Prince George
Nazko
Quesnel
Williams Lake
Columbia R.
Calgary
Fraser R.
Clinton
Kamloops
Slocan L.
Kaslo
Nelson
Int. Boundary
Olalla
VANCOUVER ISLAND
Vancouver
Cowichan L.
Saltspring I
Victoria
Seattle
Spokane
WASHINGTON
Columbia R.
Portland
55°
50°
135°
130°
125°
120°
115°

(4). Black oxide in vein outcrops probably derived from manganiferous siderite or rhodochrosite, is noted in many localities including the area near Nelson and the Portland Canal-Alice Arm area north of Prince Rupert. Manganese-bearing ankerite is noted as widespread in a considerable area east of Quesnel.

## CHAPTER III

### GEOLOGIC DESCRIPTIONS OF MANGANESE DEPOSITS

#### *Occurrences in Unconsolidated Material*

*Wad**.—Two deposits of wad on Kaslo Creek are described by Cairnes (1935, pp. 231, 232). The layer of wad or wad mixed with soil is covered by a thin layer of soil or by vegetation and is underlain by subsoil, tufa, or limonite. The wad layer extends over areas calculated as roughly 2½ and 5½ acres (Cairnes, 1932, p. 108) for the Kaslo Creek occurrence. The larger deposit has been the source of all the wad mined in British Columbia. The higher grade material has been largely exhausted from this deposit. In the smaller deposit the thickness of wad ranges from 1 inch to 33 inches and averages 13 inches.

Sampling in six pits in an area of 1.3 acres near Nazko (Stevenson, 1955, p. 30) indicated wad of varying grade ranging from 6 inches to 36 inches in thickness.

A small deposit near Birch Island (Walker, 1930, pp. 147, 148), and another on the Midnight property at Owen Lake (*Minister of Mines, B.C.*, Ann. Rept., 1928, p. 171) have also been described.

*Manganese in Limonite Deposits.*—Analyses for the Zymoetz River limonite deposits show manganese to range from 0.39 per cent to 0.85 per cent with iron from 52.19 per cent to 56.01 per cent (MacKenzie, 1915, p. 68), but other deposits may be devoid of manganese.

#### *Bedrock Occurrences of Black Oxide*

In the bedrock deposits the black oxide ** is usually compact and coats the rock as a thin film or accumulates upon and replaces the

* The term wad is used for black manganese oxide in unconsolidated material.

** The term black oxide is used for the oxide of manganese in bedrock deposits unless the manganese mineral has been determined.

rock for a thickness that in most deposits is not more than a few inches, but in some deposits is 2 or 3 feet, and in one deposit may have been present in significant volume to a depth of 15 to 20 feet. At some deposits black oxide or material heavily stained by black oxide is present mainly as the filling of joints and veins.

*Vancouver Island, Saltspring Island, Vargas Island.*—The Cowichan Lake area on Vancouver Island contains numerous occurrences of black oxide related to rhodonite, manganese garnet, and some rhodochrosite. The Hill 60 deposit in that area has yielded more than 95 per cent of the bedrock manganese ore produced in British Columbia.

Those deposits and one on Saltspring Island, some 30 miles southeasterly from the eastern end of Cowichan Lake are in cherty tuffaceous sediments mapped as Sicker group. The occurrence on Saltspring Island resembles those in the Cowichan Lake area, but pyrite may be more noticeable in it. Brown garnet and magnetite occur near by.

An occurrence on Vargas Island (Dolmage, 1920, p. 22) consisting of black oxide filming sheared ferruginous cherty tuffs may be in rocks that also belong to the Sicker group. However, it is 60 to 70 miles westerly from the nearest sediments mapped as Sicker group.

*Cowichan Lake area.*—The Hill 60 deposit is about 6 miles east of the eastern end of Cowichan Lake. The Cottonwood or Widow Creek deposit is about 12 miles northwesterly from the Hill 60 deposit, and the Black Prince or Shaw Creek deposit is a further 12½ miles to the northwest. Within this belt 25 miles long, ten occurrences of manganese have ben prospected to some degree.

The Sicker group rocks are of Permian or pre-Permian age. They consist mainly of volcanic rocks with interbedded cherty tuffs and some jasper. In the Cowichan Lake area, the cherty tuffs are in areas of moderate size separated by volcanic rocks of the Sicker group, by later volcanic and sedimentary rocks and by granodiorite and quartz diorite.

In discussing the general nature of the Cowichan Lake deposits Fyles (1955a, 65, 66) states:

"The manganese deposits occur in cherty members of the Sicker group, principally within the lower part of the 600 feet of (thin-bedded) cherty tuff immediately above (a distinctive coarse volcanic breccia a few tens of feet thick). The manganese deposits are associated with massive brick-red jasper occurring in beds 6 inches to 3 feet thick, or with red, pink, and white cherty sediments interbedded with less brightly coloured cherty tuffs. These red sediments, rich in hematite, are present at all the manganese deposits seen by the writer but also occur locally in the cherty members of the Sicker group, where no manganese deposits are known. Under the microscope, cherty rocks in which manganese occurs appear to be coarser grained and richer in quartz than the normal cherty tuffs. The quartz has a mosaic texture in thin sections, occurring in grains as much as 0.2 millimetres across. Outlines of radiolaria (?) are present in some sections, but are less distinct than those in cherty tuffs away from the manganese deposits.

"The primary manganese minerals, which are mainly silicates, occur in roughly lenticular masses with long axes parallel to the bedding of the enclosing sediments. The lenses range from a fraction of an inch to several feet thick, and from a few inches to as much as 40 feet long. Little is known of the dimension of mineralized zones down the dip, but it probably differs little from that parallel to the strike. Larger lenses are shorter in relation to their thickness than smaller lenses and appear to be made up of a number of small lenses.

"Manganese oxides coat the outcrops at all the occurrences, but fresh silicates commonly occur a few inches beneath the surface".

Only at the Hill 60 deposit have the workings reached depths of more than 4 or 5 feet below the bedrock surface. The black oxide apparently extended several feet deeper there than at other deposits, possibly because of the abundance of joints.

The main occurrence at the Hill 60 deposits was stripped of overburden in 1918. Published details of sampling (*Minister of Mines, B.C.*, Ann. Rept. 19, pp. 237-238; *Munition Resources Commission, Canada*, 1920, pp. 90-92, and Plate XXXI) gave analyses of twenty-five samples taken in an area about 25 by 50 feet. The average of the analyses was: manganese, 43.78 per cent; silica, 23.28 per cent; iron, 1.55 per cent; sulphur, 0.10 per cent; phosphorus, 0.06 per cent; and alumina, 1.02 per cent.

The Hill 60 pit has the following approximate dimensions: length, 60 feet; breadth, 20 to 30 feet; depth, 15 to 20 feet. The walls and the broken rock in the bottom of the pit are of cherty tuff and rhodonite, in part filmed or coated with black oxide. Prospecting nearby exposed several much smaller concentrations of black oxide, usually as a coating not more than a few inches thick on small lenses of rhodonite and other silicates.

Fyles (1955a, pp. 68, 69) gives details of other deposits, found in approximately the same stratigraphic position in the Sicker cherty tuffs. About a mile east of Meade Creek, lenses containing rhodonite and manganese garnet in red and white cherty tuff are as much as 3 feet thick and, as indicated by float and two trenches, may be closely spaced or more or less continuous along the strike for some 300 feet. The trenches prospect a band only a few feet wide. Black oxide is limited to relatively thin coatings on the lenses of manganese silicates.

At the Shaw Creek or Black Prince deposit manganese silicates, mainly rhodonite, occur as lenses that appear to be scattered irregularly in highly folded red and white cherty tuffs in an area about 100 by 300 feet. The manganese silicate lenses are coated with black oxide, while some lenses to a depth of 1 or 2 feet are composed of hard black siliceous oxide.

At the Cottonwood deposit, on Widow Creek, in an area not more than 50 by 100 feet, lenses of rhodonite and brown rhodochrosite are essentially parallel with the bedding in tightly folded light grey and cherty tuff and masses of brick red jasper.

*Olalla.*—A deposit near Olalla (White, 1949, p. 132; and Fyles, 1955b, p. 42) is in a 30-foot band of red chert that dips steeply northeastward and has been prospected along a 330-foot horizontal length. Chert, traversed by a network of minute veins that contain rhodonite, merges with hard black siliceous manganese ore containing masses of rhodonite and chert. Areas containing manganese in fair amount range in width from 12 inches to about 10 feet. The assays of channel samples range from 14.6 per cent manganese and 56.2 per cent silica across 7 feet 2 inches, to 48.3 per cent manganese and 15.3 per cent silica across 1 foot 11 inches. In the lowest cut a zone that is dominantly oxide grades downward into silicates at depths from 1 to 3 feet. The chert is within an area mapped as "mainly chert, tuff, greenstone, limestone" "Triasic or older" *(Geol. Surv., Canada.* Map 628A, 1941).

*Clinton.*—Three deposits of black oxide, within a few miles northwest, southwest, and southeast of Clinton, described by Reinecke (1920, p. 95) and Holland (1948, pp. 91-92), are in rocks of the Cache Creek group of "Carboniferous and Permian" age. In the two deposits described by Holland, black oxide fills narrow fractures, replaces irregular areas, and coats surfaces of grey-green chloritic schists and of pink to brick-coloured quartzite, the lowest bed in the mineralized zone. The length of the deposit trends with the strike of the beds and they dip about 45 degrees southwestward. At the one deposit black oxide is found over a stratigraphic thickness of about 50 feet in an exposed length of 325 feet. A sample of the red quartzite with oxide coating assayed 0.75 per cent manganese, and one across a 10-foot section containing numerous veinlets filled with black oxide assayed 15.8 per cent manganese. At the second deposit black oxide was found over a stratigraphic thickness of 20 feet and a length of 110 feet. In describing the third occurrence, Reinecke refers to the best ore lying in clay formed by alteration of rock along a fault; and speaks of the ore having been introduced with quartz veins and having impregnated the rock in an irregular manner. Neither author indicates that the black oxide gave out within the exposed depth, and neither identified any primary manganese mineral.

*Other Bedrock Occurrences.*—Other known occurrences of black oxides are not extensive enough to be of economic interest.

Occurrences of Silicates and Carbonates of Manganese: Information on occurrences of silicates and carbonates has become available through the exploration of occurrences of black oxide, through areal geological studies, and investigation of deposits considered of interest mainly because of silver, lead, and zinc, in which manganosiderite or rhodochrosite occur as gangue minerals.

J. M. Black (1952, p. 125) refers to assays of 0.2 to 11.5 per cent manganese from samples from silver-lead-zinc bearing veins in the Summit Camp, about 125 miles east of Vancouver. Probably siderite is the manganese-bearing mineral.

Siderite, a very common gangue mineral in the silver-lead-zinc ores of the Slocan area, usually contains manganese. The manganese content may vary in a single deposit. The Contact or Black Prince property, 14½ miles northwesterly from Kaslo, has received attention because of the manganese content. The occurrence is described by Cairnes (1935, pp. 204-205):

"A bed of limestone about 150 feet thick... is bordered by shaly and slaty, dark grey to brownish, argillaceous rocks all belonging to the Slocan series*... On the Contact claim the limestone has been ex-

* Of Triassic Age.

tensively replaced, particularly along the hanging-wall side, by manganiferous siderite that carries here and there a little galena, blende, and pyrite and is much oxidized near the surface.

"...Two adits and much surface trenching and stripping, ...designed chiefly to investigate the mineralization along the hanging-wall side of the limestone bed, ...proved the continuity of a body of partly oxidized siderite over a distance of at least 200, and probably 600, feet. Its thickness, where most closely investigated... averages at least 20 feet. ...An open-cut along the foot-wall of the limestone bed has exposed very similar siderite replacement across a width of 30 feet. The linear extent of this body has not been investigated".

Similar manganese-bearing siderite on the Con claim lying east of the Contact is described by B. T. O'Grady (1931, pp. 144-146) whose summary includes the statement: "...the five workings, aggregating a large amount of trenching, indicate an extensive zone of mineralization adjoining the limestone-contact in the vicinity of the intersection of the two cross-veins".

Analyses quoted by Cairnes and O'Grady suggest that the average manganese content of the siderite would probably exceed 10 per cent.

Veins in which manganese has been noted because of the manganese-stained outcrops and chemical or spectrochemical assays of samples include:

Bear Paw, Lemon Creek - *Minister of Mines, B.C.*, Ann. Rept. 1938, p. C 10.
Free Silver, Nelson - *Minister of Mines, B.C.*, Ann. Rept. 1915, p. 155.
Humming Bird, Omineca - *Minister of Mines, B.C.*, Ann. Rept. 1908, 172; *Geol. Surv., Canada,* Sum. Dept. 1908, p. 48.
Owen Lake - *Geol. Surv., Canada,* Sum. Rept. 1929, Part A, pp. 77-79, 83-91.
Prosperity - *Geol. Surv., Canada,* Mem. 159, p. 60.
Silver Bell, Portland Canal - *Minister of Mines, B.C.*, Ann. Rept. 1918, p. 72.
Silver King, Nelson - *Minister of Mines, B.C.*, Ann. Rept. 1896, 77.

## Manganese in Iron Ore

Analyses of magnetite ore show manganese to be present in six deposits. One analysis (Uglow, 1926, p. 185) gives manganese 1.14 per cent with iron 59.34 per cent; the five other analyses (Op. cit., pp. 197, 204, 216; and Stevenson, 1950, p. 128) show manganese from 0.016 to 0.46 per cent with iron from 35.3 per cent to 68.8 per cent.

## CHAPTER IV

### MINERALOGY AND PARAGENESIS

#### *Kaslo Creek Wad and Its Probable Source*

Cairnes' report (1935, 231, 232) on the Kaslo Creek occurrences of wad contains the following:

"The deposits consist of wad or bog manganese interstratified with and generally fairly sharply separated from deposits of hydrous iron oxides, calcareous tufa or sinter, and layers of clayey sub-soil. The principal manganese deposits occupy two irregular areas, one on the Manganese claim covering about 5½ acres and one on the Manganese No. 1 claim over 2½ acres. . . . Within these areas the bog manganese formed deposits of variable composition and ranging from less than an inch to 3 feet in thickness.

"The various types of wad in these deposits have been classified by Bancroft as follows:

" 'Unconsolidated wad forming the surface soil, in places covered by a thin layer of wood ash due to forest fires.

" 'Layers of partly consolidated wad associated with other deposits derived by chemical precipitation from mineral-bearing solutions.

" 'Hummock-like deposits, formed near mineral springs, having abrupt lateral limits.

" 'Concentrating or lumpy ore consisting of nodules and concretions of wad in beds of unconsolidated detrital material (with manganese coating and cementing pebbles together) . . .'

"Of these types, the layers of partly consolidated wad form the highest grade material, but occur in relatively small proportion to the unconsolidated wad type, which consequently is the material of principal economic interest. Analyses of both types are given below. The partly consolidated wad has a porous, clinkery appearance much like that of coke".

Cairnes made a composite sample (A) of the unconsolidated wad from 177 holes that had been sunk to the bottom of the deposit in the Manganese No. 1 claim. In fifty-three of the holes partly consolidated wad was also found and was estimated to make up about a tenth of the total amount of unconsolidated wad. A composite sample (B) of the partly consolidated wad was also made. Analyses of those samples by

A. Sadler, Mines Branch, Department of Mines, Ottawa, are quoted by Cairnes (1935, p. 233) as follows:

| — | A | B | — | A | B |
|---|---|---|---|---|---|
| Mn ........ | (31.57) | 50.10 | CoO ........ | 0.013 | ........ |
| MnO ....... | ........ | ........ | CaO ........ | 3.40 | ........ |
| $MnO_2$ ...... | 49.94 | (79.25) | MgO ....... | 0.72 | ........ |
| $SiO_2$ ....... | 12.03 | ........ | S .......... | 0.045 | ........ |
| $Fe_2O_3$ ...... | 3.73 | 0.76 | $CO_2$ ........ | 6.44 | ........ |
| $P_2O_5$ ....... | 0.21 | ........ | $H_2O$ + 105°. | 10.80 | ........ |
| NiO ........ | 0.22 | ........ | Insoluble .... | ........ | 2,57 |

Hard porous wad from the Kaslo Creek deposit was tested recently in the laboratories of the British Columbia Department of Mines. Dr. G. C. B. Cave, Chief Analyst, reported the following data:

| | Per cent |
|---|---|
| true specific gravity | 2.73 |
| pore volume | 66. |
| total water in air-dried material | 15.6 |
| manganese (acid soluble) | 38.4 |
| acid-insoluble matter (mainly silica) | 17. |

*Semi-Quantitative Spectrographic Analysis*

| | | | | | |
|---|---|---|---|---|---|
| Si | 5-50% | Ba | 0.1-1% | Co | 0.02-0.2% |
| Al | 0.3-3% | Sr | under 0.1% | Ni | 0.007-0.07% |
| Mg | 0.2-2% | Ti | under 0.1% | Cu | 0.003-0.03% |
| Ca | 0.2-2% | Na | 0.03-0.3% | V, Cr:Traces. | |
| Fe | 0.2-2% | | | | |

Note: Lower limit for the detection of K is 0.2 per cent. by the method used.

NOTES

1) All the results above are on the sample as received.
The sample "as received by the Analyst" had been stored in the lapidary's work room, heated as required, for five years.
2) Less than 0.05 per cent of Mn was found in the acid-insoluble matter.

3) The acid-insoluble matter reported is only an approximate value, probably correct to one per cent.
4) The per cent "Pore Volume" is the volume of air-space per hundred volumes of the bulk sample "as received", and was calculated from the weight per cc. (as received) and the true specific gravity.
5) Some organic matter is present in the sample.

Cairnes considered that the Kaslo Creek wad was deposited by spring waters that had derived manganese and other mineral matter from the valley slopes above the deposits. The slopes are underlain chiefly by greenstones of the Kaslo series, and they had been regarded as the source of the iron, calcium, and manganese, but Cairnes (1935, p. 233) considered that sediments of the Milford group also outcropping in the slopes were at least partly the sources of the manganese and calcium. Under the microscope he found the sediments "to be chiefly quartzitic types carrying varying proportions of black and reddish oxides and, locally, abundant grains of a manganiferous garnet (spessartite?) which are commonly surrounded by rims of black manganese oxide. Most specimens show abundant tiny crystals, commonly diamond shaped and possessing high relief, of another manganese mineral, probably either braunite or hausmannite".

He also described rock in the hangingwall and footwall of a quartz vein on the Harp Group, on the same side of Kaslo Creek as the wad deposits and possibly a mile and one-half from them, as follows (1935, pp. 221, 222):

"The hanging-wall rock is banded quartzitic argillite, very similar to that occurring on the Manganese No. 4 claim of the Manganese group. A thin section of this rock, studied microscopically, revealed a mosaic chiefly of quartz and a manganiferous garnet, the latter partly altered to oxide of manganese. The foot-wall rock is mostly a greenish schist forming a band about 2 feet wide underlain by sediments. Immediately beneath the quartz vein, however, is a close succession of narrow lenses of pink, rhodonite-bearing rock ...Under the microscope the rhodonite-bearing rock much resembles a siliceous limestone and is composed of quartz, calcite, a little garnet, considerable pyrolusite, and abundant rhodonite. The latter occurs in masses, streaks, and disseminations through the rock, in places reaching a width of several inches. ...A specimen (of rhodonite-bearing float) examined by E. Poitevin of the Geological Survey was reported by him as 'calciferous rhodonite, that is impure rhodonite, due to the presence of calcium and iron carbonate.' ...The inference from such associations and resemblances is that the rhcdonite on the Harp group is secondary after some primary manganese mineral, probably rhodochrosite, deposited as a carbonate during the formation of these siliceous limestones".

### *Bedrock Occurrences of Black Oxide and Related Silicates and Carbonates*

Minor occurrences of black oxide related to manganese garnet and perhaps to rhodonite near the Kaslo Creek wad deposit have been noted in the preceding part of this chapter.

In specimens from the Olalla occurrence, Thompson (R. M. Thompson, private communication) recornized braunite but no pyrolusite nor manganite. He also recognized rhodonite and a trace of rhodochrosite. The descriptions (*see* Chapter III) indicate that hard black siliceous oxide grades into rock containing rhodonite, that such rock is replaced along fractures by black oxide, that masses of siliceous manganese oxide a few inches thick occur along fractures in rock that is mainly rhodonite or jasper, and that masses of black oxide may contain irregular kernels of unaltered rhodonite or jasper. The red chert in which the black oxide occurs is traversed by a network of minute veins containing rhodonite.

Concerning the Cowichan Lake occurrences Fyles (1955a, pp. 66-67) states:

" Manganese oxides coat the outcrops at all the occurrences, but fresh silicates commonly occur a few inches beneath the surface. At several localities a good proportion of the silicates are oxidized to a depth of several feet and at the Hill 60 deposit oxidized material is reported to have extended to a depth of 15 feet.

"The chief primary manganese mineral is rhodonite, which is characteristically pink but locally is brick-red. Rhodonite occurs as lenses parallel to the bedding of the sediments, as veinlets cutting across the bedding, or as fine —to medium— grained irregular masses. Texturally it appears to replace the cherty sediments. Lenses parallel to the bedding have scalloped edges and terminate with blunt irregular ends, veinlets commonly merge with rhodonite-bearing bands parallel to the bedding and the irregular masses display no primary structures.

"Garnet was found in several thin sections of the manganese-bearing rocks but is too fine grained to be recognized in hand specimens. Brown bands associated with manganese-bearing rocks, however, commonly contain garnets. As seen in thin section, they appear as euhedral crystals, about 0.1 millimetre across, occurring in bands parallel to the bedding of the sediments. The garnets are probably manganiferous, though their exact identity is uncertain.

"A yellow manganese-bearing chert is common at the Hill 60 deposit and occurs in small amounts at several of the other deposits. This material, by itself, associated with rhodonite, or cut by fractures containing black oxides, is used locally by lapidaries, but the identity of the yellow constituent has not been determined. X-ray, spectrochemical and optical studies indicate that the yellow mineral is a type of manganese garnet.* In hand specimens it appears to form very closely spaced, fine irregular bands in the chert. In this sections the bands are seen to be composed of equidimensional grains of high relief but too small for identification.

"Rhodochrosite is present in small amounts in some of the deposits, especially at the Cottonwood near the head of Widow Creek. At this locality it occurs as a brown massive rock which in thin section appears to be about one-half rhodochrosite and one-half rhodonite. The rhodocrosite seen in thin section occurs as irregular masses that grade into finely crystalline rhodonite, giving a texture that suggests the rhodochrosite has replaced the rhodonite.

"The disseminated grains of pyrite occur with the manganese minerals at Hill 60 and are present at several of the other occurrences. Quartz veinlets are common, and at Hill 60 contain pyrite and chalcopyrite.

"The manganese deposits are fundamentally of two possible origins; either they are epigenetic replacement deposits or metamorphosed sedimentary deposits. Individual outcrops and hand specimens show that the manganese silicates have replaced the surrounding chert at least on a small scale. General features of the deposits and their

* Spectrochemical analyses of small chips of the yellow chert show that in addition to manganese and silica, aluminium, calcium, and iron are the essential constituents. X-ray powder photographs of similar yellow chert taken by R. M. Thompson, of the University of British Columbia, give patterns, when due allowance has been made for the extra quartz lines, very similar to those for spessartite, the manganese garnet. Dr. Thompson concludes that the mineral is "not pure spessartite but possibly something *between spessartite* and grossularite."

similarity to others known to be of sedimentary origin, however, have led the writer to believe that they are probably metamorphosed sedimentary deposits.

"Small-scale textural and structural features, such as lenses of rhodonite with blunt, feathered ends that grade into thinly banded chert or veinlets of rhodonite that spread out along bedding planes, are characteristic of replacement. The mosaic texture and relatively coarse grain size of the cherts near manganese deposits indicate that they have been affected by replacement and recrystallization. The lens-like shape and restricted stratigraphic range of the deposits may equally well be features of sedimentary deposits or features of selective replacement, but when it is considered that the cherty tuffs are probably syngenetic or diagenetic, it seems unlikely that widespread replacement should have taken place selectively in cherty rocks that appear to be no more favourable for replacement than any others in the Sicker group. The association of manganese with bedded chert, and with volcanic rocks, has been described from several localities throughout the world and suggests that manganese, chert, and volcanics are related in origin. Metamorphism of manganiferous sediments typically produces manganese garnet and rhodonite. In the cherty tuffs of the Sicker group, veinlets of quartz and plagioclase formed by solution and reprecipitation of materials in surrounding rocks are common. The textural and structural features of replacement exhibited by the manganese deposits may similarly have formed by redistribution of manganese of sedimentary origin."

### *Veins and Replacement Ocurrences of Manganese Minerals*

Concerning the Arrowhead occurrence the mineralogical data are (Bancroft, 1921, p. 111):

"Carbonates that show on weathering a considerable content of manganese occur in grey quartzite bordering a body of serpentine rock on the west slope of Sproat Mountain (Asbestos group). The serpentine carries a certain amount of carbonate material and manganese carbonates occur as local replacements or fissure fillings in the sedimentary formations on the east side of the serpentine belt. . .

"Several small open-cuts have been made showing the character of the manganese ore. Samples taken from the surface were reported on by Eugene Poitevin as follows: The material consists for the most part of granular, compact, greyish to pinkish carbonates of manganese, iron, calcium, and magnesium. These carbonates probably form isomorphous series. Some of them are near rhodochrosite (manganese carbonate) in composition, others nearer to mangancalcite or mangansiderite. . . The hydrous manganese oxides coating the carbonates are admixed with a certain quantity of limonite. It is evident that the manganese oxides were derived from the transformation of the carbonates."

Concerning siderite in the Slocan area Cairnes (1934, pp. 131-132) writes that it is the most common gangue mineral in the larger silver-lead-zinc deposits, occurring mostly in coarsely crystalline bands and lenses, and may be intimately interbanded with the ore sulphides. It is more abundantly associated with sphalerite than with galena. The colour ranges from light honey-yellow through pinkish and reddish brown to dark grey, almost black. The siderite generally carries an important percentage of manganese.

"A sample of spathic iron from the Contact (Black Prince) claim near Blaylock (Cairnes, 1935, p. 132) was reported by A. Sadler, Mines Branch, Ottawa, to contain:

| | Per Cent |
|---|---|
| "Iron carbonate | 63.20 |
| Manganese carbonate | 20.98 |
| Lime carbonate | 7.49 |
| Magnesium carbonate | 5.47 |

The manganese carbonate is equivalent to 10.0 per cent manganese.

Rhodochrosite is found at Owen Lake as the most abundant gangue mineral in veins that contain galena, sphalerite, chalcopyrite, tetrahedrite, and pyrite. The other gangue minerals are quartz, chalcedony, and barite (Lang, 1929, pp. 77-91).

Although in no sense a possible economic source of manganese, the presence of manganese-bearing ankerite in the Cariboo area (*see* Chapter I) has been mentioned because of its possible bearing on the origin of manganese deposits. The ankerite of concern occurs "as diseminated grains, streaks, narrow veinlets, and porphyroblastic crystals." Holland (1954, p. 24) draws a distinction between highly ankeritic quartzite near the top of the Midas formation, found in the same stratigraphic position over wide areas, and ankerite in other rock units, found only in the vicinity of quartz veins that contain ankerite. The vein ankerite ranges from a trace to 3.8 per cent manganese carbonate. The non-vein ankerite usually contains lees than 1 per cent manganese carbonate.

### *The Problem of Origin*

It has been noted that the larger bedrock occurrences of black oxide are related to rhodonite and to a lesser extent to manganese garnet and to rhodochrosite found in cherty rocks. Fyles, quoted earlier in this chapter, described the relationship of these minerals with the host rocks. He sees several features suggestive of replacement origin but considers that the widespread occurrence of the primary manganese minerals in a limited stratigraphic range is a weighty argument against replacement origin, and suggests that the textural and structural features characteristic of replacement deposits may have been formed by redistribution of manganese of sedimentary origin.

Cairnes (1934, p. 222) also argues that rhodonite and manganese garnet found in Milford group rocks in the Slocan area probably result from the metamorphism of an earlier manganese mineral, that probably was deposited as a carbonate during the deposition of the siliceous limestone.

Both writers end with the long-accepted notion of sedimentary origin for the manganese in manganese deposits. However, the features suggestive of replacement in the Cowichan lake deposits, and the common occurrence of manganese-bearing carbonate in veins and replacement bodies together with the deposition of manganese-bearing ankerite in metamorphosed rocks cut by veins containing manganese-bearing ankerite suggests to this writer that further study of the origin and geological history of British Columbia manganese deposits might yield geological data of real value, even though the deposits may be of limited economic importance.

## CHAPTER V

## HISTORY OF MINING AND PRODUCTION

Interest in manganese deposits was aroused during World War I when much of the prospecting for and exploration of manganese deposits was done in British Columbia. Interest has been almost entirely in deposits of wad and bedrock accumulations of black oxide because only those deposits are high enough in manganese and low enough in silica to meet trade requirements. Production has been mainly in the years 1918, 1919 and 1920, from two deposits. The records give little information on grade and may be incomplete in regard to quantity. A deposit on Kaslo Creek yielded wad that probably ranged from about 30 per cent to about 50 per cent manganese. The recorded production of this deposits is 541 tons; however, it is believed that the quantity shipped may have amounted to about 1,000 tons. From the Hill 60 deposit in the Cowichan Lake area on Vancouver Island the records show a total production of 1,167 tons. This ore consisted of hard compact manganese oxide with more or less siliceous material. Shipments in 1919 averaged about 50 per cent manganese and 19 to 20 per cent silica. The manganese content of most of the ore shipped in 1920 was reported as "more than 45 per cent," but the manganese content of the last lot shipped was reported as 40.12 per cent. In May, 1956, a shipment of about 35 tons was made from a bedrock deposit near Olalla.

## CHAPTER VI

### EVALUATION OF RESERVES AND POTENTIAL

Known deposits of wad in British Columbia could probably yield 3,000 tons of ore grading from 30 to 50 per cent metallic manganese, and might yield two or three times that quantity. Known bedrock deposits cannot be counted upon to yield more than a few hundred tons of siliceous ore averaging 35 to 40 per cent manganese. A rhodochrosite by-product could be recovered from veins that might be worked for other metals.

Much of British Columbia has received little attention from those searching for manganese ore, and in the parts that have received more attention it is probable that additional deposits of oxide ore will be found. However, as virtually the whole of British Columbia has been heavily glaciated, experience suggests that deposits of manganese oxide found will be of shallow depth and will contain small quantities. On the other hand, materially greater quantities of manganese might be recovered from vein and lode deposits, as concentrates consisting mainly of manganiferous siderite. It would be necessary to separate galena and sphalerite and other valuable minerals and possibly quartz from the manganiferous siderite. The cost of iron-manganese concentrate might be reduced by credits for lead and zinc in the ore mined.

After sintering the iron-manganese concentrate might range from 7 per cent manganese and 55 per cent iron, to 25 per cent manganese and 35 per cent iron. Such material is likely to be the most abundant domestic source of manganese.

## CHAPTER VII

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