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MANGANESE DEPOSITS OF CANADA

BY

G. HANSON

GEOLOGICAL SURVEY
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OTTAWA
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PREFACE

In 1925 Dr. W. L. Uglow investigated the manganese occurrences of the Maritime Provinces, but due to his untimely death in 1926 his report was not completed. In 1927 W. V. Smitheringale was commissioned to re-examine the deposits and complete the work initiated by Dr. Uglow. The other manganese deposits of Canada have not been examined in such a systematic way, but most of them have been visited by officers of the Geological Survey. This report on the manganese deposits of Canada, therefore, is essentially a compilation of the results of the work by Mr. Smitheringale and other geologists and engineers, and is based on the information available as late as the autumn of 1931.

The author has made free use of whatever published information on manganese he could find. Mr. Smitheringale wished to thank Mr. Flynn, Department of Natural Resources, Halifax; Dr. Lavers, New Ross; Mr. Graham, Registrar of Deeds, Windsor; Mr. A. Parsons, M.P.P., Walton; Mr. W. F. Stephens, Tennycape; Mr. R. E. Chambers, New Glasgow; Mr. G. Ross, Sydney; Mr. Bligh, Hillsborough; Prof. M. F. Bancroft, and W. A. Bishop, Wolfville; and Mr. W. E. McMullen, Inspector of Mines, Fredericton, for assistance and information given him during the course of his field work. He also wished to acknowledge the assistance and co-operation of the various members of the Department of Geology, Massachusetts Institute of Technology, during the laboratory investigation; Prof. J. T. Norton for facilities for obtaining X-ray spectra photographs; and Dr. Waldemar Lindgren, of the Department of Geology, Massachusetts Institute of Technology, for guidance and counsel.

Manganese Deposits of Canada

CHAPTER I

INTRODUCTION

USES[1]

Although manganese oxide has been used since early Egyptian time, it was believed to be a variety of magnetic iron ore until the eighteenth century when experimenters successfully showed that manganese forms a series of salts distinct from those of iron and that the metal itself is not iron. The principal use of manganese before the eighteenth century was in decolorizing glass and colouring glass and pottery. Late in the eighteenth century, in connexion with investigations of manganese compounds, chlorine was discovered and as uses for chlorine became established, considerable manganese was employed in its manufacture. In the nineteenth century it was discovered that manganese could be used to considerable advantage in the manufacture of steel and, as a consequence, over 90 per cent of the world's manganese production is now consumed in the manufacture of iron and steel. Manganese is also used to form various alloys with other metals. It is employed in the manufacture of dry cells, paints and dyes, as a colouring agent in the manufacture of brick, and in a great variety of other ways.

For commercial purposes manganese ores should contain over 45 per cent manganese. The nature of the ore determines its use; thus in the case of the iron and steel industry the ore should be of uniform composition, should not contain impurities deleterious to iron and steel, and should not be so soft and friable as to be objectionable for use in blast furnaces. For chemical uses the most important quality of manganese ore is its ability to liberate oxygen easily and, therefore, pyrolusite, which of all the manganese minerals has the highest content of available oxygen, is the most valuable. Various impurities modify the value of the ores for the various chemical uses.

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[1] Harder, E. C.: "Manganese Deposits of the United States"; U.S. Geol. Surv., Bull. 427, pp. 243-268 (1910).

CHEMISTRY AND MINERALOGY

Manganese is in group VII of the Periodic System and shows certain analogies to the halogens (fluorine, bromine, chlorine, and iodine), the other members of the group. It resembles in many ways and is often associated in nature with the metals having atomic weights not greatly different from that of manganese. Thus the atomic weight of manganese is 54·93 and the element is frequently associated in nature with titanium (48·1), vanadium (51), chromium (52), iron (55·84), nickel (58·68), cobalt (58·97), copper (63·57), and zinc (65·37). Its closest metal associate, and also its closest neighbour by atomic weight, is iron.

Manganese does not occur uncombined in nature. When extracted from the minerals containing it, the metal is greyish white and resembles cast iron. It is hard, brittle, has a specific gravity of 8, and melts at 1,245 degrees centigrade. The metal oxidizes rapidly.

Manganese occurs in many minerals (Harder lists one hundred and three), but only eight are common and only seven of these are considered common ore minerals. The eight minerals are pyrolusite, manganite, braunite, psilomelane, wad, bog manganese, rhodochrosite, and rhodonite.

Pyrolusite (MnO_2) is a greyish black to black mineral soft enough to soil the fingers when handled. Its hardness is 2 to 2·5 and its specific gravity 4·8. It occurs in well-crystallized forms, but more commonly has a columnar habit or is granular massive. It forms at or near the surface of the earth under strongly oxidizing conditions at ordinary temperatures and pressures.

Manganite ($Mn_2O_3.H_2O$) is a black mineral with a hardness of 4 and a specific gravity of 4·2 to 4·4. It occurs in prismatic crystals, in columnar forms, and, less commonly, in a granular condition. When pure it contains 62·4 per cent manganese. It forms at or near the surface of the earth at ordinary temperatures and pressures. It is not so stable under oxidizing conditions as pyrolusite and under such conditions is replaced by the latter.

Braunite ($3Mn_2O_3.MnSiO_3$) is a brownish to greyish black mineral with a hardness of 6 to 6·5 and a specific gravity of 4·8. The mineral is usually crystalline, but also occurs massive. When pure it contains 69 per cent manganese. It forms under ordinary conditions of temperature and pressure at or near the surface of the earth. Under oxidizing conditions it is replaced, eventually, by pyrolusite and during an intermediate stage in the process may be converted into manganite.

Psilomelane (H_4MnO_5) is a bluish to greyish black mineral of variable composition. It has a hardness of 5 to 6 and a specific gravity of 3·7 to 4·7. It occurs in massive forms. The percentage of manganese varies from 45 to 60. It forms under ordinary conditions of temperature and pressure at or near the surface of the earth. If subjected to oxidizing conditions it will, eventually, be transformed to pyrolusite, and in the process may pass through an intermediate stage of manganite.

Wad or bog manganese is a soft, earthy mixture consisting mainly of oxide of manganese and water, with some oxide of iron and other substances. Wad is in general not saturated with water, whereas bog manganese, as the name implies, is a wet bog deposit.

Rhodochrosite ($MnCO_3$) is a pink mineral with a hardness of 3·5 to 4·5 and a specific gravity of 3·45 to 3·6. It occurs mainly in cleavable, massive forms. When pure it contains 47·56 per cent manganese. It is rarely used as an ore of manganese, but in recent years has been used as a flux in smelting. Rhodochrosite forms at the surface of the earth under ordinary conditions of temperature and pressure, and also forms by ascending thermal solutions of igneous origin.

Rhodonite ($MnSiO_3$) is a pink mineral with a hardness of 5·5 to 6·5 and a specific gravity of 3·4 to 3·7. When pure it contains 41·9 per cent manganese. It occurs in crystal forms, but commonly is massive. It is not used as an ore of manganese, but has been used for ornamental purposes. Rhodonite forms by ascending thermal solutions of igneous origin and also in the processes of metamorphism.

Two excellent papers on the identification and study of manganese minerals have appeared in recent years. One of these, by Smitheringale, refers particularly to the manganese minerals of the Maritime Provinces.[1]

PRODUCTION

Most of the world's supply of manganese comes from four countries, Russia, India, Gold Coast, and Brazil. The annual production amounts to about 3,000,000 tons.

The annual Canadian production has always been small, never amounting to more than 2,500 tons. British Columbia produced manganese ore for only three years. The main production has come from the Maritime Provinces, where the chief producing mine was the Markhamville, in New Brunswick.

The following figures of the Canadian production have been taken from reports of the Department of Mines of Nova Scotia and of the Department of Mines, Canada.

[1]Thiel, George A.: "The Manganese Minerals: Their Identification and Paragenesis"; Econ. Geol., vol. XIX, pp. 107-145 (1924).

Smitheringale, W. V.: "Notes on Etching Tests and X-Ray Examination of Some Manganese Minerals"; Econ. Geol., vol. XXIV, pp. 481-505 (1929).

Manganese Production of Canada by Provinces

—	Nova Scotia	New Bruns-wick	British Columbia	—	Nova Scotia	New Bruns-wick	British Columbia
	Tons	Tons Exports	Tons		Tons	Tons Exports	Tons
1865	300	....	....	1896	129	....	....
1868	156[1]	861	....	1897	100	....	....
1869	156[1]	332	....	1898	75	....	....
1870	1,256[1]	146	....	1899	100	....	....
1871	102[1]	954	....	1900	8	....	....
1872	40	1,075	....	1901	10	....	....
1873	131	1,031	....	1902	150	....	....
1874	....	776	....	1903	....	....	....
1875	7	194	....	1904	....	....	....
1876	16	391	....	1905	22	....	....
1877	97	785	....	1906	2	....	....
1878	127	520	....	1907	....	....	....
1879	145	1,732	....	1908	....	....	....
1880	223	2,100	....	1909	....	....	....
1881	231	1,504	....	1910	25	....	....
1882	205	771	....	1911	150	....	....
1883	150	1,013	....	1912	233	....	....
1884	302	469	....	1913	....	....	....
1885	353	1,607	....	1914	....	....	....
1886	427	1,377	....	1915	....	....	....
1887	691	837	....	1916	544	....	....
1888	88	1,094	....	1917	180	....	....
1889	67	1,377	....	1918	....	....	440
1890	266	1,729	....	1919	45	....	616
1891	41	233	....	1920	100	....	587
1892	111	59	....	1921	450	....	....
1893	114	10	....	1922	73	....	....
1894	24	45	....	1923	....	....	....
1895	110	....	....	1924	....	584	....

[1]Exports.

CHAPTER II

NATURE AND ORIGIN OF MANGANESE DEPOSITS

Manganese is present in organic substances, in oceanic and inland waters, in minute quantities in most rocks, and, here and there, in deposits sufficiently large and pure to be of economic importance. But though widely distributed it forms only 0·07 per cent or about 1½ pounds a ton of the earth's crust as a whole. Like many of the other metals, manganese forms only a very small fraction of the earth's crust and yet, like other metals, is found in places in relatively large, pure deposits. These economically valuable deposits of manganese have formed, so far as known, in only one general way, namely, by the leaching of the scanty manganese content of the rocks at the earth's surface and its subsequent concentration in relatively rich deposits. This being so, it is desirable in discussing the origin of manganese ores, to deal first with the ways in which manganese occurs other than in the form of deposits of commercial value.

Minute quantities of manganese are present in most if not all living organisms, but there is no known reason for believing that any of the higher organisms play any important part in determining the concentration of manganese. Some bacteria, however, deposit hydrous manganese oxide and may be of importance in connexion with the formation of bog manganese deposits.[1]

Manganese is present in small but varying amounts in most inland waters such as lakes, streams, and springs. It is not ordinarily recorded in analyses of sea water, but is present in quantities large enough to be easily detected. In the analysis of most of the ordinary river waters manganese, if listed, is shown as occurring in traces only; but in some specimens, as for example in one from Mississippi river from a locality in Louisiana, Mn_3O_4 forms 0·11 per cent of the total solids dissolved in the water, and in one from Garonne river at Toulouse, Mn_2O_3 makes up 1·55 per cent of the dissolved salts.[2]

Wiebe[3] has recently presented the results of the determination of the manganese content of fifteen samples of Mississippi River water collected at Fairport, Iowa. All the samples contained manganese, the quantity in solution ranging from 0·044 to 0·128 parts per million. The iron-manganese districts of Minnesota are in the Mississippi drainage basin and although 600 miles above Fairport, they may have supplied the manganese content of the river water. The river water has not been analysed at various places to show whether or not there is any uniform change in its

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[1]Twenhofel, W. H.: "Treatise on Sedimentation", pp. 407-408 (1926).

[2]Clarke, F. W.: "Data of Geochemistry"; U.S. Geol. Surv., Bull. 695, pp. 76, 94 (1920).

[3]Wiebe, A. H.: "The Manganese Content of the Mississippi River Water at Fairport, Iowa"; Science, vol. LXXI, p. 248 (1930).

manganese content, but it is known that the amount of iron in solution does not change but is present in just as large quantities near the mouth as towards the head of the river. As manganese in solution is less readily oxidized than iron in solution, it may be assumed that the manganese content of Mississippi River water is approximately uniform throughout the length of the river. It may be, however, that some of the manganese regarded as being in solution is actually in suspension, as minute particles of oxide for bacteria exist that pass through fine porcelain filters and if any such bacteria secrete manganese oxides the secreted oxides would also, presumably, pass through filters and this manganese content would be recorded as being in solution.

The Mississippi flow is roughly 500,000 cubic feet a second and assuming that the water contains 0·09 parts per million of manganese (the mean of Wiebe's analyses), the river would deliver to the gulf of Mexico 40,000 tons of manganese a year. This amount seems large, as in a short geological time interval of 100,000 years the total amount would be 4,000,000,000 tons. The Mississippi, however, carries a great deal of silt. The annual quantity has been estimated at 812,500,000,000[1] pounds. The assumed annual quantity of 40,000 tons of manganese is a little less than 0·01 per cent of the amount of silt and if all were deposited with the silt the quantity would be so small in proportion that although it could be detected by analyses it would ordinarily be recorded as a trace. But though any of the manganese carried in suspension would probably be deposited with the silt, the part dissolved in the water might remain in solution and thus be added to the manganese content of the ocean.

Springs and underground waters in general contain much more manganese than surface waters. The manganese content of underground or spring waters ranges from a trace to 117 parts per million; commonly it ranges from 0·5 to 5 parts per million.[2] Many highly manganiferous springs deposit bog manganese at the surface near their points of issue.

The quantity of manganese in springs varies somewhat with the type of spring water. These may be classified chemically according to the negative radicals of their solutes, into carbonate, chloride, sulphate types, etc. Spring waters of the chloride type contain only traces of manganese. Some spring waters of the sulphate and carbonate types contain much manganese. In a sulphate water from southern Tyrol, manganese makes up 0·78 per cent of the total salts in solution (8,150 parts per million). In Virginia, U.S., in a sulphate water that also contains free sulphuric acid, manganese forms 0·69 per cent of the total solids (464 parts per million). Many sulphate waters also contain cobalt, nickel, zinc, and copper. In a spring of the carbonate type in Missouri, U.S., manganese makes up 0·91 per cent of the total dissolved solids[3] (489 parts per million). Filtered water from the springs at Dawson settlement, New Brunswick, contains 12 parts of manganese per million. The water is a mixed sulphate-carbonate type with a total solids content of 124 parts per million.

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[1]Clarke, F. W.: "Data of Geochemistry"; U.S. Geol. Surv., Bull. 695, p. 501 (1920).

[2]Twenhofel, W. H.: "Treatise on Sedimentation", pp. 406-407 (1926).

[3]Clarke, F. W.: "Data of Geochemistry"; U.S. Geol. Surv., Bull. 695, pp. 184, 187, 193 (1920).

Manganese is relatively abundant in deep sea deposits. Clarke[1] writes:

"Manganese, as oxide or hydroxide, exists in all deep-sea deposits, sometimes as grains in the clay or ooze, sometimes as a coating upon pumice, coral, shells, or fragments of bone, and often in the form of nodular concretions made up of concentric layers about some other substance as a nucleus.[2] Even in shallow waters, as in Loch Fyne in Scotland, these nodules have been found,[3] but they seem to be more characteristic of the deep ocean abysses, whence the dredge often brings them up in great numbers."

Clarke quotes the complete analysis of a nodule in which MnO makes up 21·45 per cent of the sample. The nodule contained a little nickel, cobalt, zinc, and copper.

The red clays from the sea bottom contain considerable manganese. A composite of fifty-one samples contained 0·83 per cent manganese oxide.[4] The manganese in the red clays may be present in the form of silicates and also as oxides or carbonates.

Igneous rocks make up 95 per cent of the lithosphere and contain, on an average, 0·078 per cent manganese. It is of interest to note what igneous rocks contain the most manganese. The table that follows is based on analyses quoted by Clarke.[5]

Rock types	No. of analyses	Average MnO per cent
Rhyolite-granite group	21	0·02
Trachyte-syenite group, including nephelite, leucite, and analcite types, and monzonite	55	0·08
Andesite-diorite group	22	0·12
Basic types, including basalt, diabase gabbro, pyroxenite, and peridotite	44	0·15

Daly also, has quoted a great many rock analyses from various parts of the world.[6] The following table was made by combining various groups of analyses listed by Daly, so as to conform roughly to the rock groups as given in the above table.

Rock types	No. of analyses	Average MnO per cent
Granite, rhyolite, liparite, quartz keratophyre	810	0·14
Syenite, trachyte monzonite, alkaline and nephelite syenites, dacite	411	0·12
Diorite, andesite	355	0·17
Norite, gabbro, basalt, diabase, peridotite, pyroxenite	691	0·25

[1]Clarke, F. W.: "Data of Geochemistry"; U.S. Geol. Surv., Bull. 695, pp. 130-132 (1920).
[2]For full description *See Challenger* Rept., "Deep-sea Deposits," 1891, 341-378. *See also* Murray, J., and Irvine, R.: Trans. Roy. Soc., Edinburgh, vol. 37, p. 721 (1895).
[3]Buchanan, J. Y.: Proc. Roy. Soc., Edinburgh, vol. 18, p. 19 (1890).
[4]Clarke, F. W.: Op. cit., p. 419.
[5]Clarke, F. W.: Op. cit., pp. 430-461.
[6]Daly, R. A.: "Igneous Rocks and Their Origin", pp. 19-36 (1914).

It is apparent from these tables that the more basic the rocks, the richer they are in manganese. Some of the igneous rocks, particularly the alkaline types, contain manganese-rich minerals and such rocks are exceptions to the general rule that the basic rocks carry the most manganese. For instance a soda minette of the trachyte-syenite group listed by Clarke contains 0·30 per cent manganese. This rock held much lepidomelane with a content of about 1 per cent manganese.

From the record of mineral analyses published by the United States Geological Survey,[1] it is apparent that feldspars carry, in general, only traces of manganese and that muscovite also contains only traces, whereas the rock-forming basic silicates have a higher percentage content than the basic rocks. The following table, compiled from the above-mentioned publication, gives the average manganese content of the more common rock-forming minerals that contain appreciable amounts of manganese.

Mineral	No. of analyses	Average MnO per cent
Enstatite	5	0·12
Hypersthene	6	0·44
Augite	6	0·20
Hornblende	6	0·22
Olivine	6	0·15
Biotite	8	0·51

The minerals listed in the table are more plentiful in basic than in acid rocks and are probably the chief bearers of manganese in the basic rocks. Some minerals, such as magnetite and chromite which contain more than 0·8 per cent manganese oxide, are present in only small amounts in igneous rocks, but are more plentiful in basic than in acid types. Several unusual rock-forming minerals such as lepidomelane and coloured tourmaline, which have about 1 per cent manganese oxide, and jeffersonite and piedmontite, which have about 8 per cent manganese oxide, are found more frequently in acid than in basic rocks, but are not abundant enough to offset the following general statement: basic rocks hold more manganese than acid rocks and do so because basic silicates contain more manganese than acid silicates. As igneous rocks make up 95 per cent of the lithosphere, as the remaining 5 per cent of the rocks contain very little manganese, and as the manganese of igneous rocks is contained in silicates, it is evident that the great bulk of the manganese occurring in nature is contained in silicate minerals.

Some rocks have a remarkably high manganese content. A sample of a dyke in Arkansas, U.S., contained 5·29 per cent MnO_2. The manganese was contained in altered basic silicates and probably originally took the place of part of the aluminium in these minerals.[2] In most cases, however, manganese probably acts chemically much as chromium and iron, and perhaps occurs in the place of these metals in minerals.

[1]Clarke, F. W.: "Analyses of Rocks and Minerals"; U.S. Geol. Surv., Bull. 419, pp. 241-315 (1910).
[2]Ark. Geol. Surv., vol. II, p. 98 (1890).

Shales and sandstones, which together make up 95 per cent of the sedimentary rocks, contain, as a rule, only traces of manganese; limestone, which makes up the remaining 5 per cent, contains on an average approximately 0·04 per cent.[1] Ordinary soils and clays hold only traces of manganese.

Sandstones in some places, for example at mount Diablo, California, U.S., contain as much as 0·57 per cent manganese oxide.[2] All the sediments at mount Diablo contain much manganese and are underlain by basic igneous rocks from which the sediments and manganese were derived. Shales in only a few places contain more than 0·10 per cent of manganese.

The manganese of shales, sandstones, and conglomerates may be present in the grains and pebbles, in the cementing material, or in both. The manganese in the grains and pebbles will be in the form it had in the rock from which the grains and pebbles were derived. If these grains consist of silicates any manganese present will be in silicate minerals. Unusual sands, such as magnetite sands, may contain a great deal of manganese. Unusual environment during sedimentation may result in the formation of highly manganiferous sediments.

The manganese in cementing material in clastic sediments occurs probably as a carbonate. By comparing the analyses of shales and sandstones listed in Bulletin 419 of the United States Geological Survey, it is very noticeable that the manganese content varies directly with the CO_2 content and inversely with the silica content. It is obvious that in some of these sediments most of the manganese occurs as a carbonate in the cement, whereas in others it occurs probably as silicates in the clastic grains, etc.

Carbonate rocks such as limestone, dolomite, and ferruginous carbonate rocks, contain more manganese than the clastic sediments. Two analyses of limestone of Windsor age, one from Cape Breton island, N.S., and the other from Pictou county, N.S., gave 0·25 and 0·48 per cent of MnO, respectively. Ferruginous limestone and dolomite in some places, as in the Hudson Bay region, contain as much as 24 per cent manganese carbonate. The average manganese oxide content of carbonate rocks is, however, only 0·05 per cent.

According to Twenhofel[3] beds of manganiferous carbonate commonly occur with strata that appear to be of marine origin. The same author writes:

"Bedded manganiferous carbonates appear to have three types of stratigraphic relationships, suggesting as many different environments. (1) They occur in fine-grained sediments which overlie coarser sediments which in turn rest on a surface of unconformity. Commonly they contain carbonaceous matter and a little pyrite. In this relation they appear to form a part of the fine marine sediments laid down near the shore of a shallow sea. (2) They occur in the alternating thin beds of coarse and fine sediments and marine limestones such as are common in the Coal Measures of the Appalachian region. The manganese is greatly exceeded by the iron. It is not clear whether such beds of carbonates were laid down in open waters, or in

[1]Clarke, F. W.: "Data of Geochemistry"; U.S. Geol. Surv., Bull. 695, pp. 29, 33 (1920).
[2]Clarke, F. W.: Op. cit., p. 185.
[3]Twenhofel, W. H.: "Treatise on Sedimentation", pp. 413-416 (1926).

coastal lagoons. (3) They occur with thin-bedded marine limestones and shales in which layers of chert are conspicuous. Such carbonates rarely contain iron, and on weathering yield high grade manganese oxides. Beds of manganese carbonates do not appear to be deposited in association with massive marine limestones such as were formed in the deeper parts of the epicontinental seas, or in coarse sediments."

Metamorphic rocks were originally either igneous or sedimentary, and the proportion of manganese they contain does not differ greatly from that in the original rocks. In metamorphism under great pressure those minerals that occupy least space, and are most stable under conditions of metamorphism will form from the constituents available. The manganese minerals of the original rock may be transformed into different ones in the metamorphic rock. The manganese-bearing minerals formed in this way are mainly silicates such as rhodonite, bementite, and spessartite, which are manganese silicates, or biotite, or piedmontite, which are silicates chiefly of aluminium and iron, but which contain much more manganese than most ordinary rock-forming minerals.

Manganese occurs in ore deposits of other metals. In these it occurs generally as rhodonite and rhodochrosite, but also as a minor constituent of fluorite, or in siderite or other carbonates, in vein-forming silicates, or as oxides. It is generally in some form associated with oxygen, but nickel ore from the Worthington mine at Sudbury, Ont., contains 0·10 per cent manganese, a few other sulphides such as tetrahedrite contain traces of manganese, and some calaverite from Cripple Creek, Colorado, U.S., contained 0·27 per cent manganese oxide.[1]

Magnetite and chromite deposits contain about 1 per cent MnO and some iron ores of Lake Superior region contain much manganese and are known as manganiferous iron ores. Manganiferous iron ores grade into ferrous manganese ores. Calcite, dolomite, and siderite, or, combination of these minerals in ore deposits, contain in general some manganese. Many veins contain rhodochrosite and rhodonite, as for example the silver veins of Butte, Montana, U.S., in which the gangue matter consists largely of these two manganese minerals.

The commercially valuable manganese deposits are local concentrations of manganese derived from the sources indicated in the preceding paragraphs. The manner in which concentration takes place will now be discussed, and for the purposes of this discussion manganese deposits are considered to form the following classes and sub-classes, the classification being based on the natures of the concentration processes that gave rise to the deposits:

(I) Sedimentary deposits
- (*a*) Oxide type
- (*b*) Carbonate type
- (*c*) Bog type

(II) Replacement and residual deposits

(III) Vein deposits

[1]Clarke, F. W.: U.S. Geol. Surv., Bull. 419, pp. 243, 246, 248 (1910).

SEDIMENTARY DEPOSITS[1]

In the case of sedimentary manganese deposits it is obvious that their manganese content must either have been transported in solid form or in solution and have been deposited or precipitated as the case may be. So far as known, manganese oxides do not accumulate in the form of sand analogous to magnetite sand. It is conceivable that in some cases manganiferous sediments may have been mechanically produced, as where bog manganese deposits have been washed away by silt laden streams to produce a manganiferous mud, or have been carried away by clear streams to be laid down as a manganese oxide sediment.

Besides transporting manganese in detrital form, water may carry it either in solution or in suspension. Since manganese in streams is afforded so much chance of oxidation, it may be that much of it is carried as oxide in suspension. On the other hand, it is known that iron is readily carried in solution in waters containing much organic matter and it may be that manganese is also so carried since manganese and iron are, chemically, closely related.

Manganese in ground water is carried in solution but when such water issues in springs, by escape of CO_2 from bicarbonate solutions, the manganese becomes insoluble and is precipitated. The precipitate is not manganese carbonate as might be expected, but the oxide, perhaps because of oxidizing conditions at the surface or because of bacteria in the water[2] or for some other unknown reason. On the other hand, manganese entering lakes or the sea by way of subsurface springs may be deposited as carbonate if the environment is strongly reducing, otherwise it is deposited as oxide. In some lakes and seas it may be that conditions at the bottom are so reducing as to change manganese oxide to manganese carbonates. In any case there are manganiferous beds in which the manganese was apparently laid down as oxide, others in which the manganese was apparently laid down as carbonate, and others in which both oxides and carbonates seem to have been deposited. No doubt in some cases many complex chemical reactions took place before the manganese carried by water finally became deposited as carbonates and oxides as they are known today. For reasons not in all cases clearly understood manganese oxides and manganese carbonates in clays or shales in some places become segregated into nodules, into oolites, or into both.

Barite, and to lesser extent phosphates, are commonly present in sedimentary manganese deposits. Iron oxide is commonly present and in some cases is the chief constituent. Cobalt, copper, nickel, and chromium are usually present in small amounts.

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[1]Twenhofel, W. H.: "Treatise on Sedimentation", pp. 405-418 (1926).

Curtis, A. H.: "Manganese Ores"; Imperial Institute Monographs on Mineral Resources, London, 1919.

Harder, E. C.: "Manganese Ores in Russia, India, Brazil, and Chile"; Trans. Am. Inst. Min. Eng., vol. 56, pp. 31-76 (1917).

Beyschlag, Vogt, and Krusch: "Ore Deposits", pp. 982-990, 1099-1113 (1916).

Dale, N. C.: "The Cambrian Manganese Deposits of Conception and Trinity Bays, Newfoundland"; Am. Phil. Soc., vol. LIV, pp. 371-456 (1915).

These references contain much valuable information on sedimentary manganese deposits and have excellent bibliographies.

[2]Thiel, G. A.: "Manganese Precipitated by Micro-organisms"; Econ. Geol., vol. XX, pp. 301-310 (1925).

Manganese deposits of sedimentary origin can be subdivided into three types: (a) oxide deposits; (b) carbonate deposits; (c) bog deposits. There is very little difference in origin between the three types. In the first type it may be that much of the manganese was deposited not as a precipitate from solution but as manganese oxide transported by the waters. Those of the second type were deposited from solution and differ from the bog deposits in that instead of being oxides they are carbonates.

OXIDE TYPE

Some of the largest and most valuable deposits in the world are of the oxide type. They are black sedimentary beds consisting mostly of manganese oxides and are interbedded with ordinary shales and sandstones. Individual beds of manganese ore are rarely thicker than 1 or 2 feet, but several thin beds each a few inches thick commonly occur in a single horizon. Beds of manganese ore, together with interbedded manganiferous sandstones and shales, which commonly contain nodules of manganese oxide, are in places 10 feet or more thick. The manganese minerals in the deposits are chiefly pyrolusite, psilomelane, and manganite. The ores are typically concretionary and oolitic. The purest are commonly oolitic, and the impure varieties, associated with shale and other sedimentary rocks, are commonly concretionary. Barite occurs in most of the ores of this type, but phosphate, silica, and iron oxides are not so common as in manganese deposits of the carbonate type. The close association between the manganese oxide beds and clastic sediments suggests that they were laid down in shallow water such as lagoons or lakes.

In regard to the origin of this type of deposit very little of a positive nature can be said. It does not seem that the manganese oxides could have been mechanically separated or concentrated, nor do the deposits afford any evidence that the manganese content was added after the sediments were laid down. Therefore, the manganese oxides must either have been precipitated out of the waters as the sedimentary beds formed or have been carried in suspension as oxides in streams otherwise relatively free of sediment. Manganese-forming bacteria, if present, might precipitate manganese oxides from the water, and, if the water were free of sediment, thus produce manganiferous beds. It has been shown that if manganese oxide, deposited by bacteria or in some other way, becomes transformed to dioxide and the water is slightly alkaline any manganese in solution will be deposited. The manganese dioxide acts as a catalytic agent. Zapffe[1] shows in a convincing manner how small nuclei of manganese dioxide would normally grow into nodules or concretions. Springs issuing into bodies of still water might deposit from solution a great deal of manganese and this might be spread over the bottom of the lake or sea by wave and stream action. The source of manganese would seem, therefore, to be springs carrying manganese in solution and clear streams carrying manganese in solution or suspension. The streams would derive their manganese from manganiferous waters, springs, and spring deposits. The ultimate source would be the manganese content of rocks.

[1] Zapffe, Carl: "Deposition of Manganese"; Econ. Geol., vol. XXVI, pp. 799-832 (1931).

A deposit of the oxide type of Recent origin occurs in the flood-plain sediments of Amazon river. The beds of manganese oxide are 2 or 3 inches thick and occur with sand and sandstone. The sandstone is itself cemented with manganese oxides. The manganese in this case was carried by the river water. It is difficult to understand how a deposit such as this could have formed unless perhaps by an abundance or plague of manganese depositing bacteria; or by river floods carrying away and re-depositing an unconsolidated deposit of manganese oxides.

One of the largest deposits in the world, that at Tchiatouri, Russia, is of the sedimentary oxide type. At that place the ore occurs as a bed near the base of Eocene sandstone lying almost horizontally over Upper Cretaceous limestone and shale and under Oligocene and Miocene sandstone, shale, and limestone. The ore zone is distinctly stratified. It is 7 feet thick and about half of this thickness is good manganese ore. It contains five or six beds ranging up to 5 inches in thickness of very clean manganese ore, and several beds up to 1½ feet in thickness of inferior ore. The ore is oolitic and concretionary, and concretions of manganese oxide occur also in the associated sedimentary rocks. The ore minerals are pyrolusite, psilomelane, and manganite. As the ore bed contains shark's teeth it is considered to be of marine origin. Beyschlag, Vogt, and Krusch believe that the deposits were formed in near-shore shallow seas, probably lagoons. These authors also believe that the manganese was deposited from waters that held it in solution, and that the waters derived their manganese content from crystalline igneous rocks. The authors quote the following analysis of clean manganese ore from this deposit.[1]

	Per cent		Per cent
SiO_2	3·85	$Na_2O + K_2O$	0·22
Fe_2O_3	0·61	CuO	0·01
MnO_2	86·25	NiO	0·30
MnO	0·47	P_2O_5	0·32
Al_2O_3	1·74	S	0·23
CaO	1·73	CO_2	0·63
MgO	0·20	H_2O	1·85
BaO	1·54		

Another very large deposit which may be of this type is that of the Wigg mine in the province of Minas Geraes, Brazil. The deposit is in sediments, probably of Precambrian age, and is associated with iron formation which is known there as itabirite. The manganese ore consists of manganese oxides and is in a bed 6 feet thick overlain and underlain by iron formation and associated sediments. Harder assumes that the deposit is an original sedimentary deposit of manganese oxides which have been modified somewhat by metamorphism. He believes the source to be deposits of manganese in the underlying crystalline rocks of the area. Apparently Harder believes that the manganese was not carried in solution but was transported as a sediment.[2]

No manganese deposit of this type has ever been mined in Canada. A deposit which may be in part a manganese oxide sediment occurs at the Hill 60 mine, Cowichan lake, Vancouver island, British Columbia. At that

[1] Beyschlag, Vogt, and Krusch: "Ore Deposits", vol. II, pp. 1101, 1103 (1916).

[2] Harder, E.C.: "The Manganese Ores of Russia, India, Brazil, and Chile"; Trans. Am. Inst. Min. Eng., vol. 56, pp. 60, 61 (1917).

place a red to pink, cherty, rhodonite-bearing quartzite has been oxidized, with the consequent formation of manganese oxides. It is possible that the manganese was present originally in part at least as thin manganese oxide beds in fine-grained sandstone.

CARBONATE TYPE

Many large manganese deposits are of the carbonate type, but these have been of slight economic importance in the past.

The manganese deposits of the carbonate type are stratified sediments interbedded commonly with shales and limestones. Some contain manganese oxides as well as the carbonate and the beds are then black. Those that contain no oxides are commonly pink. The manganese carbonate is ordinarily present in nodular and oolitic form, and where manganiferous shales are associated they contain in general manganiferous nodules. Typical deposits consist of many shaly beds ranging from a few inches to a few feet thick and making a total thickness of about 20 feet. They contain a great deal of iron carbonate and grade into iron carbonate beds. They also contain much barite and a good deal more phosphate and silica than the sedimentary oxide deposits. Manganese carbonate beds are more numerous and thicker than those of the oxide type.

The origin of deposits of this type has not been satisfactorily explained, but the following general modes have been suggested. Where springs issue beneath the surface of a lake or lagoon, if the environment is reducing in its nature, manganese carbonate may be deposited instead of the oxide. Manganese oxide sediment may also be changed to manganese carbonate if it is deposited in a place strongly reducing in its nature. The manganese may be carried in solution as an organic salt and be precipitated by bacteria as manganese carbonate.[1]

An excellent example of the carbonate type of manganese deposit occurs at Conception and Trinity bays, Newfoundland, and has been studied in a very thorough manner by Dale.[2] The manganese deposits occur sporadically over a large area, but always at the same geological horizon in Cambrian sediments. The highly manganiferous beds consist of manganese and calcium carbonates and contain also some manganese oxides and many impurities, notable among which are barite, jasper, and various phosphates. The main manganese bed, one of reasonable purity, at Manuels river, Conception bay, is only 0·7 feet thick, but the total thickness of manganiferous sediments is 17 feet. The closely associated sediments are red and green, calcareous shales. The manganese minerals occur as nodules, lentils, and discontinuous bands of a concretionary nature.

Dale believes that the manganese was carried into a restricted and shallow sea by streams. The manganese was carried chiefly in solution, but also to some extent as suspended particles of manganese oxides and as muds from which the manganese was subsequently dissolved and reprecipitated. The manganese in solution was carried as a bicarbonate and was

[1]Thiel, George A.: "Manganese Precipitated by Micro-organism"; Econ. Geol., vol. XX, pp. 307, 310 (1925).

[2]Dale, N. C.: "The Cambrian Manganese Deposits of Conception and Trinity Bays, Newfoundland"; Am. Phil. Soc., vol. LIV, pp. 371-456 (1915).

precipitated as a carbonate through escape of CO_2. Dale also believes that the source of the manganese was manganese-bearing silicates in Precambrian crystalline rocks in the vicinity.

In Canada no manganese ores of this type have been mined and no deposit of this type is known in which manganese occurs in quantity sufficient to justify any hope of future mining.

BOG DEPOSITS

Deposits of bog manganese are of very common occurrence in eastern Canada. Most deposits of this type are small and contain a great deal of iron oxide and peaty matter. Bog deposits have supplied some of the world's manganese but so little that when they are compared with manganese ore deposits of a different kind they are quite insignificant. In Canada a small production has been maintained from bog deposits, the ore finding a market in the brick trade in which it is used as a colouring agent.

Bog deposits that are forming today are simply soft, wet oozes which dry to form a very fine powder. The manganese occurs chiefly as the dioxide, pyrolusite. Quite commonly the bog manganese deposits, like those of the sedimentary oxide type, contain but little phosphate and silica as compared with those of the carbonate type.

Bog deposits are precipitated from springs issuing at the surface and, consequently, consist of manganese oxides and iron hydroxides. The precipitation is effected by escape of CO_2 from the bicarbonate solution and oxidation of the resulting manganese carbonate. Just how this oxidation is brought about has not been explained. Precipitation as oxide may be effected also by bacteria.

A typical bog deposit occurs at Caledon Station, Cape province, South Africa. It is in the form of a large circular mound 200 by 300 yards in diameter and 20 feet or more thick in the centre. It thins out and becomes more siliceous at the margin. A sample of the best ore contained: manganese 37·87 per cent; iron 16·30 per cent; silica 6·55 per cent; phosphorus 0·378 per cent; sulphur, 0·014 per cent. The deposit has been formed by precipitation from the waters of a hot spring which issues at its centre.[1]

One of the best known deposits of this type in Canada is at Dawson settlement, Albert county, New Brunswick. The deposit is on a gently sloping hillside and was formed from springs issuing at its upper margin. Near the springs this deposit is about 15 feet thick, but toward the edges it thins out. The material in the deposit is a soft, black mixture consisting of manganese dioxide and limonite more or less intimately mixed with peat. Analysis of the ore shows a 60 to 85 per cent content of moisture, and that 16 to 70 per cent of the remainder consists of peat. The material in the bog contains, then, less than 10 per cent manganese.

[1]Curtis, A. H.: "Manganese Ores"; Imperial Inst., Monograph on Mineral Resources, p. 52, London (1919).

REPLACEMENT AND RESIDUAL DEPOSITS[1]

Typical replacement deposits and typical residual deposits are distinct types easily identified as such. Gradations between the two types are common, however, and many deposits are partly of replacement and partly of residual origin.

Replacement and residual manganese deposits are usually exposed at the surface and do not extend to any great depth.

Replacement deposits are very numerous, but many are of slight economic importance and very few typical deposits are large or of great economic value. Most deposits of this type are extremely irregular in shape and occur in easily replaced rock such as limestone. They consist of psilomelane, manganite, pyrolusite, wad, and other manganese oxides and are associated with much limonite and hematite. They have a low content of silica and phosphorus.

Some replacement deposits consist of nodules and larger masses of manganese oxide embedded in clay. Many consist of irregular bodies of all sizes in limestone. Some are cellular deposits like hard sponges lying above the undecomposed rock. In all, the mode of origin is simply a breaking down of the original manganese minerals, solution of the manganese, and precipitation from this solution as manganese oxide either in open spaces formed by solution or by replacement of rock or mineral. Manganese oxides are fairly stable under surface conditions but some are more stable than others, so that after long continued weathering manganite will form at the expense of psilomelane, and pyrolusite at the expense of manganite. Most deposits that are classed as replacement deposits contain some manganese of purely residual nature.

Manganese deposits of purely residual origin are rare and of little commercial value. In climates and localities where decay of rocks can go on for a long time and the products of decay are not removed by erosion, the more stable constituents of the rocks will remain after less stable constituents have been broken down, dissolved, and carried away in solution. The most stable constituents remaining in this way become concentrated into residual deposits. A few deposits of mixed manganese and iron have been formed in this way, but in general the manganese and iron were not in the form of oxides and hydroxides in the original rock, but occurred in other chemical combinations which were broken up on weathering and the manganese and iron taken into solution and later precipitated as oxides and hydroxides on the surface, in open spaces, or by replacement of other minerals. The deposits so formed are not true residual deposits

[1]Curtis, A. H.: "Manganese Ores"; Imperial Inst., Monographs on Mineral Resources, London, 1919.
Harder, E. C.: "Manganese Ores in Russia, India, Brazil, and Chile"; Trans. Am. Inst. Min. Eng., vol. 56, pp. 31-76 (1917).
Singewald and Miller: "The Manganese Ores of the Lafayette District, Minas Geraes, Brazil;" Trans. Am. Inst. Min. Eng., vol. 56, pp. 7-30 (1917).
Beyschlag, Vogt, and Krusch: "Ore Deposits"; pp. 851-869 (1916).
Harder, E. C.: "Manganese Deposits of the United States"; U.S. Geol. Surv., Bull. 427 (1910).
Fermor, L. L.: "Manganese Ore Deposits of India"; Mem., Geol. Surv., India, vol. 37 (1909).
Penrose, R. A. F.: "Manganese"; Geol. Surv., Ark., Ann. Rept. 1890, vol. 1.
There are other excellent reports dealing with manganese deposits formed by replacement, but the ones listed, with their excellent bibliographies, make a nearly complete list of references.

and not true replacement deposits, but take on some of the characteristics of both types. Some of the deposits of mixed type are very large and valuable.

The origin and nature of manganese deposits of replacement residual nature have been very thoroughly investigated by Fermor.[1] Deposits of this type are of very common occurrence in India and yield a great deal of the manganese ore mined in that country. Some are of considerable size. Hill 5 at Ramdongri in the Nagpur area, in the central provinces of India, is one of the largest known deposits of this type. It consists of impure manganese ore and is 2,500 feet long, 1,500 feet wide, and 140 feet high. It is likely that in India the deposits were formed by weathering of sediments that contained considerable manganese.

The manganese ore deposits of Canada were mostly of replacement origin in limestone. One of the best known and most valuable of this type in Canada was at the Markhamville mine, Kings county, New Brunswick. At this place Lower Carboniferous limestone has been weathered and is covered locally with 8 to 20 feet of residual clay. In the clay are nodules and larger masses of manganese ore. In the underlying limestone are irregular deposits, following the bedding to some extent but branching into pipes and veins. The manganese bodies in the residual clay may have been present as such in the limestone and simply have been freed from the solid rock by weathering, or they may have been formed as a nodular growth which took place while the residual clay was being formed. By far the largest single body of manganese ore at the Markhamville mine contained only 3,000 tons.

A deposit of replacement-residual type in Canada occurs at the Hill 60 mine, Cowichan lake, Vancouver island, British Columbia. At that place manganiferous quartzites have been weathered and a single irregular body of manganese ore has formed by replacement of the manganese-bearing rock.

MANGANESE VEINS[2]

Although veins consisting of manganese minerals are not uncommon, very few are of commercial value. None of the vein manganese deposits is large, but some are of exceptional purity. All gradations exist between manganese vein deposits formed by filling of fissures, and vein-like deposits formed by replacement, and these in turn grade into irregular replacement bodies. Small joint planes in soluble rock such as limestone may become filled with manganese minerals, the joint fracture may be enlarged by solution, and the deposit may finally grow to one of very irregular shape. Fissures of various sizes in rocks of various kinds have been filled with manganese minerals. Many small fractures in rocks become filled with a dendritic growth of manganese oxide. Some of the veins are valuable because of some other metal than manganese and the latter is then present only in gangue minerals. Some veins which originally contained manganese carbonate or some other manganese-bearing carbonate have been enriched by surface action until the material has been converted into manganese oxide ore.

[1] "The Manganese Ore-Deposits of India"; Memoirs, Geol. Surv., India, vol. 37 (1909).
[2] Beyschlag, Vogt, and Krusch: "Ore Deposits", pp. 851-862 (1916).

The solutions from which the manganese minerals were deposited are in general of surficial origin. The manganese has been dissolved from rocks in the vicinity, probably to a large extent from rock that has been removed by erosion, and has been redeposited in the fissures as oxides or carbonates depending on whether the environment in the fissure was oxidizing or reducing. Some veins containing manganese carbonate have been formed from solutions arising from igneous sources. The carbonate veins have no commercial value as manganese ore, but are used to some extent as flux in smelting operations. The oxide veins are of greater value, and in Canada have produced some fine ore of chemical grade. Where veins have been subject to oxidation for a considerable time psilomelane has altered to manganite and the latter to pyrolusite.

The best known examples of vein manganese deposits in Canada are at New Ross, Lunenburg county, Nova Scotia. At that place fissures in granite were originally filled with manganiferous calcite. This was later oxidized so that the veins consisted of oxides. The veins were more thoroughly oxidized at the surface than in depth, and so were divisible into four zones. At the top was a zone 10 to 25 feet deep of hematite and hydrated iron oxides. Below this was a zone about 50 feet thick consisting mainly of pyrolusite. This second zone graded downward into a third consisting chiefly of manganite, and this graded downward into a zone of psilomelane. Underneath the psilomelane were manganiferous calcite and slightly altered, crushed granite.

Manganiferous ores of the vein type have been mined, also, in some foreign countries, particularly in Germany and France.

CHAPTER III

THE MANGANESE DEPOSITS OF CANADA IN RELATION TO THE GEOLOGY OF VARIOUS REGIONS

The known manganese deposits of Canada are confined chiefly to the Maritime Provinces and to British Columbia. In other parts of Canada there are only a few, small, non-commercial bog deposits.

The geological relations of manganese deposits are different from those of the other non-ferrous metals, for these are related genetically to igneous intrusives, whereas manganese deposits are formed by water taking from the rocks the minute amounts of manganese present there and concentrating them into deposits. The process of solution operated in all geological ages wherever manganese occurred in the rocks and deposition took place wherever waters contained manganese and conditions were favourable for deposition. Thus, manganese deposits may occur in rocks of any age and may be forming at the present time. As it is not known whether the special environment necessary for the formation of manganese deposits existed at any particular place in the past, the presence or absence of deposits can not be predicted. Enough is known, however, of the relation between geological environment and the different types of manganese deposits to permit predicting what types of deposits, if any, will occur in a specified area.

Deposits of the sedimentary oxide and carbonate types were, probably, laid down in bodies of shallow water near land areas. They would lie near former shorelines. Commercial deposits of these types have not so far been found in Canada. Bog deposits are forming today in Canada and were no doubt also formed in the past. Bodies of replacement origin formed through the action of surface agencies occur, but are not of great extent. Because of continental wide glaciation in the Pleistocene period superficial deposits, even if they were plentiful and large before the Pleistocene, would have been worn away and dissipated during this period of glaciation. As the time since the Pleistocene is too brief for the formation of large manganese deposits it is unlikely that large manganese deposits of surficial origin, i.e. bog and replacement deposits, will occur in the glaciated parts of Canada.

There is no known geological reason why manganese deposits should not have formed at various times in the past, but the fact remains that over the greater part of Canada manganese deposits are lacking. It has been said that there is no clear evidence that oxides of manganese have been laid down abundantly in any locality during the Palæozoic or

Mesozoic eras, but that such beds were formed in the Tertiary, Pleistocene, and possibly in the Precambrian.[1] A notable exception to this is the very extensive manganiferous bed in the Cambrian of Newfoundland, where manganese oxides as well as manganese carbonates were laid down.

In view of the general absence of manganese deposits from large areas in various parts of the earth where the rocks carry an average content of manganese and, on the other hand, the occurrence of manganese deposits where the rocks contain many manganese-bearing minerals, one is forced to the conclusion that the manganese deposits of the world, particularly of the replacement, residual, and bog types, have been derived from rocks or minerals that contain much more than an average content of manganese. Such appears to be the case in Brazil and India, as stated by Harder and Fermor. If the deposits are to be of considerable size it seems also necessary that rock decay be deep and thorough and that it take place faster than the removal of the decayed matter by erosion. When these two major conditions are fulfilled the percolating waters will necessarily contain manganese in solution which may enter into the formation of manganese deposits.

It is unlikely that large bog deposits, and more especially large replacement deposits, can be formed from springs and circulating waters unless these waters percolate through deeply weathered material in which the complex rock minerals are largely broken down into simpler constituents. In tropical countries like Brazil and India where lateritic deposits of various types occur, there are excellent opportunities for the formation of manganese deposits of the replacement type. There is no evidence that laterites have ever formed in Canada.

Canada is divisible into six geological regions, each of which exhibits a certain degree of uniformity and is quite different from the others.

(1) The Appalachian and Acadian region includes that part of Canada east of St. Lawrence river. This region makes up about 2 per cent of the area of Canada. (2) The St. Lawrence region includes the plains bordering the lower St. Lawrence and also that part of Ontario south of a line joining Georgian bay to the outlet of lake Ontario. This region makes up about 1 per cent of the area of Canada. (3) The Canadian Shield includes most of Canada north of the Appalachian and Acadian region and the St. Lawrence region and east of a line passing through Winnipeg, Athabaska, Great Slave, and Great Bear lakes and continuing thence northwest to the Arctic ocean. This region makes up about 45 per cent of the area of Canada. (4) The Arctic archipelago and Hudson Bay lowland region includes the Arctic islands north of the mainland of Canada and a low-lying strip of country 100 to 200 miles wide bordering Hudson bay from Churchill to the southern tip of James bay. This region makes up about 18 per cent

[1]Twenhofel, W. H.: "Treatise on Sedimentation", pp. 413, 414 (1926).

of the area of Canada. (5) The Great Plains region includes that part of Canada lying west of the Canadian Shield and east of the mountains of western Canada. The line separating the Great Plains from the mountains of western Canada lies approximately along the eastern boundaries of British Columbia and Yukon. This region makes up about 20 per cent of the area of Canada. (6) The Cordilleran region includes that part of Canada west of the Great Plains region. This region makes up about 14 per cent of the area of Canada.

THE ARCTIC ARCHIPELAGO AND HUDSON BAY LOWLAND

The Arctic archipelago has not been at all thoroughly explored, but a little is known of the geology and physical features. The eastern part is mountainous and peaks rise well over 5,000 feet above sea-level. In the south and west the country is plain-like and is in general 1,000 feet or less above sea-level. Some of the islands, for example Devon island, are covered with ice. Others are quite free of glaciers. The country is barren of any timber. The Hudson Bay lowland is only a little higher than sea-level and slopes gently north and east to Hudson bay. This area is wooded and only in the northern part is the ground frozen throughout the year.

The rocks in the high country of the Arctic archipelago are chiefly crystalline varieties of Precambrian age. Nearly horizontal sediments of Palæozoic age make up the plateau country and the low-lying plains country. Rocks of Triassic and Tertiary age occur at several places. The rocks of the Hudson Bay lowlands are flat-lying sediments of early Palæozoic age.

It is not known whether or not conditions were favourable for the accumulation of manganese deposits in the Arctic region at any time in the geological past. Any deposits of whatever origin that might have formed on the present surface have probably been destroyed by glacial erosion. In view of the fact that the ground is perpetually frozen in the Arctic archipelago no Recent spring deposits of any consequence can be expected.

THE CANADIAN SHIELD

The Canadian Shield is, on the whole, a region of low relief and, in general, less than 2,000 feet above sea-level. The rocks are of Precambrian age, and are chiefly granites, gneisses, and schists, but extensive areas are floored by sedimentary assemblages which in various districts are not much altered.

Manganese deposits are not known on the Shield, but this cannot be due to lack of manganese in the rocks, for analyses of the granite show as much manganese as the average granite of the earth. There is no evidence, however, that the rocks or minerals of the Canadian Shield have more than an average content of manganese, and there is very little evidence of deep decay or weathering. Sedimentary manganese deposits may, however, exist. Because of Pleistocene glacial erosion it is probable that most or all pre-Pleistocene deposits of superficial type, such as bog and replacement deposits, have been removed. Because of the low relief springs are extremely rare and when this fact is considered with the shortness of time since the Pleistocene, it is evident that deposits of post-Pleistocene age are not to be expected.

ST. LAWRENCE REGION

The St. Lawrence region is an area of low relief, in general less than 1,000 feet above sea-level. It is underlain by nearly horizontal sedimentary rocks of Palæozoic age. Manganese deposits of the sedimentary oxide or carbonate types may exist, but there is no reason to suppose that they do. Large replacement and bog deposits are not likely to occur as there is relatively little manganese in the sediments, the only possible source.

GREAT PLAINS REGION

The Great Plains region is an area sloping north and east from an elevation of about 4,000 feet to an elevation of about 1,200 feet. The whole region with the exception of one or two small areas was glaciated in the Pleistocene period. Mesozoic sediments, which cover most of the region, are underlain by Palæozoic sediments and overlain in a few places by Tertiary sediments. Manganese deposits of sedimentary type are probably absent over most of the region, because the sedimentary rocks are at a considerable distance from probable sources of manganese. Volcanic rocks, occurring locally, and some of the sedimentary rocks of direct igneous derivation may be sources of some manganese deposits of the sedimentary type. However, no rock that contains more than an average amount of manganese is known in the neighbouring areas. Replacement and bog deposits are likely to be small and scarce because of the short time since the ice left the region, and because of the general lack of manganese in the sedimentary country rocks.

CORDILLERAN REGION

The Cordilleran region is a mountainous tract of country embracing several mountain systems and plateaux, throughout the whole region the relief is considerable. Precambrian rocks outcrop over relatively small areas. Palæozoic sediments are of very common occurrence along the eastern part of the region and Mesozoic rocks along the western, although the latter occur here and there throughout the region. The Coast Range intrusives of Mesozoic age occupy most of the western half of the region. Sedimentary and igneous rocks of Tertiary age occur throughout.

Although it is not known that any of the crystalline rocks of the Cordilleran region contain more than an average quantity of manganese, some of the sedimentary rocks do contain manganiferous beds. In view of this fact it may be that the rock from which the sediments were derived also contained more than an average amount of manganese. These sedimentary rocks are potential sources of manganese ores. The Cordilleran region was glaciated, but small areas suffered practically no glacial erosion and in them bog and replacement deposits of pre-Pleistocene age may exist. Replacement and bog deposits occur elsewhere. The bog deposits such as at Kaslo were formed from the weathering of manganese-rich rocks and minerals. An example of replacement deposits occurs at Cowichan lake and originated through weathering and replacement of a manganiferous bed of quartzite that itself is probably a very low-grade manganese deposit of sedimentary type.

APPALACHIAN AND ACADIAN REGION

The Appalachian and Acadian region is an area of subdued mountains which nowhere rise much above 4,000 feet above sea-level. The region has been glaciated, except perhaps on the highest mountains. As in the Cordilleran region, however, local areas were protected from Pleistocene erosion and excellent opportunities were offered for formation of bog and replacement deposits through the circulation of ground waters. No examples of the sedimentary type of manganese deposits are known in the region, but a great many bog and replacement deposits do occur. Those of replacement origin have considerable uniformity and are related to definite geological formations.

The Precambrian rocks consist of a thick series of metamorphosed clastic sedimentary rocks known as the Meguna series, one or more series of altered volcanic rocks, and bodies of granite. Early Palæozoic rocks are chiefly slates, sandstones, and limestones. In Devonian time sedimentation was interrupted by mountain building and the intrusion of batholiths of granite. After this mountain-building period, freshwater sediments were laid down and in some places in considerable thickness. This series is known as the Horton or Lower Mississippian. The country then became reduced to a peneplain, the climate became hot and arid, and in successive invasions by the sea the Windsor series of limestone and gypsum was laid down. The Windsor is of Upper Mississippian age. It has five different stratigraphic horizons at which gypsum occurs. The manganese deposits of Nova Scotia and New Brunswick are mostly associated with the lowest gypsum and limestone beds. Above the Windsor series are freshwater sediments of considerable thickness, laid down in Pennsylvanian time during which the climate became equable. The Carboniferous history of the Maritime Provinces has been dealt with in a thorough manner by Bell.[1] Triassic rocks occur in a few places.

In the Maritime Provinces manganese deposits occur in Ordovician, Devonian, Horton, Windsor, and Lower and Upper Carboniferous sediments, in Triassic volcanics, and in Devonian granite. Nearly all the deposits, however, except the bog deposits, occur in Lower Carboniferous rocks, and most of these occur near the Horton-Windsor contact. Nearly all, if not all, were formed by replacement or by filling of open fissures.

Manganese deposits of the Appalachian region of the United States occur chiefly in rocks of Cambrian and Ordovician age. Some occur in rocks of Precambrian age. Harder is of the opinion that those in the Precambrian rocks originated by replacement, the manganese being derived by solution from manganiferous rocks of the Precambrian. In regard to those in the Palæozoic, he says that the sediments were derived from the Precambrian rocks. The sediments, therefore, contain manganese-bearing silicates and perhaps, as well, manganese oxides and carbonates formed at the same time as the sediments were being laid down. In later erosion the manganese was continually dissolved and carried down in solution as the surface was lowered by erosion.[2] The deposits as they now exist, therefore, were formed to some extent in comparatively recent time, but have been in process of formation for several geological periods.

It is known that in the eastern United States the Precambrian contains more than an average amount of manganese in manganese-rich minerals, and the Precambrian is the supposed source of the Palæozoic sediments and the manganese deposits. It is not known whether the Precambrian rocks of the Acadian and Appalachian region of Canada contain manganese in like proportion, but it seems logical to assume that in Canada, too, the sediments and manganese deposits were derived from the Precambrian. Some analytical work has been done on the Devonian granite, and this showed that the granite had only a normal amount of manganese. It is assumed, therefore, that parts of the Precambrian of the Acadian and Appalachian region contain more than an average proportion of manganese and that the manganiferous sediments of Palæozoic age were derived from this source. The manganese ore deposits were derived from both the Precambrian and the later manganiferous sediments.

The mode of origin as postulated by Harder for the deposits in the eastern United States, seems to suit the deposits of the Maritime Provinces very well. They were formed by replacement, have been in process of formation for a long time, and were formed of manganese carried in solution and obtained from manganese minerals in the surrounding and overlying rocks.

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[1]Bell, W. A.: "Outline of Carboniferous Stratigraphy and Geologic History of the Maritime Provinces of Canada"; Trans. Roy. Soc., Canada, sec. IV, pp. 75-108 (1927).

[2]Harder, E. C.: "Manganese Deposits of the United States"; U.S. Geol. Surv., Bull. 427, pp. 100-101 (1910).

In regard to the future of manganese mining in the Maritime Provinces it must be pointed out that prospecting and mining of manganese, although not done in the most up-to-date way, have gone on for a long time and, as a consequence, it is likely that very few deposits of much commercial importance remain undiscovered. It is, however, to be expected that the Windsor limestone, particularly its lowest members, contains many undiscovered bodies of manganese ore. Judging from past mining experience in the Maritime Provinces one can hardly consider these bodies of ore a probable source of revenue.

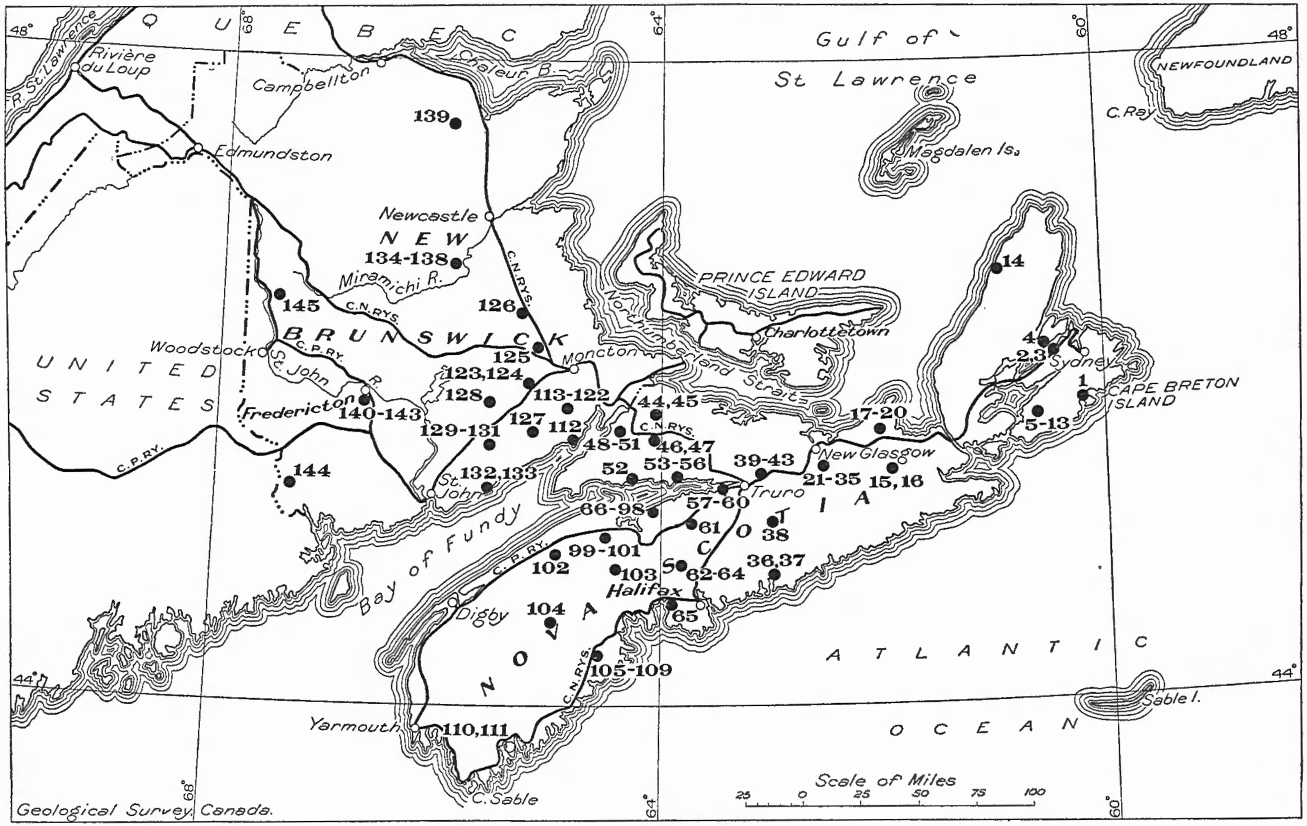

Figure 1. Index map showing location of manganese deposits in New Brunswick and Nova Scotia. (*See* page 27 for locality names.)

Explanation of Figure 1 (page 26)

The localities or properties indicated by numbers on Figure 1 are as follows:

1 Gabarus
2 Boisdale
3 Beaver Cove
4 Boularderie Island
5 Loch Lomond
6 Terra Nova
7 McVicar
8 Loch Lomond
9 Big Pond
10 Hay Cove
11 Salem Road
12 Lewis Bay
13 Soldier Cove
14 Cheticamp
15 Goshen
16 Lochaber
17 Pomquet river
18 Afton
19 Morristown
20 Ohio
21 Sutherland brook
22 Piedmont
23 Cameron brook
24 Bridgeville
25 Springville
26 Alma bridge
27 Glengarry
28 Grant brook
29 West River
30 Glengarry
31 Gairlock
32 Lorne
33 Blanchard
34 Sutherland river
35 French River
36 Jeddore
37 Ship Harbour
38 Musquodoboit
39 Borden
40 East mountain
41 Manganese Mines
42 Henry Christie's mill-brook
43 North River of Truro
44 Jersey
45 Salem Road
46 Rose
47 Springhill
48 Minudie
49 Amherst
50 Springhill
51 Joggins
52 Parrsboro
53 Lower Five Islands
54 Lower Economy
55 Londonderry
56 Moose cove
57 Clifton
58 Black Rock
59 Maitland
60 Clifton
61 Rawden
62 Fennerty
63 Mount Uniacke
64 Fennerty
65 St. Margarets Bay
66 Minasville
67 Faulkner
68 Tennycape estuary
69 Tennycape
70 Parker
71 Hibernia
72 Wheadon
73 Shaw and Churchill
74 Stephens
75 Pembroke
76 Feuchtwanger
77 Sturgis
78 Tomlinson
79 Cheverie
80 Dinsmore mills
81 Minasville
82 "
83 "
84 Walton
85 Sugar woods
86 Burnt Barren
87 Whale creek
88 " "
89 Walton
90 "
91 McLennan meadow
92 Minas Basin
93 Kennetcook Corner
94 Noel river
95 Rainy cove
96 Lantz
97 Kennetcook
98 Bass creek
99 Wolfville
100 Greenwich
101 Beech Hill
102 Nicholsville
103 New Ross
104 Pleasant River
105 Conquerall
106 Lahave
107 Chester
108 Bridgewater
109 Chester Basin
110 Shelburne harbour
111 Shelburne
112 Salisbury bay
113 Albert
114 Memel
115 Shepody mountain
116 Dawson settlement
117 Gowland mountain
118 Turtle Creek
119 Harvey
120 Hopewell
121 Hillside
122 Sawmill creek
123 Petitcodiac
124 Holmes brook
125 Canaan river
126 Adamsville
127 Pollet lake
128 Jordan mountain
129 Hillsdale
130 Glebe
131 Markhamville
132 Quaco head
133 Henry lake
134 McKay brook
135 North Renous
136 Upper Blackville
137 Doaktown
138 Miramichi river
139 Tetagouche
140 Lincoln
141 Douglas
142 Fredericton
143 Queensbury
144 Lynfield
145 Glassville

CHAPTER IV

DESCRIPTION OF OCCURRENCES

NOVA SCOTIA

BOULARDERIE ISLAND

Main Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces"; Manuscript report written in 1928.

Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, p. 157 (1907); Ann. Rept., vol. V, pt. S, pp. 99 (1893); Rept. of Prog. 1880-2, pt. H, p. 12; Rept. of Prog. 1878-79, pt. H, p. 17. Roy. Soc., Canada, vol. II, sec. IV, p. 7 (1884).

The description of the manganese deposits of Boularderie island is derived chiefly from Smitheringale's manuscript.

Two deposits of bog manganese or wad occur on the southeast shore of Boularderie island near Island point, Cape Breton island. The more northerly deposit is on the property of J. McNeil, Big Bank, Victoria county. It is on the lake shore and a secondary motor road connects it with North Sydney. The other deposit is 2 miles farther south on the same road and is on the farm of J. O'Handly, Island Point, Victoria county. This second bog is on the gently sloping, eastern bank of a small stream about half a mile west of the lake shore.

The rocks in the vicinity are limestone and gypsum beds of Windsor age, and shale, sandstone, and conglomerate of Pennsylvanian age. Some of the sediments contain siderite. The strata dip west at low angles.

McNeil's Property

The bog manganese deposits at McNeil's property have been developed by trenches, but these are now caved and the deposits are exposed best along the sea cliffs. The bog ore lies on sandstone strata, but locally penetrates the rock and apparently replaces it along joints. Limonite is common throughout and in places layers of limonite alternate with layers of bog manganese. The material is semi-consolidated and is said to contain much iron and silica. The deposit extends southwestward up the steep slope of the shore. It is as much as 5 feet thick and covers an area of 5 or more acres. J. A. Gillis did some work on it in 1912 and in 1917. The British Empire Steel Company investigated it in 1915, but did nothing more. In 1917 it was acquired by D. A. Cameron and has since remained idle.

O'Handly's Property

The occurrence on O'Handly's farm is similar in type to that on McNeil's farm. The bog manganese lies at the surface above a fine white sand. It ranges in thickness from 1 to 7 feet and extends over an area of 27 acres. The deposit has been known since 1878, but the first development work on it was done in 1915 when several long trenches were dug. Nothing has been done on the property since 1915.

The following are analyses of the O'Handly deposit.

—	1	2	3
MnO_2	25·42	11·04	44·33
Fe_2O_3	....	12·49	35·50
Insoluble	....	57·76	10·00
Water	35·52	....	....

Analysis No. 1 is by C. Hoffmann (Geol. Surv., Canada, Rept. of Prog. 1880-82, pt. H, p. 12). Analysis No. 2 is also by Hoffmann (Geol. Surv., Canada, Rept. of Prog. 1878-79, pt. H, p. 17), and the specimen analysed was said to contain traces of copper, nickel, and cobalt making a total of roughly 0·2 or 0·3 per cent. Analysis No. 3 is by E. Gilpin (Trans. Roy. Soc., Canada, vol. II, sec. IV, p. 7 (1884)). Mr. G. J. Ross of Sydney who worked on the property in 1915 claims that 110 samples gave an average of 40 per cent manganese.[1]

Origin

Smitheringale suggests that the manganese and iron of these deposits were dissolved out of the sedimentary rocks of the area and deposited by springs as bog ore. If the surface slopes in the same direction as the dip of the strata, springs would be numerous, as the water would follow porous strata and bedding planes. Such a relationship of surface to dip of strata appears to have existed at the O'Handly deposit.

Future Possibilities

The wad is friable and fine grained and, therefore, would have to be briquetted before it could be used in the manufacture of ferro-alloys. The accessibility, grade, and size of these deposits makes them worthy of examination by manganese mining companies.

LOCH LOMOND

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.
Uglow, W. L.: Notebooks, 1925.
Hayes, A. O.: "Investigations in Nova Scotia"; Geol. Surv., Canada, Sum. Rept. 1917, pt. F, p. 27.
Ingall, E. D.: "Section of Mines Report in 1902"; Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, pp. 152, 153 (1907).
Fletcher, H.: "Report on the Geology of Northern Cape Breton"; Geol. Surv., Canada, Rept. of Prog. 1882-4, pt. H, pp. 92, 93.
Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, pp. 527-529 (1890).
Gilpin, Ed.: "Notes on the Manganese Ores of Nova Scotia"; Trans. Roy. Soc., Canada, vol. II, sec. IV, pp. 12, 13 (1884).

Minor References: Mun. Res. Comm., Canada, Final Rept., pp. 62, 63 (1920).
Geol. Surv., Canada, Ann. Rept., vol. IV, pt. SS, p. 58 (1891).
Geol. Surv., Canada, Rept. of Prog. 1880-82, pt. H, pp. 8, 12.
Dept. of Mines of Nova Scotia: "Economic Minerals of Nova Scotia," 1903, p. 29.
Dept. of Mines of Nova Scotia: 1891, p. 50; 1890, p. BB; 1889, pp. 46, CC; 1885, pp. 34, 72; 1884, p. 70; 1883, p. 60; 1882, p. 52; 1881, pp. 17, 56.

[1]Presumably MnO_2 is meant.

The manganese deposits of Loch Lomond are on the adjoining farms of Messrs. Morrison and McCuish on the Enon-Big Glen road about 3 miles east from Enon post office, Cape Breton county. The workings on Morrison's farm are about a quarter of a mile south of the road, on the west side of a small stream flowing north. On McCuish's farm the ore occurs along the eastern bank of a brook. The Morrison mine is three-quarters of a mile east of the McCuish mine. An old road, about half a mile long, leads from the main road to the showings.

The discovery of manganese at Loch Lomond was made by H. Fletcher about 1879. Shortly afterwards E. T. Mosely, of Sydney, obtained the mining rights and produced 129 tons in the two years 1881 and 1882. The reports of the Department of Mines of Nova Scotia record a production of 243 tons up to 1889. The mines were idle from 1890 to 1915 when the Dominion Steel Corporation sank a shaft at the Morrison mine. In 1916 C. B. Wetmore of Sydney obtained the right of search in the locality and mined 12 tons of ore from the McCuish mine. Since 1916 the mines have been idle.

Much of the ore mined was taken from soil as loose masses that had weathered out of the shales and limestones; some ore occurred as loose nodules or gravel in creek beds; and some ore was mined from pits and tunnels. The ore was packed into casks and most of it shipped to Boston, where it was used for the manufacture of chlorine and bleaching powder and for decolorizing glass.

Morrison Mine

The manganese deposits at the Morrison mine were developed by shallow trenches and pits, a shaft 20 feet deep, and a tunnel. The workings are now caved and the exact mode of occurrence of the deposits cannot be seen.

The rocks on the property are Windsor and Horton conglomerate, red arenaceous shale, and limestones, dipping 25 degrees northwest and overlying a pink granite of pre-Carboniferous age. Specimens of dark, manganiferous limestone have been analysed and Gilpin[1] quotes the following analysis:

	Per cent
$CaCO_3$	49·269
$FeCO_3$	4·044
$MgCO_3$	28·034
$MnCO_3$	14·586
Insoluble	1·298

The ore occurs as irregular bodies in red shale, as veinlets, nodular masses, and irregular replacements in limestone, as a cement and as a coating of pebbles in the conglomerate, and as small, irregular replacements in the underlying granite. In the limestone, the replacements tend to follow the bedding planes and retain to some extent the original structure of the limestone. Most of the ore found in the rocks lies in red shale, but a large part of the ore obtained was found as loose nodules in the creek bed. The manganese in the conglomerate and underlying granite

[1]Trans. Roy. Soc., Canada, vol. II, sec. IV, p. 9 (1884).

occurs only in minor quantity and has not been mined. Judged from descriptions of the property, the thickness of the manganese ore-bodies and even of the manganiferous strata was measurable in inches rather than in feet. Gilpin states that the combined thickness of the ore and the overlying manganiferous limestone varied from 2 to 8 inches. Fletcher stated that a tunnel 30 feet long had been driven on a "vein" 7 inches thick. Hayes was informed that at the bottom of the shaft there was a 3-inch layer of ore.

The ore consists of pyrolusite, and within dense, massive nodules groups of radiating, acicular crystals are common. Associated minerals are calcite, barite, and selenite. Analyses of ore specimens yielded 91·84 per cent MnO_2, 0·12 per cent Fe_2O_3, and 2·91 per cent insoluble.[1]

McCuish Mine

The manganese deposits at the McCuish mine were developed by pits, shallow shafts, and trenches. As at the Morrison mine the workings are now caved and the deposits are very poorly exposed.

The rocks at the McCuish mine are of Windsor and Horton age, dip gently northwest, and consist of the following sediments, which are listed in order from top to bottom: (1) grey to buff crystalline limestone; (2) hard conglomerate consisting mostly of pebbles of a porphyritic rock; (3) red shale, and (4) brown, crystalline limestone.

Most of the ore in the solid rock occurred in the red shale, but much of the ore mined occurred as loose nodules in soil. In the red shale, which is from 1 to 10 feet thick, the ore occurs as layers and lenses lying roughly parallel to the bedding planes of the shale. Gilpin says that the layers were as much as 18 inches thick and were connected by cross stringers of ore. The shales on weathering liberate manganese nodules and this is probably the source of the loose manganese nodules in the soil and creek beds.[2] Manganese occurs also as irregular replacements in the limestone underlying the red shale and to a minor extent in the cement and as a coating on the pebbles of the overlying conglomerate.

Smitheringale states that the minerals are pyrolusite, manganite, and hausmannite, which form massive or finely porous ore made up of interlocking, acicular crystals. The porous ore is mostly pyrolusite containing scattered remnants of the other manganese minerals. Manganite and hausmannite are more plentiful in the massive ore, but even in this the alteration to pyrolusite is conspicuous. Vugs in the porous ore contain delicate incrustations of barite. Some of the massive ore was formed as a replacement of limestone. In thin section this replacement is seen to begin as a slight yellowish smudge on calcite; the smudge gradually becomes intensified and manganite blebs appear within and eventually completely replace the calcite. In the final replacement of the calcite, manganite and hausmannite appear in crystalline form. Oxidation resulted in porous ore consisting mostly of pyrolusite.

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[1] Geol. Surv., Canada, Rept. of Prog. 1880-82, pt. H, p. 12.
[2] Trans. Roy. Soc., Canada, vol. II, sec. IV, p. 12 (1884).

Future Possibilities

The following remarks are quoted from Gwillim's report.[1]

"There is a small area of manganese-bearing Lower Carboniferous rocks from one-quarter to one mile wide extending for 4 miles east of Loch Lomond. These strata may be worth prospecting by shallow pits or bore-holes, and if such prospecting develops commercial quantities of manganese ore some systematic work could be undertaken. As it is at present, local pits, trenches, etc., are made to depths of 20 feet, more or less, at points far apart; a few tons of ore are taken out, then water and overburden fill in the workings and nothing but hearsay can be obtained as information. If, as is reported, the managanese horizon carries from 1½ to 5 inches of ore, more or less in kidneys, this horizon might by systematic work be made to pay the costs of opening up the rather heavy loose ground, such as overlies the productive stratum. The ore is apparently of the high priced type not used for making ferromanganese, and there does not appear to be much chance of an early or large production, without much expensive development."

Hayes[2] states, " detailed study of the local geology, combined with systematic prospecting, might result in locating deposits of ore."

TERRA NOVA

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript. The Terra Nova manganese deposit is between the headwaters of Gaspereau and Salmon rivers 3½ miles south of Big Pond, Cape Breton county. Access from Big Pond is over the Big Pond-Enon road for 3½ miles and then over a side road to the property. The first work on the property was done in 1893 by A. Morrison. Very little was done at that time and the property then lay idle until 1919 when another unproductive effort was made. The district is underlain by porphyries and granites and by Carboniferous conglomerates, limestones, and grits. The deposit is on low, swampy ground and rock exposures are few.

The property was developed by trenches, but as these are now caved very little information can be gained from them. According to Mr. Morrison the main showing as exposed in a trench was a fairly flat-lying, wedge-shaped mass of manganese 3 feet wide and up to 2 feet thick.

Specimens show that the ore occurs as a replacement of a dark buff, limy clay and as veins in granite. The minerals present are braunite and pyrolusite. Braunite is mostly associated with clay and forms a dense, hard ore in which are fragments of clay. The veins consist of braunite and pyrolusite. Polished sections show that braunite is the earlier mineral and that it is replaced by pyrolusite. Thin sections of granite show braunite in cracks.

MCVICAR

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript. A manganese-bearing deposit occurs on the farm of John McVicar, Loch

[1]Mun. Res. Comm., Canada, Final Rept., pp. 62, 63 (1920).
[2]Geol. Surv., Canada, Sum. Rept. 1917, pt. F, p. 27.

Lomond, Richmond county. A shaft 25 feet deep in Windsor limestone, which was sunk in prospecting for iron ore, intersects a bed of manganese-bearing limestone as much as 8 feet thick. Specimens from the dump contain well-crystallized hausmannite associated with calcite, rhodochrosite, manganite, pyrolusite, limonite, and hematite. Hausmannite replaces limestone and the rhodochrosite is distinctly later, occurring as veinlets and also as incrustations in cavities in the hausmannite. Manganite and pyrolusite occur as alteration products of hausmannite. Limonite occurs as a coating on hausmannite.

BORDEN

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript. The Borden property is 7 miles east of Truro and about 3 miles north of Valley station on the Truro-New Glasgow division of the Canadian National railway in Colchester county. It is half a mile northeast of the property known as Manganese Mines.

The property was owned by Philip Archibald until 1926 when it was acquired by Mr. Borden. The occurrence is said to have been the original discovery of manganese in the district. The workings consist of a number of pits which are now caved so that no bedrock is visible. Pieces of altered greenish slate occur on the dumps around the old caved trenches. No manganese minerals were seen in the material on the dumps.

EAST MOUNTAIN MINE

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

"Manganese Mines, Colchester County, Nova Scotia": Mun. Res. Comm., Canada, Final Rept., pp. 88, 89 (1920).

Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, p. 157 (1907); Ann. Rept., vol. V, pp. 91, 184 (1893).

The report by Uglow purports to describe "Manganese Mines," but from his description it seems clear that he is referring not to Manganese Mines but to the deposits at East mountain. The two references to publications of the Geological Survey, listed above, refer to a manganese deposit at Farnham's millbrook. Judged from the descriptions given in these reports, the deposit referred to is the one known in this report as the East Mountain mine.

The East Mountain mine, known locally also as the Fraser property, is 6 miles east of Truro and half a mile northwest of Manganese Mines post office, Colchester county. Access to the property is over the Truro-New Glasgow highway for 4½ miles and thence by secondary road for 1½ miles. The deposit is beside this road where it passes along the northwest bank of a small gully eroded by a little tributary of Clifford brook. The workings are on the farm of John Hoar.

Manganese was discovered at East mountain about 1897 in digging a water hole for cattle, in the bottom of a small creek. The ore was traced upstream for 200 feet by trenches to a place where a larger mass was found. At this place a shaft was sunk, vertical for the first 5 feet and then on an incline of 55 degrees for 20 feet. Residents of the district say that 100 tons of ore were removed from these early workings in 1897. The property then lay idle until 1918 when W. S. Carlisle of Truro, who holds the right of search in this district, pumped out the old shaft, deepened it 5 feet, and obtained about 10 tons of ore.

The old trenches are caved and the shaft is full of water, so that recent investigators have not seen the ore in place.

Smitheringale states that the rocks at the workings are sediments consisting of buff-coloured limestone which grades upward into red calcareous shale, and is underlain by a thinly laminated, reddish to grey sandstone. The sediments are probably of Lower Carboniferous age. The attitude of these rocks could not be accurately determined, but a small outcrop of shattered, limy shale some distance away gave a strike of north 60 degrees east magnetic and a dip of 60 degrees northwest. The rock on the dumps is buff-coloured limestone partly replaced by brownish to red, calcareous material which on being tested chemically showed strong reactions for manganese and iron.

The old trench by which the ore was traced trends northeast. The shaft is inclined northwest at an angle of 55 degrees. As the ore presumably follows a bed of limestone, its dip probably was also 55 degrees northwest.

Old reports state that the ore was pyrolusite occurring as nodules in limestone at its contact with underlying sandstone. One who worked on the property in 1918 says that the ore occurred in three layers each about a foot thick and separated by 3 or 4 feet of limestone containing nodules of ore from the size of a pea up to 4 inches in diameter.

Smitheringale says that specimens from the dumps show that the ore is pyrolusite with minor amounts of manganite. In the main it consists of a compact mass of fibrous, interlocking crystals. Small vugs are common, however, into which project minute acicular crystals of pyrolusite and in some of which tiny plates of barite occur. Within the ore calcite is rare, but adjoining it and in stringers veining the country rock it is common. Some of the calcite in the veinlets contains manganese as a veneer over crystal faces and along fractures.

Origin

Smitheringale believes that the deposit is a replacement resulting from a progressive concentration of manganese by meteoric waters. The initial stages of this concentration consisted of the introduction of manganese and iron, probably as carbonates, into the limestone. Later, solution and oxidation resulted in the formation of vugs and the precipitation of manganese oxides.

Future Possibilities

Uglow[1] says,

"Whether or not the property merits further exploration could not be determined without an underground examination. With the exception of the fact that upwards of 3 tons (perhaps even 7 or 8 tons) of ore have been taken out of the incline, there appeared to be no feature sufficiently encouraging to warrant the expenditure of such a sum of money as would be required for exploration purposes."

Special Notes

A sample of ore collected by Mr. Smitheringale from ore stored at the property was analysed in the Mines Branch, Ottawa, and the result is listed below.

	Per cent
Manganese	57·89
Insoluble and silica	0·64
Iron	0·31
Phosphorus	0·017
Available oxygen	16·48
Sulphur	None
Copper	None

Two samples were taken by Uglow from the store of manganese ore at the property. The average of the two analyses is as follows:[1]

	Per cent
Moisture	5·81
Manganese	47·94
Iron	0·90
Silica	15·77
Phosphorus	0·027
Sulphur	0·017

MANGANESE MINES

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.
Uglow, W. L.: Notebooks, 1925.
Fletcher, H.: "On Geological Surveys and Explorations in the Counties of Pictou and Colchester, Nova Scotia"; Geol. Surv., Canada, Ann. Rept., vol. V, p. 184 (1893).

Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, p. 154 (1907); Ann. Rept., vol. VI, pt. S, p. 89 (1895); Ann. Rept., vol. III, p. 98 (1889).
Acadian Geology, p. 275.
Dept. of Mines of Nova Scotia: "Economic Minerals of Nova Scotia," 1903, p. 28.
Dept. of Mines of Nova Scotia: 1896, p. 76; 1894, p. 74; 1891, p. 50; 1888, p. BB; 1887, p. 61; 1886, pp. 21, 63; 1885, pp. 34, 72; 1884, pp. 33, 72; 1882, p. 52.

Several manganese properties occur in the vicinity of Manganese Mines, and in the literature on the area considerable confusion exists as to their names. As descriptions are brief it is not always possible to tell which property is being described. In the references listed above Fletcher describes a manganese mine at "East Onslow." In the Annual Report of the Geological Survey, volume XV, Manganese Mines and East Onslow are referred to as separate properties. In the Annual Report,

[1]Mun. Res. Comm., Final Rept., 1920, p. 89.

volume VI, there is a reference to a manganese mine at Onslow. Annual Report, volume III, refers to a manganese mine near Valley. "Acadian Geology" refers to the property of "Onslow East Mountain Manganese and Lime Company." In the publications of the Department of Mines of Nova Scotia, the report for 1903 refers to a manganese property near Valley station. The reports for 1896 and 1894 list production from Truro. The reports for 1891, 1887, and 1886, page 21, refer to Onslow mine. The reports for 1888, 1884, and 1885, page 72, refer to East Mountain mine. The report for 1886, page 63, refers to East Onslow. The report for 1885, page 34, refers to Salmon River mines. The report for 1882 refers to mines near Valley. It seems that all of the reports have reference to one property, here described as Manganese Mines.

The property known as Manganese Mines is on the farm of Stanley Coulter about 6½ miles east of Truro, in Colchester county. It is near Manganese Mines post office. The property is ¾ mile north of the Canadian National railway and 1¾ miles south of the Truro-New Glasgow highway. A secondary road passes within 200 yards of the workings.

According to the articles referred to above, and the residents of the district, the property was worked from about 1880 to 1896. Work was also done at irregular intervals from 1896 to 1905, since which time the mine has been idle. The reports of the Department of Mines of Nova Scotia list a production of 334 tons of manganese ore from the district, but residents claim that there was a production of 2,000 tons from Manganese Mines. The ore was crushed and concentrated prior to shipment. Ore was also handpicked for high-grade shipments.

The workings consist of a number of scattered pits now badly caved and full of water. The main pit is 100 feet long and 70 feet wide, and at the bottom of it a shaft has been sunk to a depth of 100 feet below the surface of the ground. There is little now to be seen at the property except fragments of red sandstone and brecciated sandstone lying on the dumps. Pyrolusite occurs in the rock fragments as narrow seams following joints and bedding planes and also as part of the matrix of the breccia. According to Fletcher, the rocks at the mine are red Devonian[1] sandstone and argillite dipping steeply south. The ore which was mainly pyrolusite occurred in the joints and along the bedding planes of one band of flinty rocks. The ore-bodies in the joints were as much as one foot thick. Much of the ore mined was taken from the soil.[2]

From an examination of specimens collected from the dumps, Smitheringale says that the principal ore mineral is pyrolusite, which occurs as compact masses of small, interlocking prisms or as veinlets of fine, acicular crystals that are perpendicular to the walls of the veinlets and in places attain a length of one inch. Manganite is present as small grains. Calcite is associated with the manganese minerals and commonly lines the walls of manganese veins, but is also found within the ore minerals and in some places forms thin partings along the centres of veins. The general appearance of this breccia suggests that during or immediately

[1]These rocks are now considered to be of Lower Carboniferous age.

[2]Geol. Surv., Canada, Ann. Rept., vol. V, p. 184 (1893).

subsequent to the deposition of the sandstone, the stratum became consolidated enough to be broken and the fragments were then rolled about until they became subangular and were cemented together by finer-grained cement of the same nature as the original. The manganese oxide replaces the cement and is also disseminated to some extent through the coarser material of the fragments.

JERSEY

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript and notebook.

The Jersey bog ore deposit is on the farm of Charles Weatherby, 2½ miles north of Atkinson siding on the Canadian National railway, in Cumberland county. A good road extends from Atkinson siding to the farm.

The occurrence is within an area that has been mapped as underlain by the New Glasgow conglomerate (Upper Carboniferous age) and younger Carboniferous or Permian strata. The bog manganese is in lenticular deposits 6 feet or more across and up to 1½ feet thick. It occurs as a cement in the soil, and encrusting fragments of rock and permeating porous sandstone boulders.

A few trenches have been dug in various places in the swamp areas and show some bog manganese. Masses are frequently turned up during the ploughing of fields. The main occurrences are along the lowest ground of swampy areas, and there the bog manganese occurs in sporadic pockets. In the case of one area of about 4½ acres the bog ore may be more uniformly distributed, but even there is scarcely of economic significance.

An analysis of the bog manganese follows:[1]

	Per cent
Mn	24·81
Insol. and silica	13·71
Iron	8·72

SALEM ROAD

Main Reference: Faribault, E. R.: "Investigations in Western Nova Scotia"; Geol. Surv., Canada, Sum. Rept. 1918, pt. F, p. 3.

Minor References: Dept. of Mines of Nova Scotia: "Economic Minerals of Nova Scotia," 1903, p. 29.

Geol. Surv., Canada, Ann. Rept., vol. X, pt. A, p. 101 (1899).

The following description is quoted from the above-mentioned report by Faribault.

"The deposits are situated on Fred S. Shipley's farm, Brookvale, on the west side of the road leading from Amherst to Salem, Cumberland county . . . where a broad belt of limestone holding manganese has been largely quarried. The limestone is of light reddish and grey colour, concretionary, yielding no fossils . . . . (This limestone is now mapped as Windsor.) From several of the openings manganese ore has been extracted which is said to have nearly paid for the cost of working. The ore was found in pockets, irregular cavities, and along fractures and joints in the rock. About twenty years ago 60 tons of good ore was extracted from one opening 13 feet in diameter and 30 feet in depth, close to Mr. Shipley's house. The deposits are no

[1]Analyst, A. Sadler, Mines Branch, Ottawa.

doubt the result of local deformation and fracturing of the rocks, followed by the filling of the cracks with manganese oxide. Three sets of fractures or joints have been observed, two of which are vertical and at right angles, to the northeast and to the southeast, and a third one horizontal, dividing the rock in rectangular blocks. It is impossible to come to any practical conclusion, however, regarding the possible distribution of the ore-bodies. Though exploratory work for ore-bodies may not give promise of successful results, the working of the quarries for the limestone and its excellent lime product might lead to important discoveries of manganese ore."

ROSE

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript.

Bog manganese occurs at Rose on the farm of S. Halliday, Cumberland county. This locality may be reached either from Westchester station or from Oxford junction, on the Canadian National railway. From the former one takes the main motor road west for about 8 miles and from the latter one proceeds 6 miles south to Collingwood corner and then east on the Collingwood-Westchester road.

The surrounding country is rolling agricultural land and has been mapped as being underlain by Lower Carboniferous strata. The bog manganese occurs as small, nodular masses about the grass roots. The nodules range in size from that of sand grains to an inch or so in diameter. They occur in small patches varying in size up to a yard or so across and several inches to a foot thick. The patches are most common in swampy areas along the main water channel. A sample of the material was analysed by the Mines Branch, Ottawa, and gave the following results:

	Per cent
Manganese	21·21
Insoluble and silica	24·64
Iron	6·50

BLACK ROCK

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.
Uglow, W. L.: Notebooks, 1925.
Faribault, E. R.: "Investigations in Western Nova Scotia"; Geol. Surv., Canada, Sum. Rept. 1918, pt. F, pp. 1, 2.

Minor References: Geol. Surv., Canada: Ann. Rept., vol. V, pt. P, p. 95 (1893); Rept. of Prog. 1882-4, pt. L, p. 23.

Black Rock manganese deposit is on Lockherd point near Clifton, at the mouth of Shubenacadie river, Colchester county. The deposit is 100 yards west of the ferry wharf and lies between low and high tide levels, which are here 45 feet apart.

The rocks in the immediate vicinity of the manganese occurrence are thinly laminated, dark grey, fine-grained manganiferous limestone, overlain by a limestone conglomerate. These rocks are of Windsor age and are overlain by Triassic sandstone and grit. The Carboniferous rocks strike roughly east magnetic and dip 20 degrees south, but are locally warped into many small folds. Joints and inconspicuous fractures are numerous in the laminated limestone and many are healed by calcite. The limestone holds many specks and irregular veinlets of a pink carbonate.

As the deposits have been idle for many years there is now very little evidence of former development. Faribault says that the deposit,

"occurs in the form of a fissure vein (which) . . . . cuts the rocks vertically in a southwesterly direction towards the river, in the course of which it divides into two veins extending to low-water mark. The main vein is exposed for a length of 180 feet, from mud flats near the high tide to the low tide; and the branch or north vein for 143 feet from the point of divide to low-water mark, where the two veins are 30 feet apart. The two veins are lenticular, and vary in width from 1 to 30 inches, but for the greater part of their length they are from 2 to 6 inches. One lens of ore which occurs at a bend on the main vein, has a width of 12 to 30 inches for a length of 50 feet; and a smaller lens on a branch vein measures 15 to 24 inches for 15 feet. At their extremities the veins thin out to nothing. The ore consists of manganese oxides, with a few small pockets or streaks of crystallized pyrolusite, and includes calcite, iron oxides, and fragments of wall-rock."[1]

The following information is taken from Smitheringale's manuscript. Besides the main veins, smaller replacement stringers containing manganese oxides occur in the lowest thinly laminated limestone member. These veinlets contain calcite, limonite, manganite, pyrolusite, and hausmannite. Some of the calcite is dark brown and contains much manganese and iron. The limonite is botryoidal and has crystallized in radiating groups of crystals which extend across the original formational banding of the limonite. Polished sections of specimens from the veinlets show that the manganese is chiefly present as manganite in crystalline form, but exhibiting as well, rough colloform banding. This suggests that the manganese oxides were originally deposited as a colloidal mass, and later crystallized as manganite. Pyrolusite is rare and replaces manganite. Hausmannite occurs as minute grains and clusters. It is suggested that meteoric waters percolating through the limestone deposited manganese and iron along the joints, bedding planes, and fractures forming the present veinlets. Evidence supporting this view is found some distance away where a small trickle of water emerges from the contact between laminated limestone and limestone conglomerate. The seepage has enlarged the contact plane and is depositing limonite on the walls and on the rock over which it flows. Possibly the larger fissures were filled in the same way.

Future Possibilities

The veins described by Faribault were sampled by him at intervals of 5 feet. The average analysis obtained is given below.

	Per cent		Per cent
Mn........................	31·70	P........................	0·011
Fe........................	4·22	S........................	0·120
Ca........................	8·14	Insoluble..................	16·41

Faribault says further, "The analysis shows that the ore is of inferior quality at the surface. . . In view of the recent decrease in the demand and the price of manganese ore, the deposit now may not deserve the attention it might have received during war time."[2]

[1]Geol. Surv., Canada, Sum. Rept. 1918, pt. F, pp. 1, 2.
[2]Geol. Surv., Canada, Sum. Rept. 1918, pt. F, p. 2.

MINASVILLE

Main References: Smitheringale, W. V.: "The Manganese Occurrences of The Maritime Provinces, Canada"; Manuscript report written in 1928.
Uglow, W. L.: Notebooks, 1925.

Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, pp. 156, 157 (1907); Ann. Rept., vol. VI, pt. AA, p. 63 (1895).

The Minasville property is probably the one referred to by Smitheringale as the Macdonald property which is on the farm owned by Joe and Amos Macdonald half a mile south of Minasville along the western slope of Moose brook, Hants county. About 1891 two shafts were sunk on the property by J. Mosher who at that time owned the farm. Mr. Mosher made a small shipment of ore.

The rocks are interbedded, reddish to brown, thin sandstones and shales. The strata strike magnetic east, dip 55 degrees south, and are probably of Horton age. The manganese seen by Smitheringale was probably manganite and it occurred as thin films along cracks in the rocks. According to Fletcher the ore occurred in " veins and blotches varying from $\frac{1}{4}$ inch to 5 inches in thickness and holding also crystals of calcite."[1]

FAULKNER PROPERTY

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript. The Faulkner property is one mile east of Tennycape, Hants county. Access is over a secondary road from Tennycape. The property was formerly owned by Joseph Faulkner who leased it to Wm. Stephens of Tennycape about 1887. During a period of one and a half months in 1887, Mr. Stephens obtained some 1,200 pounds of ore from surface workings. In 1907 Leonard Reynolds of Moose Brook bought the property and sank a vertical shaft 35 feet deep, but obtained only a ton of good ore.

The strata are a series of red shales and brown limestone. The manganese occurs in vugs and narrow stringers associated with calcite. Fine crystalline aggregates of intergrown pyrolusite and manganite, and large crystals of either pyrolusite or manganite up to 1 inch long characterize the ore.

TENNYCAPE ESTUARY

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript. Manganese occurs in the sea cliffs along the western shore of Tennycape estuary, Hants county. The rocks at this place consist of Horton sediments overlain unconformably by Triassic rocks. The older rocks strike magnetic east, dip 50 degrees south, and are considerably crumpled and

[1]Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 63 (1895).

sheared. The Triassic rocks strike magnetic east, dip 10 to 15 degrees north, and consist of sandstone, grit, and conglomerate. In the lower part of the series, the finer grained sediments are in general yellow to grey and the coarser grained sediments are reddish brown.

The basal bed of the Triassic is a well-sorted conglomerate, but immediately overlying it is a very poorly sorted conglomerate containing material that ranges from fine sand to boulders 4 feet in diameter. Above this are alternating bands of poorly sorted and well-sorted material. The pebbles and boulders are mostly of sedimentary rocks such as sandstone, grit, arkose, and slate, but boulders of granite and porphyry also occur. The cement in the main is calcite with some iron oxides and kaolin and is particularly plentiful in the coarser beds.

Manganese minerals occur throughout the lower part of the Triassic, but chiefly in the coarser, poorly sorted conglomerate beds. The minerals are magnetite, pyrolusite, and psilomelane. They occur as small masses resembling pebbles, as fine crystalline aggregates, as films around boulders and pebbles, and as a replacement of the carbonate cement. Vugs lined with calcite crystals occur and in some of them the calcite is coated by small, hair-like crystals of manganite.

The rocks containing the manganese are believed to be of Lower Triassic age, and, if they are, the concentration of the manganese oxides replacing the cement of conglomerates must be post-Lower Triassic.

TENNYCAPE MINE

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Ingall, E. D.: "Section of Mines Report for 1902"; Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, pp. 154, 155 (1907).

Willimott, Chas. W.: "Report on Observation in 1883 on the Mines and Minerals of Ontario, Quebec, and Nova Scotia"; Geol. Surv., Canada, Rept. of Prog. 1882-4, pt. L, p. 22.

Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, pp. 518-522, 532-538 (1890). (Two figures illustrate the mode of occurrences of the manganese ore, and one figure illustrates folding and brecciation of the manganese-bearing limestone and shale.)

Minor References: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, pp. 58, 59. Geol. Surv., Canada: Ann. Rept., vol. XIII, pt. S, p. 85 (1903); Ann. Rept., vol. VI, pt. AA, p. 63, pt. S, p. 88 (1895); Ann. Rept., vol. V, pt. S, pp. 97, 98, 184 (1893); Ann. Rept., vol. IV, pt. S, p. 52, pt. SS, p. 58 (1891).

"Acadian Geology", pp. 273-275 (1878).

Roy. Soc., Canada, vol. 2, sec. 4, pp. 8, 9 (1884).

Dept. of Mines of Nova Scotia, "Economic Minerals of Nova Scotia", 1903, p. 29.

Dept. of Mines of Nova Scotia: 1905, p. 116; 1899, p. 56; 1896, p. 76; 1895, p. 55; 1891, p. 50; 1890, p. BB; 1889, p. 49; 1887, p. 61; 1886, p. 63; 1885, p. 72; 1884, p. 72; 1883, p. 60; 1881, pp. 17, 56; 1879, p. 54; 1877, p. 46.

The Tennycape mine is 1½ miles southwest of the town of Tennycape in Hants county. The mine is reached by 1½ miles of a secondary road which leaves the main post road half a mile west of Tennycape. The workings are on the north side of Rennie brook near its source.

Smitheringale obtained the following historical account from W. F. Stephens and David Brown of Tennycape.

The mine was first owned by Mr. Hill and associates of Halifax and in 1862 work was started under the management of J. Brown. Early production was from boulders of manganese ore in the soil overlying the occurrence. Open-cuts were made into the underlying limestone and a considerable quantity of ore was obtained from them. As a result of open-cuts a large lens of ore was encountered within a short distance of the surface, and this single ore-body yielded 1,000 tons of good ore. It was mined between 1870 and 1875.

In 1877 J. W. Stephens of Tennycape bought the Tennycape mine and during the following fifteen years carried on active mining operations, resulting in an annual production of about 200 tons. The production figures for all years are not given in the old reports. The figures are given, however, for most of the years from 1879 to 1889, and in this interval the average annual production was about 130 tons.[1]

In 1895 Messrs. McVicar and Shaw bonded the property and did a little work, but later sold to a company the chief members of which were Mr. Boak of Halifax, Mr. Barnes of Boston, Mr. French of Maine, and W. F. Jennison of Truro. Very little development was done by this company. During the winter 1917-1918 Mr. Hassan dewatered and sampled the mine for an American company, but nothing further was done and the property has since lain idle.

Geology

The rocks include in the immediate vicinity of the manganese occurrences a sandstone overlain by an 8-foot bed of limy shale, the "hard" rock of the local miners known also as the foot-wall ore zone. This is overlain by a brown or grey dolomitic limestone, the lower part of which is brecciated and recemented with calcite. This brecciated limestone was known locally as "soft" rock and carried the best ore. Penrose states that the limestone is at least 250 feet thick, and that it is overlain by gypsum, the outcrop of which is near the creek bottom and is now covered with debris.[2] Gypsum has been quarried within half a mile of the mine and the gypsum horizon is only a short distance above the manganese-bearing limestone. The rocks strike roughly east and dip 40 degrees south. The strike and dip are of the sandstone, as local warpings and flexures in the limestone and shale make it difficult to obtain their true attitude, although they are in all likelihood conformable with the sandstone. If any unconformity exists it must be a slight one. Fletcher states that the limestone is separated in some places from the underlying sandstone by 2 to 4 inches of hard red clay.[3] The ore-bearing limestone is probably of Windsor age and the underlying sandstone may be of Horton age. Gilpin gives the following chemical analysis of the limestone at Tennycape.[4]

[1]Dept. of Mines of Nova Scotia for the years 1879-1889.
[2]Ark. Geol. Surv., Ann. Rept., vol. I, p. 519 (1890).
[3]Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 63 (1895).
[4]Roy. Soc., Canada, vol. 2, sec. 4, p. 9 (1884).

	Per cent
Lime carbonate	49·81
Iron carbonate	2·56
Magnesia carbonate	35·44
Manganese carbonate	4·58[1]
Insoluble matter	8·06
Moisture	0·37

The Deposits

Some of the workings are caved but the deeper ones are full of water, so that recent observers have not been able to study the mode of occurrence of the deposits. Some of the older descriptions are fairly complete. The best ore occurred in the brecciated limestone as stringers, nests, and pockets. The stringers varied in thickness from a fraction of an inch to 10 inches and were, according to David Brown, mostly perpendicular to the bedding. According to Penrose[2] the veinlets in the limestone possessed no regularity. Near the calcareous shale many of the stringers widened and joined to form pockets which in some places coalesced making a blanket-like deposit of considerable lateral extent parallel to the bedding. The nests and pockets varied in size from an inch or two in diameter to huge masses weighing several hundred tons. One mass yielded 1,000 tons of ore. The pockets of ore are in some places isolated and in others connected by thin seams of ore. Only the bottom 40 feet of the limestone contained commercial ore. The ore extends along the strike of the limestone 500 feet east and 300 feet west of the main shaft. Penrose states that the ore in the stringers at the time was of higher grade and purer manganese than that occurring along the bedding planes.[3]

Penrose quotes part of a letter written by John Brown, the former manager of the mine, which pictures the mode of occurrence of the ore as follows:

"On the south side of the ridge a large open-cut was brought in, running nearly north and south, in which was discovered the first large deposit, at a depth of only 15 feet from the surface. It extended some 12 fathoms in length, varying in thickness from 14 feet to as little as 6 inches. From this pocket we took from 120 to 130 tons, leaving nothing in the bottom but a few small veins. Upon these we sank our shaft, and at a depth of 15 feet, making in all 30 feet from the surface, we intersected pocket No. 2, immediately underneath the first deposit and making in the same direction. The manganese in the second pocket is of far superior quality to that found nearer the surface, and we have returned from it some 180 tons."

In the calcareous shale or "hard" rock, the ore occurred as veinlets ramifying in all directions. In some places these stringers are narrow and widely spaced and in others though still narrow they are so closely spaced that the veined rock is good milling ore.

Besides being found in the rock, a considerable amount of ore was obtained from the clay immediately north of the outcrops of limestone. Penrose states (page 522) that this clay has resulted from the decay of ore-bearing limestone. This ore in clay occurred in pieces from nut size to masses weighing 100 pounds or more.

The ore was mostly of the soft needle type (pyrolusite) and was exceptionally pure. Psilomelane and manganite were present in varying amount.

[1]As peroxide.
[2]Ark. Geol. Surv., Ann. Rept., vol. I, p. 520 (1890).
[3]Op. cit., p. 538.

The minerals associated with the ore were limonite in botryoidal masses, calcite, selenite, and barite, one or more of which were present in considerable amount in some places and absent in others.

Penrose, dealing at length with the origin of the brecciation of the limestone (pages 532 to 538), suggests that the bed of gypsum overlying the brecciated limestone may have been formed from anhydrite and that the resulting increase in volume brecciated the less rigid rocks nearby. Assuming this as true he then points out, that there would be considerable solution and redeposition of calcite and manganese minerals and that as this process of solution and redeposition would tend to purify the manganese there would be here an explanation of the greater purity of the manganese in the veinlets. The larger bodies of manganese would be less disturbed and would, therefore, not be purified by solution and redeposition.

Development and Mining

According to Smitheringale, the first development work consisted of making a large open-cut 500 feet long and 50 feet wide and then sinking shafts in the bottom of the open-cut. From the shaft stringers of ore were followed by drifts, and the ore was stoped out. Later, a main shaft, a short distance south of the open-cut, was sunk to 160 feet and a short crosscut was driven north to the foot-wall of the ore and then connected with earlier workings. Other shafts were sunk along the strike of the limestone, but these were not all connected underground with the main workings. The underground workings extend 400 feet east and a shorter distance west from the main shaft.

The ore was hand cobbed and sorted to some extent into two grades. Ore was also crushed at the mine, and the crushed ore concentrated and sorted on shaking tables to a marketable grade and put into barrels for shipment. No figures are available to show the annual total production from the mine. Judged from figures given for isolated years it seems probable that this mine furnished about 4,000 tons, or half of the total production of manganese of Nova Scotia.

Future Possibilities

Smitheringale points out that the mine has not been worked below the 160-foot level and ore may be found at greater depths. He also states that under favourable market conditions it might be possible to work the dumps and foot-wall shale, but that the total quantity of manganese from these sources would probably be small.

PARKER MINE

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Ingall, E. D.: "Section of Mines Report for 1902"; Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 155 (1907).

Minor References: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, p. 59. Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 64 (1895). Ark. Geol. Surv., Ann. Rept., pt. I, p. 522 (1890). Dept of Mines of Nova Scotia, 1880, p. 14.

The Parker mine is half a mile northwest of the Tennycape mine or about 2 miles west of Tennycape, Hants county. Access to the mine from the Tennycape mine may be had over a poor road which is in places quite swampy.

The mine was worked by Wm. Stephens who in 1881 mined 30 tons of high-grade pyrolusite. Denis says that from 20 to 100 tons of good ore were taken from this mine.[1] The ore was taken from a large pit 100 feet by 50 feet. This is now full of water.

The rocks in the vicinity are limestones of Windsor age occurring as an outlier of the large area of limestone exposed at the Tennycape mine. The ore occurred as a large pocket in the limestone and consisted of very pure pyrolusite.

HIBERNIA

Main Reference: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Minor Reference: Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, pp. 155, 156 (1907).

The Hibernia property is about 2 miles southwest of the Tennycape mine or about 3½ miles southwest of the town of Tennycape, Hants county. It is accessible over the road that passes just east of the Tennycape workings, but between the Tennycape and Hibernia mines the road is in very bad condition and in places difficult to follow.

Mr. J. Stephens about 1885 did some work on manganese showings at this place and is said to have taken out about 2 tons of ore. The ore was taken from surface pits which were examined by Smitheringale. He says that the manganese occurred in Lower Carboniferous rocks. Reddish shale and sandstone are overlain by a conglomerate, and this in turn by gypsum. The conglomerate contains rounded, waterworn pebbles of quartz, sandstone, and shale varying in size from ¼ inch to 4 inches in diameter and cemented by calcareous matter which forms the greater percentage of the rock. The manganese minerals, consisting of psilomelane and a little pyrolusite, occurred in the cracks and seams of the shale, around the pebbles, and in joints in the conglomerate.

WHEADON

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following account is taken from Smitheringale's manuscript. The Wheadon property is just south of the post road about halfway between Rennie and Wilcox brooks, Hants county. The ground slopes north to Cobequid bay. The old workings are about 75 yards from the barn on Mr. Wheadon's farm. The ground was acquired by Mr. Beckman who sold in 1924 to Mr. Wheadon. It is said that 2 tons of pyrolusite were obtained from this property. An open-cut shows a Triassic conglomerate containing pebbles of heterogeneous character and size and cemented with calcite and pyrolusite. This occurrence is correlated with that in the Tennycape estuary and may have been formed at the same time and under the same conditions.

[1]Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, p. 59.

SHAW AND CHURCHILL MINE

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Willimott, Chas. W.: "Report on Observations in 1883 on the Mines and Minerals of Ontario, Quebec, and Nova Scotia"; Geol. Surv., Canada, Rept. of Prog. 1882-4, pt. L, p. 21.

Minor References: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, pp. 59, 60.

Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, tp. 155 (1907); Ann. Rept., vol. VI, pt. AA, p. 64 (1895).

Dept. of Mines of Nova Scotia, "Economic Minerals of Nova Scotia," 1903, p. 29.

The Shaw and Churchill mine is on the west bank of Walton river, directly opposite Walton and within 75 yards of the main road between Walton and Pembroke, Hants county.

Work on this property began in 1881 and continued in a small way for the following two years. It is reported that during this time about 200 tons of good chemical ore was mined from open-pits and shipped to American markets. Willimott records a production of 20 tons in 1883.

The ore occurred in a small outlier of Windsor limestone in a depression in the older sandstones and shales of Horton age. It consisted chiefly of pyrolusite, but manganite was present in small amounts. Barite and calcite occurred with the ore. At the present time the pits show only a few manganese stringers in the sandstone. Willimott states that the ore occurred in detached pieces from $\frac{1}{2}$ pound to 3 tons in weight in decomposed limestone.

STEPHENS MINE

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Willimott, Chas. L.: "Report on Observations in 1883 on the Mines and Minerals of Ontario, Quebec, and Nova Scotia"; Geol. Surv., Canada, Rept. of Prog. 1882-84, pt. L, p. 21.

Minor References: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, p. 59. Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, pp. 155, 156 (1907).

Dept. of Mines of Nova Scotia, "Economic Minerals of Nova Scotia," 1906, p. 40.

The Stephens mine is $\frac{3}{4}$ mile southwest of Walton, Hants county. The mine can be reached by a good secondary road that leaves the main post road about $\frac{1}{2}$ mile west of the bridge over Walton river.

Mr. W. F. Stephens of Tennycape furnished Smitheringale the following information regarding the history of the property. The mine was first owned by Wm. Stephens, and from 1870 to 1875 was worked by J. Brown who is said to have obtained a few tons of very good ore. About 1885 R. J. Stephens removed 10 or 20 tons of ore. In 1899 the property was acquired by W. F. Stephens and from 1902 to 1907 Wm. Stephens recovered about 20 tons of ore. There are at present 3 barrels of ore in a shed on the property.

The property was developed by pits and shafts, but these now are mostly inaccessible and do not expose ore in place. They do, however, show the rocks. Smitheringale says that the strata are thinly laminated limestone overlain by brownish grey, apparently massive limestone about 10 feet thick and this overlain in turn by a conglomerate containing small, rounded pebbles of quartz, chert, and limestone. The main mass of the uppermost bed is limestone. This series exhibits many local crinkles and warpings, particularly in the laminated member, but in general strikes east and dips 45 degrees south. The rocks are probably basal members of the Windsor series underlain at this place by the Horton formation.

Occasional shafts and pits follow the Horton-Windsor contact for 1,800 feet. Manganese was found in the conglomerate and in the laminated limestone, but the best ore occurred in the latter. Joints in the laminated limestone in places have been enlarged by solution and lined with calcite crystals. Willimott says that the ore occurred as pockets and irregular veins. The only manganese seen by Smitheringale consisted of pyrolusite and manganite and occurred as narrow stringers cutting the limestone and as films along joints. Smitheringale furnished the following information about the shafts and other workings of the Stephens mine. They are enumerated in order from west to east.

1	—	—	Vertical shaft sunk for ventilation. Not completed
2	60 feet north of No. 1..	Brown, calcareous conglomerate at collar of shaft. Specimens on dump show stringers of pyrolusite ½ inch thick in same type of rock	Shaft on 35-degree slope to south for 60 feet. Drift 30 feet long from bottom of shaft
3	595 feet east of No. 2..	Brown limestone........................	Shallow pit
4	40 feet east of No. 3...	Calcareous conglomerate at collar; grey, platy limestone along sloping part of shaft	Shaft vertical for 40 feet and then on 35-degree slope to south for short distance
5	110 feet east-southeast of No. 4	Rocks strike north 80 degrees west magnetic and dip 57 degrees north. The rock succession is calcareous conglomerate over grey, crystalline limestone over thinly laminated limestone	Caved vertical shaft. Large open-cut
6	425 feet east-southeast of No. 5	Shaft follows wrinkled, thin-bedded limestone striking south 70 degrees west magnetic and dipping 40 degrees south. Joints in the limestone contain calcite and pyrolusite	Shaft on 40-degree slope to south for 50 feet. Large open-cut.
7	420 feet east-northeast of No. 6	Thinly laminated limestone strikes south 85 degrees west magnetic and dips 45 degrees south	Large open-cut. Old working
8	210 feet southeast of No. 7	....	Old pit
9	90 feet north of No. 8..	Reported to have produced good ore....	Old pit

PEMBROKE

Reference: Hayes, A. O.: "Investigations in Nova Scotia"; Geol. Surv., Canada, Sum. Rept. 1917, pt. F, p. 28.

Hayes reports as follows:

"A pyrolusite-bearing sandstone occurs 2 miles south of Pembroke, in Hants county. Recent development work has indicated that the low-grade ore-body has a considerable tonnage and working samples, treated in the ore dressing laboratory of the Mines Branch, gave suitable concentrates for the manufacture of ferromanganese."

The property referred to by Hayes may be one of several south of Pembroke which are referred to in this report under other names.

FEUCHTWANGER PROPERTY

Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following account is taken from Smitheringale's manuscript. The Feuchtwanger property is south of Pembroke and about 2 miles west of Walton, Hants county. The workings are about 100 yards east of the shaft at the Sturgis mine. The property was worked from 1885 to 1894 by F. Ward of Windsor, who did most of the development now represented by three shallow shafts and several pits. No figures of the production are available. In 1918 E. Chisholm pumped out one of the shafts and mined 1 or 2 tons of ore.

The ore occurs in thinly laminated limestone of Windsor age striking northeast and dipping 60 degrees southeast. The ore occurs as stringers up to 5 inches wide and as small pockets and nests, and consists of pyrolusite in fine, pulverulent masses and also crystallized in needles and platy grains. Limonite exhibiting colloform structure is associated with the ore and is replaced by the pyrolusite. It is reported that good ore occurred in all of the workings on this property. The workings are scattered over a square area about 50 yards across and do not appear to lie along any particular bed, vein, or other ore horizon.

Smitheringale furnished the following information about the workings at the Feuchtwanger property.

1	—	Thinly laminated limestone strikes northeast and dips 60 degrees southeast	Old open-cut
2	5 feet east of No. 1....	Limestone..............................	Old open-cut
3	75 feet east of No. 2...	Ore reported to occur....................	Old pit
4	70 feet north of No. 3..	Ore reported to occur....................	Old shaft
5	55 feet north-northwest of No. 4	Ore reported to occur....................	Shaft 30 feet deep and 60 feet of workings from bottom of shaft
6	60 feet north-northeast of No. 5	Limestone..............................	Old open-cut
7	80 feet southeast of No. 6	....	Shaft 30 feet deep full of water

STURGIS MINE

Main Reference: Smitheringale, W. V.: "The Manganese Occurrences in the Maritime Provinces, Canada"; Manuscript report written in 1928.

Minor Reference: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, p. 156 (1907; Ann. Rept., vol. VI, pt. AA, p. 64 (1895).

The Sturgis mine is 2 miles west of Walton and 2 miles south of Pembroke, Hants county. Smitheringale says that the mine was worked intermittently by the owner, Dr. Sturgis, from 1877 to 1882, but very little, if any, ore was shipped, and that in 1918 E. Chisholm did considerable work on the property and is said to have removed about 16 tons of ore. Fletcher states that this property was also worked for a time by the Provincial Manganese Mining Company.[1] Two shafts and a large pit exist on the property.

Fletcher reported that the ore occurred as veins and impregnations in limestone and in underlying sandstone. Smitheringale does not mention ore as occurring in limestone. The following description is from his manuscript report. The manganese occurs in light reddish grey quartzite that weathers brown and underlies Windsor limestone. Pyrolusite and limonite occur in veinlets along joints in the quartzite and appear to replace it by forming many coalescing, irregular veinlets, some of which are several inches across. From laboratory studies, Smitheringale concluded that much of the limonite and manganese had replaced quartzite. Smitheringale furnishes the following information about workings at the Sturgis mine:

1	——	Most of the ore came from this pit	Pit 30 feet deep
2	70 feet southeast of No. 1	Shaft and crosscut in clay sandstone with manganese stringers at end of crosscut	Shaft 40 feet deep and 30 feet crosscut towards the pit. Work done in 1917 and 1918
3	40 feet southeast of No. 2	....	Shaft

TOMLINSON MINE

Main Reference: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, p. 156 (1907; Ann. Rept., vol. VI, pt. AA, p. 64 (1895).

The Tomlinson mine is somewhat more than 2 miles west of Walton and about 3 miles south of Pembroke, Hants county. The property can be reached from Pembroke over a very poor road.

Smitheringale states that the workings, consisting of a few trenches and a shaft, expose a ferruginous sandstone probably of Horton age, which on weathering has yielded a surface product of siliceous limonite. He saw cherty limonite with small amounts of specularite and some psilomelane on the dumps, but saw none of this material in place.

[1] Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 64 (1895).

Fletcher, who saw the property twenty-six years earlier, states that the workings disclosed hematite and pyrolusite occurring together and also separately.[1]

The following table is compiled from Smitheringale's manuscript.

1	——	Red ferruginous sandstone. Dump shows some psilomelane	Pits 8 to 17 feet deep connected by trench; total length, 70 feet along a northeast direction
2	55 feet northeast of northeast end of No. 1	At bottom on northwest side mashed rock suggests a fault	Shaft 25 feet deep caved
3	Commences 45 feet northeast of No. 2	Red sandstone. The weathered surface of specimens on the dump contain iron and manganese oxides	Trench, 40 feet long in a northeast direction
4	55 feet east of No. 2...	Red ferruginous sandstone..............	Pit
5	North end 15 feet south of No. 4	Red ferruginous sandstone..............	Trench, 95 feet long in a direction east-southeast

CHEVERIE

Main References: Smitheringale, W. V.: "The Manganese Occurrences of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, pp. 522-524 (1890).

Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, p. 156 (1907); Ann. Rept., vol. IX, pt. S, p. 79 (1898); Ann. Rept., vol. VI, pt. AA, pp. 63, 65 (1895); Ann. Rept., vol. V, pt. S, p. 98 (1893); Rept. of Prog. 1882-4, pt. L, pp. 22, 23.

Dept. of Mines of Nova Scotia: 1888, p. BB; 1887, p. 61; 1886, p. 63; 1884, p. 72; 1883, p. 60; 1882, pp. 13, 52; 1881, pp. 17, 56; 1880, pp. BB, 14; 1877, p. 46.

The Cheverie mine is at the mouth of Cheverie creek on the south shore of Minas basin, Hants county. Two main deposits are present, known as the Brown and the Lake occurrences. That on the property of Mr. Brown is just west of the main post road and the Lake occurrence is 200 to 300 yards farther west near the northern end of the sea cliffs that border the farm formerly held by Mrs. Lester Lake, but owned in 1927 by Mr. T. Macumber.

Manganese ore was probably first shipped from the Cheverie mine in 1880, when J. W. Stephens sent out a trial cargo to Boston. The mine was thereafter operated in a small way for at least eight years, for which there is a recorded production of 80 tons. The ore was taken from a series of open-cuts and one large pit and it is reported that a total of 200 or 300 tons of ore was shipped.[2] At the present time very little information can be gleaned from the pits and open-cuts.

[1]Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 64 (1895).
[2]Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 65 (1895).

On the farm of G. Brown, along an old road leading south to the beach, are knobs of Lower Carboniferous, brown, crystalline limestone. In these are several pits of sizes varying up to 30 by 40 feet and displaying brecciated limestone or possibly a limestone conglomerate of Windsor age. Manganite and pyrolusite, in places accompanied by calcite, occur along joint planes and filling spaces between the limestone fragments of the breccia or conglomerate.

At a second locality, on a farm formerly owned by Mrs. L. Lake, manganese occurs in cliffs along the shore of Minas basin. The rock of the cliffs is a brownish, brecciated limestone or, possibly, limestone conglomerate, of Lower Carboniferous age. The limestone fragments vary in size up to 12 or 15 inches and are cemented together by brown, crystalline limestone. Black manganese oxide occurs along joints and in the matrix of the breccia or conglomerate. It forms narrow veinlets and larger masses as much as 6 inches across. The small masses are irregularly distributed and though very pure, do not appear to be of economic value.

Penrose visited this locality in 1889 or 1890. He reported that no mining was then being done, though he was informed that 200 to 300 tons had been won and shipped. He described the locality as being

"a rocky bluff rising from 10 to 30 feet above the water and skirting the . . . shore . . . for several hundred yards . . . . Most of the manganese at Cheverie is a black, crystalline ore composed partly of pyrolusite and partly of manganite. It is associated with white calcite in a network of small veins from ⅛ inch to 3 or 4 inches in thickness running through a calcareous breccia composed of broken fragments of massive and shaly limestone. The ore frequently encircles the fragments or runs along the bedding planes of the unbroken parts of the bed. In fact it is found wherever a cavity or joint gives access to it, but it is usually in thin seams. Below the water it is said to be more plentiful and has been mined there on a small scale, but the operations were necessarily carried out at considerable expense and were soon abandoned. Frequently the calcite associated with the manganese is in the form of long crystals standing at right angles to the walls of the veins and forming a comb structure, in the centre of which is the ore."[1]

The two following analyses of Cheverie ore are taken from Gilpin.[2]

—	I	II
Peroxide of manganese	90·15	....
Manganese oxides	....	86·81
Iron peroxide	2·55	....
Baryta	1·12	....
Iron peroxide and baryta	....	2·05
Insoluble matter	2·80	1·14
Phosphoric acid	1·03	....
Moisture	2·05	10·00
Lime	Trace	

[1]Ark. Geol. Surv., Ann. Rept., vol. 1, pp. 522, 523 (1890).
[2]Trans. Roy. Soc., Canada, vol. 2, pp. 10, 11 (1884).

NICHOLSVILLE

References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.
Uglow, W. L.: Notebooks, 1925.
Faribault, E. R.: "Geological Mapping of Berwick and Lakeview Map-areas, Kings and Annapolis Counties, Nova Scotia"; Geol. Surv., Canada, Sum. Rept. 1920, pt. E, pp. 12, 13.
"Investigations in Western Nova Scotia"; Geol. Surv., Canada, Sum. Rept. 1918, pt. F, pp. 2, 3.
Dept. of Public Works and Mines of Nova Scotia, Ann. Rept., 1923, pp. 111, 112.

The Nicholsville or Aylesford manganese deposit is on the Wentzell farm, on the northern slope of South mountain, on the north side of Zebe creek, 1½ miles west of Nicholsville, Kings county. Access may be had from Aylesford, on the Dominion Atlantic railway, over a road 4 or 5 miles long.

Manganese was first mined at the property in 1885 when A. McPhail did considerable stripping, excavated a long trench, and obtained 3 barrels of ore. The property lay idle until about 1908 when A. Banks of Morristown did some exploratory work and sank a pit 8 feet deep. After another inactive period, the mine was taken over in 1918 by W. E. Bishop of Aylesford who sank a test pit 25 feet deep at the western end of the workings. In 1920 the Aylesford Manganese Company (W. E. Bishop, manager) was organized to carry on development and mining, but nothing was done on the property.

The rocks in the vicinity of the deposits are pink quartzites, red, arenaceous slates and phyllites, and soft, laminated slates of the Dictyonema series and probably of Devonian age. They strike east and dip steeply south. They directly overlie Precambrian sediments and are intruded by a reddish-weathering gabbro dyke about 100 feet wide.

The property was developed by two shallow shafts and one pit. Faribault examined the property in 1918, but as the workings were full of water he could not see the ore in place. It was reported, however, that the ore occurred as lenses and stringers, following in general the strike of the strata. The largest vein, striking south 75 degrees west magnetic and vertical, was said to be 3½ feet wide near the old shaft and to have associated with it three smaller veinlets totalling 1 foot in thickness. Iron oxides, calcite, and siderite are associated with the ore. The vein lies practically at the eastern contact of the gabbro dyke. It is reported that the vein was traced for a distance of 400 feet.

The ore minerals are manganite, pyrolusite, and hard, black psilomelane. The manganese is not of chemical grade. Faribault lists the following four partial analyses which show a high iron, silica, and phosphorus content and a rather low manganese content.

—	No. 1	No. 2	No. 3	No. 4
Weight in pounds	50	20	193·75	
Manganese, per cent	25·97	30·57	25·96	38·4
Iron, per cent	20·10	1·90	13·60	....
Silica, per cent	20·52	44·88	31·82	21·8
Phosphorus, per cent	0·835	0·051	0·39[1]	....

[1]Geol. Surv., Canada, Sum. Rept. 1918, pt. F, p. 3.

NEW ROSS

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Fearing, F. C.: "Manganese Deposits of Lunenburg County, Nova Scotia"; Eng. and Min. Jour. Press, vol. 115, No. 1, pp. 11-15 (1923).

Gwillim, J. C.: "Manganese in New Brunswick and Nova Scotia"; Mun. Res. Comm., Canada, Final Rept., pp. 63-66 (1920).

Hayes, A. O.: "Investigations in Nova Scotia and New Brunswick"; Geol. Surv., Canada, Sum. Rept. 1918, pt. F, pp. 23-28.

Kramm, H. E.: "On the Occurrence of Manganese at New Ross in Nova Scotia"; Can. Min. Inst., vol. 15, pp. 210-217 (1912).

Wright, W. J.: "Geology of the New Ross Map-area, Nova Scotia"; pp. 199-260. Manuscript written in 1912.

Dept. of Public Works and Mines of Nova Scotia: 1921, pp. 62-64; 1920, pp. 50-53; 1919, pp. 52-53; 1917, pp. 60-63, 74; 1916, pp. 99, 100.

Minor References: Eng. and Min. Jour. Press: vol. 115, No. 23, pp. 1008, 1009 (1923); vol. 115, No. 11, pp. 482, 483 (1923); vol. 115, No. 7, pp. 307, 308 (1923).

Can. Min. Jour., vol. 33, No. 13, pp. 659, 660 (1912).

Geol. Surv., Canada: Sum. Rept. 1917, pt. F, pp. 27, 28; Sum. Rept. 1912, pp. 387, 388; Sum. Rept. 1910, p. 253; Sum. Rept. 1908, p. 154; Ann. Rept., vol. XV, pt. AA, p. 186 (1907); Ann. Rept., vol. XIII, pt. S, p. 86 (1903); Ann. Rept., vol. XII, pt. S, p. 77 (1902).

Dept. of Public Works and Mines of Nova Scotia: 1930, p. 123; 1923, p. 212; 1918, p. 53; 1914, p. 112. Dept. of Mines of Nova Scotia: 1912, pp. 174, 189, 190; 1911, pp. 190, 205, 206; 1910, pp. 160, 161; 1899, p. 56.

"Economic Minerals of Nova Scotia", 1906, pp. 40, 41. A flow sheet of a screening mill at New Ross is shown in Dept. of Mines Report of Nova Scotia, 1912, p. 190.

Photographs of the surface equipment of the mines at New Ross are shown in the Dept. of Mines Reports of Nova Scotia, 1911, p. 205, and 1910, p. 160.

Photographs of surface equipment and dumps and plans of the Upper and Lower mines are shown in Eng. and Min. Jour. Press, vol. 115, No. 1, pp. 12, 13 (1923).

Photographs of pyrolusite, pseudomorphs after a carbonate, of goethite in the gossan, and of the surface plant at the "new" mine are shown in Can. Min. Inst., vol. 15, pp. 210, 217 (1912).

The manganese mines at New Ross are in the northern corner of Lunenburg county, about the middle of the "Dean and Chapter" grant. They may be reached by two routes: the first and better is from Windsor; the second is from Chester Basin and Mahone Bay. Leaving Windsor, one proceeds to upper Falmouth over 6 miles of very good road and thence over 4 miles of road that is now grown in with brush, but the road-bed is firm and in very good condition. On leaving Chester Basin one travels a good road to New Ross and from there takes a very rough road, 7 miles in length, to the mines.

Three properties were operated by mining companies. The mines of the New Ross Manganese Company and of the International Manganese and Chemical Company adjoin and the shafts are less than ¼ mile apart. The third mine, owned by the Nova Scotia Manganese Company, is 2 miles northeast.

The following historical sketch was obtained from the reports listed above and from information supplied to Smitheringale by Dr. Lavers of New Ross.

Manganese was discovered in New Ross district about 1891 by W. Rafuse who developed the discovery until 1893 when he sold to M. T. Foster of Halifax. Mr. Foster operated the mine for some years and made some shipments of ore. He sold the mine to the New Ross Manganese Company, which carried on mining until about 1903 when litigation regarding ownership of the land commenced, and mining operations ceased until 1916. This property was known in the earlier days as " Cains " mine and later as the " Old " mine. In 1916, the New Ross Manganese Company shipped 15 tons of ore sorted from the dumps, and in 1917 they shipped 7 tons, also obtained from the dumps. In 1919 the mine now known as the " Lower " mine, passed under the control of the Consolidated Manganese Company, who moved to it the plant from their adjoining property and commenced operations resulting in the shipment of 100 tons of low-grade and 15 to 20 tons of high-grade manganese ore. In 1920 the company shipped 100 tons of ore and in 1921, 150 tons of manganite and 30 tons of pyrolusite. Most of this production came from the " Lower " mine. Mining ceased in 1921. In 1930, the Dominion Mining and Power Company began unwatering one of the shafts and erected a small concentrating mill in which part of the old dump was treated.

A second discovery was made in 1907 by E. Turner at a point 2 miles northeast of the original discovery. This second discovery became known as the " New " mine and in 1910 the Nova Scotia Manganese Company, with Dr. Cain as manager, was organized to operate it. In 1911 active underground development and construction of camp and plant buildings began, but in 1912 operations ceased owing to lack of capital and in the same year the mill was destroyed by fire. In 1915, the property was leased to the Metals Development Company who unwatered the mine in October, 1915. In 1916 they produced 544 long tons of high-grade manganese ore. They then subleased the property to the Rossville Manganese Company, Limited, who in 1917 shipped 179 long tons of high-grade ore. No shipments were made in 1918, and in the same year fire destroyed part of the surface plant. In 1919 the Consolidated Manganese Company took an option on the mine, which now became known as the " Upper " mine. In 1920 control of this property passed to Dr. Lavers.

A third discovery was made adjacent to the original discovery and in 1916 the International Manganese and Chemical Company was organized and began to develop this latest discovery. In 1919 a reorganization of the company resulted in the Consolidated Manganese Company, who moved the mine plant to the adjoining, original discovery whose control had passed into their hands. In 1921, mining ceased.

Geology

The mines are situated about 600 feet above sea-level, near a height of land and in a district characterized by swampy areas, knobs of bedrock, and the presence of many large granite boulders. In the immediate vicinity, the country is level in general, but irregular and rough in detail. The outcrops of the mineralized zones are marked by depressions and at each of the workings a scarp of granite marks the northwest wall and extends with interruptions along the mineralized zone. Extensive bogs exist on the southeast side of the mineral zones.

The deposits occur in a biotite granite presumably of Devonian age and forming part of a batholithic body about 20 to 25 miles wide and 100 miles long that invades Precambrian sedimentary strata. About 4 miles to the south, the biotite granite is cut by a body of muscovite granite of variable characters. The biotite granite is composed of pinkish and white phenocrysts of microcline up to 3 inches long set in a medium-grained, bluish grey ground of plagioclase, quartz, orthoclase, and biotite. In the vicinity of the manganese deposits the granite is jointed along three directions, namely, horizontally and parallel to two nearly vertical planes one of which strikes northeast and the other northwest.

The mineral deposits are lenticular veins lying in faults or crushed zones 25 to 100 feet wide and striking northeast with steep dips to the northwest. The veins vary in width from a few inches to 5 feet. They are markedly lenticular and only the wider parts were mined profitably. The ore is separated from wall-rock by a narrow transition zone of granite, mixed with calcite, and iron and manganese oxides. The wall-rocks are soft and crumbly for a distance of several feet from the veins and consist of weathered granite in which the plagioclase feldspars are almost completely altered to kaolin. In the deepest workings the wall-rocks were only slightly weathered and were practically normal granite.

A vein has been mined at the "Upper" mine, at the "Lower" mine, and on the adjoining property of the International Manganese and Chemical Company. It is possible that the three mines are on a single vein, or at least on veins in a single large fracture or fault zone. A line of limonite and weathered carbonate float that may represent the outcrop of a second vein and which is roughly parallel to the vein lies about half a mile south of the "Upper" mine and is known as the "Bone Pit." Some specimens from the "Bone Pit" consist of closely spaced lamellæ of quartz in parallel sets intersecting at angles corresponding to those characteristic of the rhombohedral cleavage of calcite. The material is very light and some specimens float on water.

The best ore mined consisted of solid black pyrolusite. Less valuable ore consisted of manganite and psilomelane with more or less gangue that consisted of calcite, barite, iron oxides, and country rock. The calcite contains from 0·5 per cent to 3 per cent manganese.[1] The ore contains locally as much as 5 per cent barium carbonate.[2]

According to Wright the outcrops of the veins are made up almost entirely of limonite and goethite. Below the surface small amounts of pyrolusite appear and the amount increases with depth until at 10 to 25 feet below the surface it is great enough to constitute ore. Below, this depth the ore and gangue matter are confined to rather definite bands, the iron oxides occurring as a rule along the walls and the manganese

[1]Fearing, F. C.: "Manganese Deposits of Lunenburg County, Nova Scotia"; Eng. and Min. Jour. Press, vol. 115, No. 1, p. 13 (1923).

[2]Faribault, E. R.: Geol. Surv., Canada, Sum. Rept. 1910, p. 253.

oxides in the centre of the vein. Kramm[1] describes four zones in the deposits which from the surface downward are as follows: (1) a zone 10 to 25 feet thick of gossan consisting of hematite, limonite, and goethite, solid at the surface and crumbly and floury at a depth of several feet. (2) A zone of pyrolusite with some manganite. Manganite is scarce in the upper part of this zone, but rather plentiful in the lower part. Much of the pyrolusite is pseudomorphous after manganite and some after a carbonate. Drusy cavities and fine crystals of pyrolusite are common. Ochre is plentiful in this zone. There is a gradual transition from the gossan of zone 1 to the ore of zone 2. (3) A zone of hard, steel-blue manganite and psilomelane. Occasional clusters of pyrolusite crystals occur, and ochre is less plentiful than in upper levels. There is a gradual transition from the pyrolusite to the manganite zone. (4) A zone of hard, bluish brown psilomelane, iron oxide, and manganite. No pyrolusite is present and ochre occurs only as gouge on the vein walls.

Hayes[2] states that the ore below a depth of 70 feet is mainly manganite. He lists the following analyses which show that manganese dioxide decreases with depth, whereas the manganese content remains nearly constant. The samples assayed represent in each case an average of the quantity stated.

Quantity in barrels	Mn	MnO_2	Fe	Where obtained
	Per cent	Per cent	Per cent	
7	61·37	91·04	0·50	28- to 42-foot level
28	60·56	89·76	0·81	28- to 42-foot level
90	60·54	70·50	0·77	42- to 75-foot level
100	59·40	53·75	1·22	75- to 90-foot level

According to Fearing, commercial ore disappeared at 180 to 215 feet below the surface. In some places below the commercial ore zone some calcite and oxides of iron and manganese occur, and the wall-rocks are only slightly altered. At other places, particularly in the "Lower" mine, below the ore level there is only porous granite, partly altered. The manganese oxides in depth consist of nodules that have apparently grown by accretion and that by further growth would eventually result in manganese ore. This authority says, also, that pyrolusite was purer and more plentiful at the "Upper" mine than at the "Lower" and that at the property of the International Manganese and Chemical Company very little pyrolusite occurred.[3]

Genesis

The zones as outlined above show that the deposits consist of gossan containing very little manganese and, below the gossan, of manganese ore

[1] "On the Occurrence of Manganese at New Ross in Nova Scotia"; Can. Min. Inst., vol. 15, pp. 210-217 (1912).

[2] "Investigations in Nova Scotia and New Brunswick"; Geol. Surv., Canada, Sum. Rept. 1918, pt. F, p. 26.

[3] Fearing, F. C.: "Manganese Deposits of Lunenburg County, Nova Scotia"; Eng. and Min. Jour. Press, vol. 115, No. 1, p. 13 (1923).

which grades from highly oxidized manganese minerals near the surface to less oxidized minerals at depth. Kramm says:[1]

"The uniform character of the 4th zone, that is the depth at which probably no secondary alteration has taken place, suggests that the particular oxide of manganese which was deposited, is psilomelane and that limonite was deposited with it. . . . That carbonates were also deposited. . . .is shown by the presence of pseudomorphs . . . . . . .Changes of a secondary nature produced conditions as they are found at present. The oxide of manganese. . . .went into solution. The iron capping which is barren of manganese is a proof of the greater solubility of the manganese. Psilomelane, therefore, probably went into solution and was redeposited as "manganite".... A further oxidation....produced pyrolusite and accounts for the many pseudomorphs after manganite.....(Evidence that points to the derivation of the pyrolusite from psilomelane is the fact that even in the purest pyrolusite, chemical analysis shows) .....appreciable quantities of BaO which psilomelane contains and which.......... remained with the manganese ore through all its secondary changes."

Fearing says[2]

"The ore at the Upper mine is .... pyrolusite .... of unusual purity .... At.... (the Lower mine), the ore, although pure, is manganite, the lower oxide of manganese ......The amount of calcite is also notably greater.... The elevation of the outcrop is about 60 feet below that of the Upper mine. Evidently, conditions governing ore formation at the Lower mine were less strongly oxidizing than where a pyrolusite ore-body was created. At the...... International workings, the fissure filling consists of calcite and iron minerals with subordinate amounts of manganese oxides. Conditions governing ore formation here must have been far less oxidizing than in the other two deposits.... Increasing amounts of calcite in local individual workings indicate fading out of the ore (and), likewise, on a larger scale, a similar increase in the general abundance of this mineral at one property as compared with the others is accompanied by a decrease in oxidizing action and a corresponding lowering of the grade and relative amount of ore present....... At the bottom of the Lower mine shaft, 196 feet from the surface, the lead consists merely of partly altered porous granite......Commercial ore appears to have faded out rather suddenly near the 180-foot level.... the lead becoming more calcitic and ferruginous, with here and there a nodule of manganese.... At the Upper mine.... commercial ore vanishes quite suddenly 215 feet from the surface.... Below the 215-foot level, the lead is characterized by........ calcite and iron oxide, in which occasional..... ('niggerheads') of more or less impure manganese and iron ore occur...... The lower limits of both the Upper and the Lower mine ore-bodies are at nearly the same elevation above sea-level. Also, topographic conditions at the Upper mine could be expected to result in somewhat faster water circulation, and the presence of predominant pyrolusite is, therefore, not surprising. Nor is one to consider unusual the predominant manganite.... And the greater quantities of carbonate at the Lower mine, and still less remarkable is it to find mainly carbonate and comparatively little manganese oxide at the International......where local relief is down almost to the level of the swamps themselves, and where the circulation of underground water must be the most sluggish of all."

Hayes says,[3]

"The origin of the manganiferous calcite is not known, but secondary enrichment of the manganese oxides by action of surface water appears to be the immediate cause for the presence of workable ore-bodies. This is indicated by the replacement of calcite by pyrolusite in the pseudomorphs found in the International shaft and by the presence of botryoidal forms of manganese oxides in the ore from both the New Ross and Nova Scotia workings. The soft outcrop along the vein has

[1]Can. Min. Inst., vol. 15, p. 216 (1912).
[2]Eng. and Min. Jour. Press, vol. 115, No. 1, pp. 12, 13 (1923).
[3]Geol. Surv., Canada, Sum. Rept. 1918, pt. F, p. 28.

formed depressions on the surface which act as catchment basins for surface water at certain points, and thus marshy ground along a fissure appears to be favourable for underlying ore. Secondary enrichments from surface waters would tend to form ore-bodies at some distance below the surface in chutes which would be local and limited in depth. The ore tends to follow the zone of greatest weathering, and to diminish as unaltered parts of the vein are reached."

The evidence and opinions presented by Fearing, Kramm, and Hayes leave very little doubt that the manganese ore has resulted from downward-moving, manganese-bearing solutions enriching previously deposited minerals.

The source of the manganese in the veins has also been discussed at length.

Kramm found that the biotite in the granite contained manganese and concluded that surface weathering freed the manganese from the biotite and that this was the source of the manganese in the veins.

Wright discusses the origin of the manganese at considerable length. He states that the granite contains only 0·10 per cent MnO, which is approximately that of a normal granite. A composite analysis of a collection of specimens of the Precambrian rocks from several localities in Nova Scotia, however, yielded 1·18 per cent MnO. Yet even the Precambrian rocks with suitable fractures and with eleven times as much manganese as the granite, contain no veins of manganese ore similar to those of New Ross. Wright thus disposes of the theory that the biotite of the granite supplied the manganese and then considers two possibilities. (1) The manganese was derived from overlying or nearby manganese-bearing formations since removed by erosion. (2) The manganese was derived from hypogene solutions originating in the granite. According to this idea the vein consisted originally of rhodochrosite.

If the area had been overlain by the manganese-bearing limestones of Lower Carboniferous age (Windsor), the manganese might have leached directly down into fissures, or it might have collected as bog ores extending downward into the fissures. The Precambrian, early Palæozoic, and Triassic rocks also contain manganese, and if these rocks existed in a drainage basin draining over New Ross area they might be the source of veins of manganese ore. The veins as they were mined were the result of surface action on a previous vein, and in this surface action the iron and manganese oxides were separated to a notable degree, resulting in gossan of iron oxides and bands of iron oxides at various depths. If the original vein matter came from surface sources this separation would have been effected before the manganese and iron reached the vein. The result would be veins of pure manganese oxides or of pure iron oxides. In the New Ross veins, however, the separation is best near the surface where known secondary action has gone on almost to completion and much less marked in depth where oxidation is not complete.

The wall-rocks are to some extent replaced by manganese ore. Wright reviews the evidence and comes to the conclusion that the replacement of the type noted in the vein wall could have been effected only by descending solutions. He found no evidence of any wall-rock alteration of a hypogene type. The only mineral known to be of hypogene origin in the New Ross manganese veins is rhodochrosite and this mineral is known only from pseudomorphs. No pyrite or even sulphur has been detected in the veins, so that the iron present was probably originally an iron carbonate. After reviewing the literature to show that rhodochrosite is deposited only as a primary vein mineral, Wright concludes that the original vein matter in the New Ross veins consisted of carbonates of manganese and iron and was deposited from ascending or hypogene solutions.

J. A. Reid in a letter in criticism of Fearing's paper on the New Ross manganese ores states his belief that the original veins were manganiferous calcite veins of hypogene origin.[1]

Fearing shows that the weathered granite near the surface contains more manganese than it does at depth, which suggests that manganese has been added from some outside source. He also points out that although the biotite of the granite does contain manganese this mineral is in general unaltered even in the weathered granite. Having thus disposed of the biotite as a possible source, Fearing considers two possibilities. (1) The manganese was derived from older or younger rocks. (2) The manganese is a primary deposit from hypogene solutions.

In regard to the possible hypogene origin, Fearing says that one or more primary vein constituents should contain more manganese than the biotite of the granite, the latter being the only primary mineral in the New Ross area known to contain manganese, but vein matter that could possibly be classed as primary contains less than half as much manganese as the biotite. If the veins were primary they would contain quartz, sulphides, and probably various silicates, but they do not. There is no hypogene or thermal wall-rock alteration associated with the veins. Only a few feet below the general ore zone the fissures contain only granite very little altered, i.e., there is no vein of low-grade manganese or of any other material extending downward.[2] Fearing does not believe that Precambrian rocks could have been the direct source of the manganese in the deposits, but holds that the manganiferous Lower Carboniferous or Windsor limestone, which he assumes formerly overlay the New Ross area, was probably the source of the ores. The Windsor limestone contains nearly all the known deposits of manganese ore, other than bog deposits, in Nova Scotia.

The feldspars in the wall-rocks of the fissures have been attacked by solutions that first deposited $CaCO_3$ along fracture planes and later introduced iron and manganese oxides. The successive alteration is distinct and plainly in this order, and is clearly related to the fracture planes. At the International No. 2 workings similar secondary replacement of an earlier calcite by iron and manganese occurs, but this calcite contains some disseminated manganese oxide that may have been produced by later alteration. The intermittent character of the mineralizing conditions is well illustrated at this place where a calcite crystal shows eight growth layers. If the source of the ore was a manganese-bearing limestone the cause of the association of calcite and manganese ore in the veins would be apparent.

[1]Eng. and Min. Jour. Press, vol. 115, No. 7, p. 307 (1923).
[2]Fearing, F. C.: Eng. and Min. Jour. Press, vol. 115, No. 11, pp. 482, 483 (1923).

Quoting directly from Fearing's paper,

"While the manganese-bearing sediments . . . . were undergoing erosion and weathering, surface waters dissolved out their contained manganese, subsequently sank to the underlying surface of the granite . . . followed (its) drainage system . . . with . . . (which) a small portion of the fissures happened to be favourably located. Precipitation of the dissolved metals . . . took place at these favoured points along the fissures . . . Deposition of the metals occurred largely as carbonate, but some pure calcite was also formed. . . . As weathering continued to act the manganiferous vein matter became further concentrated and purified with each cycle of oxidation, solution and re-precipitation, as dioxide or sesquioxide, according to whether the conditions were more or less strongly oxidizing. As erosion advanced, conditions within the fissures became more and more like those found in bogs, and the deposit increased slowly in size and purity partly through the growth of nodules of manganese ore." [1]

Smitheringale made detailed optical examinations of a considerable number of carbonate specimens from the various dumps, and in all cases the refractive indices were those of calcite. These specimens included clear calcite, and carbonate varying from light to dark grey and various shades of brown and red. Even in those cases in which manganese oxides were replacing the carbonate, the latter mineral had the normal refractive indices of calcite. Chemical tests for manganese on carbonate specimens yielded manganese in all cases, the darker grey, brown, and reddish varieties giving the stronger reactions. From these observations it does not appear certain that either rhodochrosite or siderite exists in the veins as carbonate corresponding to their respective formulæ, but rather that a small but persistent amount of iron and manganese is present in the calcite as isomorphous mixtures. Smitheringale considers it probable that the original vein was of hypogene origin and consisted of calcium carbonate containing iron and manganese. The point brought out by Wright that if the ore came from the surface the original material should have been separated into veins of manganese oxide or of iron oxide has not been mentioned by other writers on the New Ross ores. Judging from such examples as the bog deposits at Dawson settlement, and at Canaan river, New Brunswick, one concludes that separation of iron and manganese does occur, but only in degree. Near the sources the bogs have considerably more iron than farther away, but the iron does not all occur near the source nor does all the manganese occur farther from the source than the iron. It should be noted as well that in the case of the bog deposits mentioned the separation took place at the surface under strong oxidizing conditions, where iron is almost immediately precipitated. If the iron and manganese were precipitated under a cover of limestone or other rock, either as carbonate or as oxides, they might not be so markedly separated as when deposited under strongly oxidizing conditions.

The present writer believes that in the discussion regarding the origin of the New Ross ores, Fearing has made the best case. The evidence presented by Fearing, however, does not point to a single definite source, but does point to a source rock that at one time overlay the deposits. This source could be inclusions of Precambrian rocks (inclusion of these rocks

[1]Eng. and Min. Jour. Press, vol. 115, No. 1, p. 15 (1923).

10 miles long and over a mile wide occurs $2\frac{1}{2}$ miles southeast of the deposits) or post-Devonian rocks. In either case the suggested source rocks have been removed by erosion.

Mining Practice

Wright[1] says, regarding the Nova Scotia Mining Company,

"The ore is sorted in the pit, loaded into skips, hoisted to the surface, ... where it is hand-picked, washed, and put in the dry room. The dry ore is . . . fed into a jaw crusher, ... (and then) by the aid of a series of separators and a centrifugal roll, is separated into five sizes, four of which are merchantable."

The ore was hauled to Chester Basin, a distance of 28 miles.

Future Possibilities

The ore cannot be expected to extend to depths greater than 250 feet in the vicinity of the New Ross manganese mines. The fault zones on which the mines are located may, however, extend for a considerable distance along the strike, and other fracture zones may exist as well. Any such fracture zone may be ore bearing. Faribault,[2] says

"Drift manganese has been found at many places in this section of country, lying between Wallaback, Dean and Chapter, Porcupine, and Baptist lakes, as much as 5 barrels having been found in one spot. This would indicate the presence of several veins not yet discovered and should encourage prospecting in this promising field."

Fearing[3], however, says,

"The outlook for finding new bodies of commercial manganese is considered discouraging. Except where ore has already been discovered, the outcrops of the known fissures are not favourably situated with respect to the topography and drainage system of the granite."

The Nova Scotia Manganese Company Mine

The vein at the mine of the Nova Scotia Manganese Company outcrops along the southeastern base of a granite scarp which strikes northeast. A bog covers the area southeast of the vein. The vein strikes northeast and dips steeply northwest. It was markedly lenticular and on the 155-foot level varied in width from 4 feet to about 6 inches. Individual ore-shoots were small and on this level ore-shoots over 2 feet wide were not over 40 feet long. Commercial ore did not extend for more than 250 feet along the strike, nor for more than 215 feet along the dip.

The ore was chiefly of the pyrolusite type and was very high grade. It was in most places well crystallized, but occurred to some extent in compact, dense masses. In places manganese ore was absent and the fissure was filled with iron oxides.

The granite walls in this mine were so decomposed that close timbering was necessary, and during mining, decomposed granite ran into several stopes.

The mine is developed by two shafts sunk on the vein about 120 feet apart. The main or more westerly shaft is 235 feet deep, and levels exist

[1]Geol. Surv., Canada, Sum. Rept. 1912, p. 388.
[2]Geol. Surv., Canada, Sum. Rept. 1908, p. 154.
[3]Eng. and Min. Jour. Press, vol. 115, No. 1, p. 15 (1923).

at 155 feet and 215 feet from the collar. The 155-foot level extends 170 feet northeast and 200 feet southwest from the shaft. The 215-foot level extends 180 feet northeast and 75 feet southwest from the shaft. The other shaft goes down to the 155-foot level. A 90-foot level has been driven 150 feet northeast from this shaft. Most of the available ore exposed by the workings has been stoped out.

The New Ross Mining Company Mine

The mine of the New Ross Mining Company is 2 miles southwest of the Nova Scotia mine, and is on a vein in a fault zone striking northeast, which is perhaps the same fault zone as that at the Nova Scotia mine. The vein is lenticular and in the shaft varied from 6 feet to a few inches in width. One side of the shaft showed a width of over 2 feet of ore for a depth of 45 feet. The vein pinches and swells abruptly, and at one place in the shaft a width of 4 feet narrowed to 4 inches in a distance of 5 feet. Commercial ore extended to a depth of 180 feet and for a distance of 180 feet along the strike.

The ore was chiefly steel-grey, massive manganite containing much pyrolusite 60 feet or less from the surface. At a depth of 70 feet the ore was mostly unaltered manganite.

The mine is developed by a shaft 196 feet deep and by levels 100 feet northeast and 135 feet southwest at 45 feet, 100 feet northeast and 150 feet southwest at 95 feet, and 20 feet northeast and 30 feet southwest at 165 feet.

The International Manganese and Chemical Company Mine

The International mine adjoins the New Ross mine on the southwest and the No. 1 or main shaft is only a quarter of a mile southwest of the New Ross mine workings. The vein at the International is in a fault zone striking northeast and dipping steeply northwest, and which is probably the same fault zone as that at the New Ross mine.

The vein consists of manganese oxides, calcite, and crushed granite. Pyrolusite, apparently pseudomorphous after calcite, occurred near the surface, but no commercial ore was discovered in development. Much of the calcite is black and contains manganese.

No. 1 shaft at the property is 100 feet deep and from the bottom drifts were driven 500 feet northeast to the New Ross Mining Company boundary and also some distance southwest. A second shaft 25 feet deep was sunk about a quarter of a mile north of No. 1 shaft, also on fault breccia, but it did not encounter ore.

CONQUERALL

Reference: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

The following description is taken from Smitheringale's manuscript.

Bog manganese occurs in the marshes and low ground on the farm of Arthur Hebb about 2 miles north of Conquerall station, Lunenburg county.

It is found as a layer varying in thickness up to 8 or 10 inches and is in a semi-consolidated state. The manganese is of very good quality for bog ore, yielding: 34·16 per cent manganese; 11·51 per cent iron; 4·53 per cent insoluble and silica.[1] A layer of calcareous material that forms a crust on the bedrock, slates and phyllites, immediately underlies the ore in most places. The two layers, i.e., bog ore and calcareous matter, are either in sharp contact with one another or are intermixed. This association suggests that the waters forming the bog deposits are carbonate solutions and that the manganese has been transported as a bicarbonate. In the flat or marshy places, opportunities were presented for the displacement of the weak carbonic acid, by stronger organic ores, with a resultant precipitation of the lime and manganese formerly held in solution.

On polished sections the ore exhibits beautiful colloform banding, and etching with various reagents gave no indication of crystalline texture. This suggests that the minerals were formed as aggregates of colloidal particles, and X-ray powder photographs substantiate this view. There are two minerals present but what they are is not known, and they are grouped under the general term "wad" or "bog manganese."

There are many occurrences of manganese in Nova Scotia concerning which little information is available. These occurrences are arranged in the following table:

	Location	Description	References
1	Cape Breton co., Gabarus.....	Bog manganese..............	Geol. Surv., Canada, Mem. 74, p. 234 (1915)
2	Cape Breton co., Boisdale, Fox brook	A mixture of bog manganese and bog iron occurs in an irregular surface layer 2 feet thick in marshy land	Geol. Surv., Canada, Rept. of Prog. 1876-77, p. 450
3	Cape Breton co., Beaver Cove	Bog manganese..............	Smitheringale, Wm. V.: manuscript
8	Cape Breton co., 2 miles east of the head of loch Lomond	Specimen containing pyrolusite and manganite assayed 81·52 per cent MnO_2. Specimen of pyrolusite contained 88·98 per cent MnO_2 and 0·21 per cent Fe_2O_3	Geol. Surv., Canada, Rept. of Prog. 1879-80, pt. H, pp. 17, 18
9	Cape Breton co., 3 miles from Big Pond, along L'Ardoise road	Pyrolusite float reported......	Geol. Surv., Canada, Rept. of Prog. 1876-77, p. 450
10	Richmond co., Toms brook, 2 miles east of Hay Cove	Manganese-bearing nodules in clay	Smitheringale, Wm. V.: manuscript
11	Richmond co., Salem road....	In a quarry in Lower Carboniferous limestone pockets of manganese ore were encountered and mined in 1897	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 154 (1907)

[1]Assay of Mines Branch, Dept. of Mines, Ottawa, Canada.

	Location	Description	References
12	Richmond co., Grand Mira at head of Lewis bay	Sample of bog manganese consisted of dark brown friable lumps. After moisture loss of 22·22 per cent at 100°C. residue contained 44·99 per cent MnO_2 and 12·25 per cent insoluble	Geol. Surv., Canada, Ann. Rept., vol. II, pt. T, p. 19 (1887)
13	Richmond co., Bras d'Or lake, Soldier Cove	Specimen containing manganite and limonite assayed 36·64 per cent manganese and 18·72 per cent iron	Geol. Surv., Canada, Ann. Rept., vol. XIII, pt. R, p. 63 (1903)
14	Inverness co., Cheticamp......	Manganese occurs in workable quantities	Geol. Surv., Canada, Ann. Rept., vol. IX, pt. S, p. 80 (1898)
15	Guysborough co., near Goshen	Bog manganese..............	Geol. Surv., Canada, Ann. Rept., vol. II, pt. P, p. 118 (1887)
16	Antigonish co., near Lochaber.	Bog manganese..............	Geol. Surv., Canada, Ann. Rept., vol. II, pt. P, p. 118 (1887)
17	Antigonish co., Pomquet river. Below J. Chisholm's house	A deposit of bog manganese occurs near salt springs	Geol. Surv., Canada, Ann. Rept., vol. II, pt. P, pp. 105, 118 (1887)
18	Antigonish co., on telegraph road near Afton	Bog manganese..............	Geol. Surv., Canada, Ann. Rept., vol. II, pt. P, p. 118 (1887)
19	Antigonish co., east bank of Gould ck. ½ mile south of Morristown	A test pit was sunk in 1910 on a vein reported to contain manganese ore	Geol. Surv., Canada, Sum. Rept. 1920, pt. E, p. 13
20	Antigonish co., near head of Ohio	Large pieces of pyrolusite occur as drift on a hill	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
21	Pictou co., Sutherland brook just above East River St. Marys	Bog manganese occurs as nodules in soil	Geol. Surv., Canada, Ann. Rept., vol. II, pt. P, p. 118 (1887)
22	Pictou co., hill south of railway west of Piedmont station	Bog manganese occurs as nodules in soil	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 58 (1907)
23	Pictou co., East river, Cameron brook	Concretion of bog manganese..	Geol. Surv., Canada, Ann. Rept., vol. V, p. 183 (1893)
24	Pictou co., hill south of Bridgeville	Manganite yielding beautiful specimens and boulders and concretions of psilomelane and wad occur associated with the limonite iron ores. Export of manganese ore from Bridgeville was 60 tons in 1885	Geol. Surv., Canada, Ann. Repts.: vol. XV, pt. S, p. 158 (1907); vol. V, p. 183 (1893); vol. III, pt. A, pp. 38, 39 (1889). Dept. of Mines of Nova Scotia, "Economic Minerals of Nova Scotia", 1903, p. 29. Dept. of Mines of Nova Scotia, 1885, p. 72

	Location	Description	References
25	Pictou co., Springville.........	Psilomelane and manganite occur in the iron ores. Analyses of two limonite ores showed 62·95 per cent manganese oxide and 14·41 per cent manganese peroxide. A shipment of 37 tons of manganese ore was made in 1890	Geol. Surv., Canada, Ann. Rept., vol. V, pt. S, p. 98 (1893). Can. Min. Rev., vol. XXII, No. 10, p. 204 (1903). Dept. of Mines of Nova Soctia, 1890, p. BB
26	Pictou co., East river, Rear brook, Alma bridge	A small quantity of pyrolusite occurs in a conglomerate	Geol. Surv., Canada, Ann. Rept., vol. XIV, pt. M, p. 28 (1906)
27	Pictou co., on a branch of Middle river above Glengarry	Several test pits have been sunk on a small deposit of bog manganese 6 inches to 1 foot thick	Geol. Surv., Canada, Ann. Repts.: vol. V, pt. P, p. 183 (1893); vol. III, pt. A, p. 38 (1889)
28	Pictou co., Grant brook.......	Bog iron ore in a bed 1 foot thick contains psilomelane	Geol. Surv., Canada, Ann. Rept., vol. V, pt. P, p. 176 (1893)
29	Pictou co., West River........	Manganese is associated with iron deposits	Geol. Surv., Canada, Ann. Rept., vol. III, pt. A, pp. 38, 39 (1889)
30	Pictou co., Glengarry..........	Manganese is associated with iron deposits	Geol. Surv., Canada, Ann. Rept., vol. III, pt. A, pp. 38, 39 (1889)
31	Pictou co., Gairlock...........	Manganese is associated with iron deposits	Geol. Surv., Canada, Ann. Rept., vol. III, pt. A, pp. 38, 39 (1889)
32	Pictou co., Lorne.............	Manganese is associated with iron deposits	Geol. Surv., Canada, Ann. Rept., vol. III, pt. A, pp. 38, 39 (1889)
33	Pictou co., Blanchard.........	Manganese is associated with iron deposits	Geol. Surv., Canada, Ann. Rept., vol. III, pt. A, pp. 38, 39 (1889)
34	Pictou co., Sutherland river...	Manganese is associated with iron deposits	Geol. Surv., Canada, Ann. Rept., vol. III, pt. A, pp. 38, 39 (1889)
35	Pictou co., French river.......	Manganese is associated with iron deposits	Geol. Surv., Canada, Ann. Rept., vol. III, pt. A, pp. 38, 39 (1889)
36	Halifax co., Jeddore...........	Wad occurs in superficial deposits and was at one time shipped to England	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907). Geol. Surv., Canada, Mem. 20E, p. 292 (1912). "Mineralogy of Nova Scotia," by How, pp. 110-126 (1868)
37	Halifax co., Ship Harbour.....	Pyrolusite occurs as veinlets in granite	Geol. Surv., Canada, Ann. Rept., vol. IX, pt. S, p. 80 (1898)
38	Halifax co., Musquodoboit....	Pyrolusite....................	Geol. Surv., Canada, Ann. Rept., vol. IX, pt. S, p. 80 (1898)

	Location	Description	References
42	Colchester co., Salem river, Henry Christie's millbrook	Red quartzite and argillite underlying Triassic rocks hold numerous veins of white crystalline quartz containing traces of crystalline pyrolusite	Geol. Surv., Canada, Ann. Rept., vol. V, pt. P, p. 44 (1893)
43	Colchester co., North river of Truro	Messrs. McLellan and Archibald prospected for the source of boulders of good manganese ore. They obtained 15 tons and shipped 6 tons of good manganese ore. They found several manganese-bearing veins	Dept. of Mines of Nova Scotia, 1881, pp. 17, 56
47	Cumberland co., Springhill....	Boulders and concretions of psilomelane, manganite, and wad occur associated with iron ore deposits	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
48	Cumberland co., Minudie......	Small quantities of soft, fine-grained pyrolusite were obtained from Lower Carboniferous limestone	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
49	Cumberland co., Amherst.....	Manganese occurs in Lower Carboniferous limestone	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
50	Cumberland co., Springhill....	Bog manganese occurs in superficial deposits	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
51	Cumberland co., Joggins.......	Specimen of manganiferous calcite from Cumberland seam gave an analysis 2 per cent $MnCO_3$	Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. G, p. 38.
52	Cumberland co., Parrsboro ...	Veinlet of pyrolusite, psilomelane, and other manganese oxides occur in Triassic volcanics	Smitheringale, Wm. V.: manuscript
53	Colchester co., Lower Five Islands	Thin seams and small pockets of psilomelane exposed in volcanics, red sandstones, and shales of Triassic age. It is reported that several barrels of ore were mined at this place many years ago	Smitheringale, Wm. V.: manuscript
54	Colchester co., Lower Economy	Several barrels of fine crystalline pyrolusite were obtained in 1891 from Carboniferous rocks	Geol. Surv., Canada, Ann. Rept., vol. VI, pt. A, p. 61 (1895)
55	Colchester co., Londonderry iron mines	The brown hematite contained an average of 1½ per cent manganese. Locally through secondary action the proportion of manganese has been increased up to 14 per cent MnO_2	Gilpin, E.: Roy. Soc., Canada, vol. 2, sec. 4, p. 78. Smitheringale, Wm. V.: manuscript

	Location	Description	References
56	Colchester co., Cobequid bay, Moose cove, Bear brook	Red quartzite and shale of Carboniferous age contain stringers of calcite and manganese ore	Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 63 (1895)
57	Colchester co., half a mile south of Clifton	Bog iron deposit contains manganese	Dawson, J. W.: "Acadian Geology," pp. 238, 239 (1855)
59	Colchester co., Maitland.......	One ton of manganese ore mined in 1887	Dept. of Mines of Nova Scotia, 1887, p. 61
60	Colchester co., near Clifton at mouth of Shubenacadie river. Black Rock mine	Manganese deposit of a ferruginous and magnesian nature occurred in limestone	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 157 (1907)
61	Colchester co., Rawden.......	Manganite has been found.....	Geol. Surv., Canada, Ann. Rept., vol. IV, pt. T, p. 44 (1891)
62	Halifax co., half-way between South Uniacke and Fennerty	Stringers in sandstone and shale yielded 100 pounds of pyrolusite in 1858	How, H.: "Mineralogy of Nova Scotia" (1868)
63	Halifax co., Mount Uniacke....	Pyrolusite occurs in small pockets and veins in granite and quartzite	Geol. Surv., Canada, Mem. 20E, p. 292 (1912)
64	Halifax co., Fennerty, 19 miles north of Halifax	Area prospected in 1858. Pyrolusite occurs in whin or granite in pockets containing as much as 100 pounds and assaying up to 70 per cent MnO_2	Geol. Surv., Canada, Mem. 20E, p. 292 (1912). "Mineralogy of Nova Scotia," by How, pp. 110-126 (1868)
65	Halifax co., St. Margaret bay.	Manganese is reported.........	Geol. Surv., Canada, Mem. 20E, p. 292 (1912)
80	Hants co., East Noel near Dinsmore mills	Small stringers of pyrolusite in Horton sandstone yielded about a ton of ore in 1880 from a shaft 25 feet deep	Smitheringale, Wm. V.: manuscript
81	Hants co., Minasville, property of John Wright	Manganite occurs in cracks in Horton sandstone and shale. A small amount of ore was mined between 1887 and 1902	Smitheringale, Wm. V.: manuscript
82	Hants co., 1¼ miles southwest of Minasville	Pyrolusite and manganite occur in joints in buff-coloured Windsor limestone. Developed in 1887 by Capt. Scott and known as the Scott mine. Purchased by Wm. Hughes in 1924	Smitheringale, Wm. V.: manuscript
83	Hants co., 1¼ miles west of Minasville	Stringers of manganese oxides in steeply dipping sandstone and shale of Horton age. Developed by Mr. McVicar in 1891, who is said to have recovered 3 tons of ore. Property known as Morton Reynolds	Smitheringale, Wm. V.: manuscript

	Location	Description	References
84	Hants co., ¾ mile southwest of Walton and a few hundred feet east of Stephens mine	It is reported that good crystalline manganese ore was obtained from a shaft	Smitheringale, Wm. V.: manuscript
85	Hants co., near sugar woods...	Bog manganese occurs and 100 tons have been mined but none shipped	Smitheringale, Wm. V.: manuscript
86	Hants co., near burnt barren...	Bog manganese occurs on the McDougal property	Smitheringale, Wm. V.: manuscript
87	Hants co., 1 mile northeast of Walton on south bank of Whale creek	Manganese stain occurs in joints in Windsor limestone. Old open-cuts	Smitheringale, Wm. V.: manuscript
88	Hants co., 1 mile northeast of Walton on north side of Whale creek	Knob of thinly laminated Windsor limestone striking north 35 degrees east magnetic and dipping 30 degrees northwest. Tunnel 80 feet long exposes veinlets of pyrolusite in the limestone	Smitheringale, Wm. V.: manuscript
89	Hants co., on sea cliffs 1 mile northeast of Walton	A small quantity of manganese ore has been taken from narrow veinlets in shales of Horton age	Smitheringale, Wm. V.: manuscript
90	Hants co., ½ mile west of plaster quarries at Walton	Manganese ore has been reported in workings known as "Jennison pit" at the contact between Windsor limestone and rocks of Horton age	Smitheringale, Wm. V.: manuscript
91	Hants co., at McLennan meadow near Tennycape	Bog manganese occurs in a swamp	Smitheringale, Wm. V.: manuscript
92	Hants co., in Minas basin ¼ mile from the shore at Cheverie	Crystalline pyrolusite occurs as stringers in grit, red shale, and limestone, seen as small rock knobs at low tide	Smitheringale, Wm. V.: manuscript
93	Hants co., at two places ¼ mile and 1 mile south of Kennetcook corner	Manganese float found in ploughed land	Smitheringale, Wm. V.: manuscript
94	Hants co., on shore road east of Noel river at Peter Stevens'	One ton of crystalline pyrolusite was mined from a vein in white, flinty, quartzose Carboniferous sandstone. Shaft 30 feet deep	Geol., Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 63 (1895)
95	Hants co., Rainy cove on west side of Walton river	Manganese ore on the surface was washed and hand-picked. Two contiguous manganese-bearing veins, 3 and 4 inches wide, occur at this place and were being developed by Mr. R. Kennedy in 1876	Dept. of Mines of Nova Scotia, 1877, p. 47
96	Hants co., Walton, Lantz mine	Fine specimens of pyrolusite were found in several shallow pits in limestone	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 156 (1907). Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 64 (1895)

	Location	Description	References
97	Hants co., 100 yards west of road between Noel and Kennetcook, 50 yards south of J. Hennigar's house	A pit exposes soft sandstone, probably carboniferous, and numerous calcite veins with threads and specks of pyrolusite in a reddish and grey rock. Limestone and gypsum occur in the vicinity	Geol. Surv., Canada, Ann. Rept., vol. V, pt. P, p. 97 (1893)
98	Hants co., head of Bass creek..	Bog manganese................	Geol. Surv., Canada, Ann. Rept., vol. VI, pt. AA, p. 65 (1895)
99	Kings co., near Wolfville......	Pyrolusite occurs in small masses and stringers in slates of Carboniferous age	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
100	Kings co., Greenwich, 3 miles south of Wolfville	One ton of mixed psilomelane and pyrolusite ore was taken from a hard, siliceous rock in 1864	Geol. Surv., Canada, Mem. 20E, p. 292 (1912). "Mineralogy of Nova Scotia", by How, pp. 110-126 (1868)
101	Kings co., Beech Hill, 2 miles south of Kentville	Small patches of bog manganese ore associated with ochre. How says that 400 tons of mixed bog manganese and iron were shipped to the United States for manufacture of paint and glass	"Mineralogy of Nova Scotia", by How, pp. 110-126 (1868). Dept. of Public Works and Mines of Nova Scotia, 1923, p. 213
104	Queens co., on farm of Almond Parks at Pleasant River	Bog manganese occurs in deposits up to 8 inches thick	Smitheringale, Wm. V.: manuscript
106	Lunenburg co., Lahave.........	Bog manganese reported.......	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
07	Lunenburg co., Chester........	Bog manganese reported.......	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 158 (1907)
108	Lunenburg co., Bridgewater...	Ochre contains up to 11 per cent MnO_2	Geol. Surv., Canada, Mem. 20E, p. 292 (1912)
109	Lunenburg co., Chester Basin..	Ochre contains up to 20 per cent MnO_2	Geol. Surv., Canada, Mem. 20E, p. 292 (1912)
110	Shelburne co., between Shelburne and Sandy point on east side of Shelburne harbour	Bog iron and bog manganese reported as found in digging wells	Faribault, E. R.: Geol. Surv., Canada, Sum. Rept. 1917, pt. F, p. 19
111	Shelburne co., Shelburne......	Manganese is reported.........	Geol. Surv., Canada, Mem. 20E, p. 292 (1912)

NEW BRUNSWICK

ALBERT VILLAGE

Reference: Ingall, E. D.: Geol. Surv., Canada, Ann. Rept., vol. VI, pt. S, p. 88 (1895).

The following account was given by Ingall. About 2½ miles west of Albert village and north of the main road to Alma a property under lease to C. J. Butcher, *et al*, of Moncton, was being actively prospected for manganese with but slight success. Several test-pits have been sunk, in some of which small quantities of high-grade ore have been found. On the southern limit of the lease a large body of ore was opened up some years ago and a considerable quantity extracted and shipped. This fact, combined with the prevalence of large masses of "float" manganese to the northward and higher up the hill, led the lessee to undertake the present operations. The rocks of the vicinity are sandstone interstratified with limestone, in which latter it is expected will be found paying quantities of ore. The ore so far found is high-grade pyrolusite with manganite.

MEMEL MINE

References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Gwillim, J. C.: "Manganese in New Brunswick and Nova Scotia"; Mun. Res. Comm., Canada, Final Report, pp. 59, 60 (1920).

The Memel mine is on the west side of Sawmill creek, about 1½ miles from Hopewell Hill post office, Albert county. A little manganese ore, chiefly pyrolusite, was shipped from the mine many years ago.

Smitheringale says that the country rock is reddish conglomerate of Carboniferous age, dipping northwest, and is very similar in general appearance to that at Shepody mountain. He also says that the manganese oxides are psilomelane and pyrolusite and that they occur as pebbles in the conglomerate and appear to have been incorporated into it in the same manner as the rock pebbles.

The workings, consisting of open-cuts and two very short tunnels, are badly caved and do not expose very well the manganese-bearing conglomerate. Gwillim says that conglomerate beds adjacent to the one from which the ore was taken contain nodules of manganese ore about as big as walnuts and that these constitute about one-half of one per cent of the rock. He suggests that some beds may contain more manganese and may even be rich enough to mine from surface workings.[1]

SHEPODY MOUNTAIN

Main References: Smitheringale, Wm. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Bailey, L. W.: "The Mineral Resources of the Province of New Brunswick"; Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 54, 55 (1899).

[1] Mun. Res. Comm., Canada, Final Rept., p. 60 (1920).

Minor References: "The Minerals of New Brunswick"; Can. Min. Jour., vol. L, No. 8, p. 171 (1929).
Mun. Res. Comm., Canada, Final Rept., p. 59 (1920).
Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, p. 61.
Geol. Surv., Canada: Pub. No. 983, pp. 97, 98 (1907); Ann. Rept., vol. XV, pt. S, pp. 163, 164 (1907); Ann. Rept., vol. V, pt. S, p. 96 (1893); Ann. Rept., vol. I, pt. E, p. 35 (1886); Rept. of Prog. 1878-79, pt. D, p. 24; Rept. of Prog. 1877-78, pt. D, p. 11; Rept. of Prog. 1870-71, p. 224.

The Shepody Mountain manganese mine, known in the early days as the Hopewell manganese mines, is on the "Chemical road" about 3 miles from Hopewell hill, Albert county. The deposit is on the west side of Shepody mountain.

According to Bailey, the mine was first opened about 1860 by Mr. Steadman of Hopewell who mined and shipped 500 tons of ore to England and the United States.[1] The mine was worked for only a few years. Nothing more was done until 1926 when J. C. Wright and B. J. Fales did some surface work and started a shaft.

Smitheringale states that the lower part of Shepody mountain is composed of chlorite schists and the upper part of conglomerate, sandstone, shale, and limestone of Lower Carboniferous age. Near the mine the chlorite schists are overlain by thinly laminated limestone which is overlain by a thin bed of reddish clay. The clay is overlain by conglomerate containing pebbles of igneous and sedimentary rocks. The sediments appear to dip 45 degrees into the hill. The workings, which are mainly tunnels, are now inaccessible and ore in place can not be seen.

Bailey states that the ore occurred in veins and beds and that the beds were up to 5 feet thick.[1]

The earlier reports referred to above merely state that the ore occurred at the base of the Lower Carboniferous conglomerate. Smitheringale says that Mr. Fales, who worked in the mine when it was producing ore, states that the ore occurred as nodules in a red to greyish, sticky clay between the limestone and the conglomerate. A little ore was also found as streaks in the limestone but was not mined. The clay occurred as circular or elliptical pockets thinning at the edges to narrow seams which connected with other clay pockets. Some large masses of manganese ore also occurred in the clay. In the shaft that was sunk in 1926 the red clay can be seen and it there contains nodules of manganese.

Smitheringale collected manganese specimens showing two types of ore occurrence: (1) replacement of limestone; and (2) manganese nodules in clay. The limestone containing manganese is finely laminated and the alternate laminæ show various degrees of replacement by pyrolusite. The nodular masses in clay are as much as 8 inches in diameter and on being broken show a vesicular and drusy structure. Botryoidal prominences on nodules, on being broken show a drusy interior of fine, interlocking grains of pyrolusite. Some such druses contain only a very small quantity of pulverulent material, and others contain a core separated from the outer

[1]Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 55 (1899).

shell and consisting of a porous, crumpling mass of pyrolusite. Remnants of limestone occur in the clay and some of these are cellular. The walls of the cellular openings are in some places encrusted and in other places partly replaced by manganese oxides. Specimens suggest that the ore consisted chiefly of pyrolusite and manganite. The manganite occurs as residual remnants in pyrolusite.

Smitheringale suggests that the clay, and its contained nodules of manganese ore, between the laminated limestone and the conglomerate may have been derived from the underlying limestone by weathering. According to this idea the manganese occurred as nodules, etc., in the limestone; the limestone was subjected to weathering in Lower Carboniferous time and the nodules were freed, concentrated, and embedded in surface clays. The clays were then covered by gravels which later became hardened and cemented into conglomerate.

The old workings consist of an incline shaft 250 feet long on a slope of 45 degrees, an adit 1,000 feet long joining the bottom of the shaft, and numerous crosscuts and drifts driven from the shaft, totalling about 1,800 feet of underground work. New developments consist of a trench and a shallow shaft.

Gwillim suggests that the contact between the conglomerate and the limestone in other places in the vicinity may contain ore-shoots similar to those mined.[1]

DAWSON SETTLEMENT

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: "Bog Manganese Deposits, Dawson Settlement, Albert County, N.B."; Mun. Res. Comm., Canada, Final Rept., pp. 79-88 (1920).

Denis, T. E.: "Investigation of some Manganese Ore-Deposits in Nova Scotia and New Brunswick"; Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, pp. 61, 62.

Ingall, E. D.: "Mineral Statistics and Mining"; Geol. Surv., Canada, Ann. Rept., vol. XI, pt. S, p. 107 (1901).

Bailey, L. W.: "The Mineral Resources of the Province of New Brunswick"; Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 55-57 (1899).

Uglow's report includes plans and cross-sections of the deposits and a photograph of the old briquetting and smelting plant. Bailey's report includes a photograph of a bog manganese deposit.

Minor References: Dept. of Lands and Mines of New Brunswick: 70th Ann. Rept., 1930, p. 48; 69th Ann. Rept., 1929, p. 57; 68th Ann. Rept., 1928, p. 59.

Ann. Rept. of the Crown Land Dept. of New Brunswick: No. 63, 1923, p. 61; No. 58, 1918, pp. 16, 17.

Geol. Surv., Canada: Sum. Rept. 1915, p. 182; Pub. No. 983, pp. 98, 99; Ann. Rept., vol. XV, pt. S, pp. 164-166 (1907); Ann. Rept., vol. XIII, pt. S, pp. 85, 86 (1903); Ann. Rept., vol. XII, pt. A, p. 156 (1902); Ann. Rept., vol. X, pt. A, p. 95, pt. S, p. 125 (1899); Ann. Rept., vol. V, pt. AA, pp. 51, 62, pt. S, pp. 96, 97 (1893); Ann. Rept., vol. IV, pt. R, p. 68, pt. S, p. 52 (1891); Ann. Rept., vol. III, pt. S, p. 44 (1889).

The Dawson Settlement manganese deposits are in Albert county, half a mile south of Dawson settlement and 5½ miles northwest of Hills-

[1] Mun. Res. Comm., Canada, Final Rept., p. 59 (1920).

borough. The deposits are less than 1½ miles from the Salisbury and Harvey branch of the Canadian National railway and are connected by road with Stony Creek crossing on the railway. About 1897 a spur track was constructed from the deposits to the railway, but now only the grade is left.

The deposits began to attract attention in 1887, in which year a trial shipment of ore was made. In 1890, the property, then known as the Duffy, was taken over by the Crimora Manganese Company, but soon abandoned and later reopened by the Mineral Products Company of New York. The ore was dried in kilns and shipped for the manufacture of ferromanganese, but owing to its pulverulent state caused a great deal of trouble in the furnaces and was, therefore, unsatisfactory. In 1897, the Mineral Products Company built a drying and briquetting plant at the property and shipped the briquetted ore to Bridgeville, Nova Scotia, where it was used by the Preston Charcoal Iron Company in the manufacture of ferromanganese. In 1900, owing to an accident at the furnaces, operation ceased and the ore has not since been used for the manufacture of ferromanganese. In recent years the ore has been used as a colorizing agent in the brick trade.

The following information was supplied by Mr. Blight of Hillsborough, N.B. At present (1928) the ground is held by F. M. Thompson and associates of Hillsborough. In 1922, 1923, 1924, and 1927 Mr. Thompson shipped bog ore to the National Brick Company of Laprairie, Laprairie, Que. In 1926 small shipments were sent to the National Sales Corporation, Cincinnati, Ohio, U.S.A., and in 1926 and 1927 a small amount was sent to the St. Lawrence Brick Company, Montreal, Que. About 1,875 tons have been shipped to these companies and the ore was shipped without preliminary treatment.

The Deposits

The bogs are on a gentle slope on the south side of Hopper creek, which flows east into Weldon creek. The ground rises with a gradient of 9 to 14 per cent to a height of 250 feet above the creek. The lower extremities of the bogs are in general about 20 feet above the level of the creek and the upper extremities, 600 to 800 feet farther south, are about 90 feet higher.

The bedrock in the vicinity of the deposits is drift covered, and the reports dealing with these manganese deposits make no mention of the geology of the district. The district has, however, been mapped geologically by Wright and, judging from the map accompanying his geological report, the deposit is at the contact between zone 2 of the Petitcodiac series (Millstone Grit) and the underlying zone[1] of the Petitcodiac series. The rocks are nearly horizontal, but have a general northerly dip. The contact is at least slightly unconformable. The upper series consists of fine- to coarse-grained sediments having a total thickness of 300 feet, and the lower series contains limestone as well as clastic sediments.[2]

[1]According to W. A. Bell zone 1 is now correlated with the Upper Windsor series.
[2]Wright, W. J.: "Geology of the Moncton Map-area": Geol. Surv., Canada, Mem. 129 (1922).

Wright[1] says that three bog deposits are present. Uglow has made detailed examinations of two and the following is quoted from his report.

"The manganese bogs are situated for the most part below the orifices of a series of mineral springs, from which the manganese has been, and is yet being, deposited. The upper limits of the bogs lie in places 50 to 100 feet up the slopes above the present mouths of the springs . . . . The manganese deposits are somewhat fan-shaped, spreading out from a point slightly above the mouths of the springs and with their thickest portions within a few feet of the mouths . . . Laterally, and at the lower extremities of the bogs . . . (the deposits) gradually pinch to nothing . . . . (They) are consequently like blisters or laccoliths, which have arched the soil upward and made room for themselves between the hard bottom and the grass roots.

The bogs, by which is meant all the material between the grass roots and the bottom of sand, gravel, or clay, vary in thickness from less than a foot to upwards of 15 feet. The greatest depth found during this investigation was 15 feet, although it is reported that depths of 25 and 30 feet were encountered in the course of boring operations some years ago. This discrepancy may be accounted for by the fact that the hard bottom is of a rolling character, and some of the bore-holes showing the greatest depth may have gone down into local depressions in the foot-wall . . . . .

The deposits consist of a (soggy) mixture of manganese dioxide, presumably pyrolusite, and the bog iron or limonite. Both minerals occur in the form of an impalpable powder, sometimes intimately mixed, sometimes forming separate bands more or less pure. Large quantities of peat are commonly associated with the ore. In some parts of the bogs the manganese dioxide is confined to a relatively pure layer immediately beneath the veneer of vegetation, followed in depth by a bed of peat down to the sandy or clayey bottom. In other places the wad occurs throughout the whole thickness of the peat bog, and in this form it is usually mixed with a considerable quantity of bog iron.

Analyses show that the manganiferous material from these bogs carries from 60 to 85 per cent moisture (at 110° C.), and that the remaining 15 to 30 per cent of dry material carries from 16 to 70 per cent of peat, which is lost on ignition. Even the best grade of ore in its natural state seldom carries more than 10 per cent of manganese.

The water from the springs has apparently deposited manganese dioxide on top of the original surface of sand, gravel, and clay, by a process of oxidation or bacterial action . . . . Manganese dioxide and limonite are still being deposited by the springs, and the continuance of this process is causing knolls of ore to be built up in close proximity to the orifices, thereby increasing the length of the upward journey of the ore depositing waters through previously deposited wad and bog iron."[2]

Ore was shipped from the property first in 1887, but no figures of production are available except for recent years. It is probable that the property was idle for at least half the time from 1887 to 1900, when mining ceased until 1922. The production in 1898 was 600 tons. Mr. Blight stated to Smitheringale that 1,875 tons were mined from 1922 to 1927. The production in 1928 was 380 tons; in 1929, 300 tons; and in 1930, 275 tons.[3]

When the ore was first mined trenches were dug across the bog to drain it and the material was then removed by shovelling and placed in drying kilns. The dry ore was, however, too powdery for use in steel furnaces. Later the dried material was made into briquettes. In this process the ore was ground and screened to a suitable size. The powder was then mixed with a suitable binder and made into briquettes 3 inches in diameter by 2½ inches long. All the ore that has been mined has been taken from drainage trenches or large open pits.

[1]Geol. Surv., Canada, Sum. Rept. 1915, p. 182.
[2]Mun. Res. Comm., Canada, Final Report, pp. 80, 81 (1920).
[3]Ann. Rept. of the Dept. of Lands and Mines of New Brunswick.

Uglow has estimated the tonnage of manganese ore in the two bogs as 42,690 tons, and the area is 9·6 acres.[1] This estimate is for crude wet ore with an average manganese content of about 7 per cent. The weight per cubic foot is approximately 70 pounds. About twenty years prior to the date of Uglow's estimate Bailey made an estimate of 173,176 tons of ore. He used the same weight per cubic foot, but based his estimate on an area of 17 acres and a greater supposed thickness of bog ore.[2]

Uglow[3] says,

"The bogs have well-defined, hard, compact, foot-walls, from which in most cases the material can readily be separated by shovelling or scraping. Care should be taken to avoid the inclusion of any of the foot-wall material with the ore, on account of its high content of silica. As a rule the grass and tree roots lie upon the manganese layer and are not embedded in it. This facilitates the stripping of the deposits. No boulders or pebbles have been found within the manganiferous zones. Wherever the manganese dioxide occurs in relatively pure beds, it can be readily separated from the underlying peat by shovelling."

The following table summarizes the information given by Uglow regarding tonnage and assays. "Moisture per cent" is the percentage of moisture in the wet ore completely driven off at 110 degrees C. Tonnage of dry ore is obtained by subtracting the moisture from the tonnage of wet ore. This is shown in the following example. Bog 2 contains 20,320 tons of wet ore with a moisture content of 73·20 per cent. This percentage amounts to 14,874 tons of moisture and by subtracting this total from 20,320 there remains 5,446 tons of dry ore. "Loss on ignition" is the percentage loss in weight when dry ore is ignited to burn off peaty material. The tonnage of ignited ore is obtained by subtracting the "Loss on ignition" from the tonnage of dry ore.

—	Crude wet ore				Dry ore				Ignited ore		
	Tons	Mn, per cent	Fe, per cent	Moisture, per cent	Tons	Mn, per cent	Fe, per cent	Loss on ignition, per cent	Tons	Mn, per cent	Fe, per cent
Bog No. 1....	22,370	6·98	6·74	65·68	7,677	20·33	19·65	29·19	5,436	28·71	27·75
Bog No. 2....	20,320	6·96	2·80	73·20	5,446	29·98	10·44	37·415	3,408	41·51	16·68
Total.......	42,690	......	......	....	13,123	....	....	....	8,844	......	....
Average per cent........	....	6·97	4·77	69·44	....	25·155	15·045	33·302	......	35·16	22·215

[1]Mun. Res. Comm., Canada, Final Report, p. 84 (1920).
[2]Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 55-57 (1899).
[3]Mun. Res. Comm., Canada, Final Report, p. 88 (1920).

The following table gives partial analyses of two springs. Spring No. 1 issues from bog No. 1 and spring No. 2 from bog No. 2. Both springs are cold. Through a misunderstanding the samples were not tested for manganese:

—	Spring No. 1 (parts per million)	Spring No. 2 (parts per million)
Sodium chloride	23	23
Sodium sulphate	43	43
Calcium bicarbonate	46	46
Carbonic acid (free)	2·6	2·5
Oxide of iron and alumina	Trace	Trace
Silica	Trace	Trace
	114·6	114·5

The following table shows an analysis of filtered water from the springs:

	(Parts per million)
Potassium	None
Sodium	Trace
Iron as Fe_2O_3	3
Alumina	3
Manganese	12
Calcium	21·4
Magnesium	None
Sulphuric acid, SO_4	33
Bicarbonic acid, HCO_3	49·9
Chlorine	Trace
Silica	1·8
Total	124·1

All the water analyses were done by the Mines Branch, Dept. of Mines, Canada.

The interesting fact that in bog deposits the proportion of manganese to iron increases with the distance from the source of the material is brought out clearly by analytical data presented by Uglow. In several instances he sampled the deposit at intervals along lines passing close to the orifices of springs. In one case six samples taken at intervals of 100 feet along a line passing near the orifice of a spring and continuing down hill gave the following results when assayed:

Mn, per cent	Fe, per cent
18	30
3	32
13	5
47	20
42	11
55	5

In another instance the analyses of samples taken at 100-foot intervals along a line passing close to a spring, gave the following results.

Mn, per cent	Fe, per cent
35	27
44	17
34	13
57	4

A third sample is given below.

Mn, per cent	Fe, per cent
19	13
39	8
25	4

Though there are many irregularities in detail, the general rule seems to be an increase in the proportion of manganese to iron as the distance from the source of the material increases. It seems clear that iron is precipitated sooner than manganese under conditions such as exist where springs issue at the surface.

GOWLAND MOUNTAIN

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.
Uglow, W. L.: Notebooks, 1925.
Hayes, A. O. "Investigations in Nova Scotia and New Brunswick"; Geol. Surv., Canada, Sum. Rept., 1918, pt. F, pp. 5-30.
Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, p. 164 (1907); Ann. Rept., vol. V, pt. S, pp. 95, 96, pt. SS, p. 92 (1893); Ann. Rept., vol. I, pt. M, p. 20 (1886).

The manganese occurrence at Gowland mountain is on the farm of Seward Harrison about 4 miles east of Elgin, Albert county. It is at an elevation of 1,000 feet on the northerly slope of Gowland mountain and half a mile from the main road leading to the railway at Elgin.

The reports listed above do not state when the manganese deposits of Gowland mountain were discovered, but specimens of the ore were analysed by the Geological Survey as early as 1885. In 1890 several pits were sunk and a short tunnel was driven and in the next year 20 tons of rock material containing about 25 per cent of low-grade psilomelane was taken from one of the pits. About 1917 some work was done on the property by F. M. Thompson of Hillsborough.

The rocks of the locality are granite, greenstone, and felsite, which have been grouped together as Precambrian igneous rocks. The old workings are now caved, so that manganese was not seen in place by recent observers. According to Hayes,[1] manganese oxides occur in several places in joints in granite and felsite. The principal occurrence is described by Hayes as follows:

"A pit through about 6 feet of glacial drift was cleaned out for an examination and at the bottom of the pit a vertical, slickensided fault was exposed to the east, having a strike due magnetic north......Massive manganese oxide 5 inches wide and nearly free from rock fragments, occurs in contact on the west side of the fault-wall. A transition zone about an inch wide occurs between the massive oxide and a leaner zone 10 inches wide composed of angular fragments of felsitic rock cemented by manganese oxide....followed by 1 foot of pink, weathered felsite. The remaining 2 feet 6 inches width to the west side of the pit was composed also of felsite breccia with manganese oxide cement. The west limit of this material was not uncovered. The exposure as a whole has the appearance of a fault zone which was originally filled with a fault breccia, a part of which, probably the most comminuted material,

[1]Geol. Surv., Canada, Sum. Rept. 1918, pt. F, pp. 28, 29.

was replaced by manganese oxide. This replacement was apparently most effective along the east wall where purer oxide ends abruptly against the smooth slickensided surface."

Two samples analysed by the Mines Branch, Department of Mines, Ottawa, Canada, in 1918 gave the following results.

—	Sample of best ore	Sample of low-grade ore
Mn	50·62	24·69
Fe	0·30	3·00
SiO_2	15·00	....

Water concentration tests on a Wilfley table were also carried out on the low-grade ore by the Mines Branch and from these tests the following conclusions were drawn. "In practice, on an ore of this class to obtain a concentrate of grade 50 per cent manganese, a recovery of 50 per cent of the manganese values could be expected. To obtain a concentrate of 40 per cent manganese a recovery of 60 per cent could be expected."[1]

From a study of specimens that he obtained from the dump, Smitheringale says that the ore occurs as stringers and small bunches in a buff-coloured granite. It exhibits colloform banding, which is clearly seen on polished surfaces, and shows that the original mineral has been transformed into crystalline aggregates and clusters. The crystals are elongated and in some places are perpendicular to the original banding, but in other places are in heterogeneous orientation. The original mineral was probably psilomelane. Most of the crystals are braunite, but some are perhaps manganite and pyrolusite. The latter two minerals occur as alteration products of braunite. Limonite occurs with the ore. The deposition appears to have taken place in open cracks in the granite forming non-crystalline colloform masses, which later crystallized.

According to Hayes,[1] development at the property is not extensive enough to prove the size of the deposit. If further development work is done it should be where it would show the size and shape of the deposit. The overburden is not thick and could be removed easily. Hayes says that although the manganese in the vicinity is probably secondary and does not extend to great depth, yet a workable tonnage of ore may exist.

TURTLE CREEK

By G. W. H. Norman

Reference: Dept. of Lands and Mines, N.B., 70th Annual Report, p. 48 (1930).

This deposit is in Hillsborough township, Albert county, near the mouth of a small tributary called Berryton (Berry) brook, which joins

[1]Hayes, A. O.: Geol. Surv., Canada, Sum. Rept. 1918, pt. F, p. 29.

the west fork of Turtle creek at Berryton post office.[1] A good gravel road lies a few hundred feet east of the deposit and connects it with Moncton, 15 miles to the north-northeast. The Canadian National Railway branch line between Salisbury and Albert, passes 5½ miles north of the deposit. Turtle Creek, a small flag station on this line, is the nearest depot and is on the road from the deposit to Moncton.

Thirty-three claims, each of 40 acres, have been taken up in this district and four are held by the Manganese Mines, Limited, and the remainder by Moncton Mining Syndicate. The four claims held by the former company are those on which mining has taken place. The principals in each company are the same, Joseph H. Rogers, U. S. Steeves, Thomas McCarthy, W. Guy Rogers, of Moncton, N.B., and J. Hebert Irving, of Newcastle, N.B.

The strata in the vicinity of the manganese occurrence are Carboniferous sediments dipping northward at angles of about 10 degrees. The lowest beds belong to the Hillsborough conglomerate, a thick series of interbedded, reddish brown sandstone, arkose, and conglomerate. On this lies a limestone, a member of the Windsor series. The limestone is overlain by a thick series of Pennsylvanian age consisting of brownish to grey sandstone and conglomerate.

The manganese deposit occurs in the Windsor limestone on both banks of Berryton brook a few hundred feet upstream from its junction with Turtle creek. The brook, which here flows parallel to the strike of the rocks, has cut down through the deposit and exposes the rocks overlying and underlying the deposit. The thickness of the limestone is judged to be about 25 feet. The main body of the manganese that could be extracted as ore occurs as a replacement in the uppermost beds of the limestone. It, for the most part, parallels the bedding and thus has a bedded structure. The manganese pinches and swells from a few inches to a few feet but is persistent laterally, and has probably an average thickness of 3 or 4 feet throughout the main body of the deposit. The ore now in sight extends for 200 feet along the north side of the brook. The limestone has a very low dip and, consequently, the deposit is nearly horizontal.

The manganese minerals in the samples examined consist predominantly of psilomelane with minor amounts of pyrolusite. These are accompanied by clay, limonite, a little barite, and a finely disseminated copper mineral, the presence of which is indicated locally by green copper stains. The ore has a rather porous nodular appearance, due to botryoidal structure of the psilomelane. The individual globular masses, where broken open, are either hollow or consist of concentric layers of hard, dull grey, metallic-looking psilomelane separated by thin partitions of softer, dark brown, earthy matter which is partly pyrolusite. The brown, earthy matter also occurs on the outer borders of the globular masses and separates them one from the other. A polished surface of the ore brings out the concentric colloform growth of the psilomelane and the arrangement of the pyrolusite which occurs in the centre of some of the larger globular masses surrounded

[1]*See* Hillsborough sheet, Map 243A, Geol. Surv., Canada.

by rings of psilomelane. Copper minerals were not detected in the polished surface of the ore, but are reported by the Southwestern Engineering Corporation to be slightly concentrated in the softer parts of the ore.

The average of the assays in No. 1 tunnel, taken at 5-foot intervals, is as follows:

Width	Mn	Cu	Si	Ph	Fe	Moisture
4·4............	48·57	0·66	5·4	0·068	5·13	13·30

The immediate source of the manganese is in the overlying Pennsylvanian sandstone and conglomerate. These Pennsylvanian rocks are widely distributed over the central part of New Brunswick and are characteristically associated with occurrences of bog manganese deposited where springs issue from these rocks. At Turtle Creek the limestone acted as an underground channel for circulating water which contained considerable manganese. This was deposited to a minor degree in the matrix of the sandstone and conglomerate overlying the limestone. In the limestone it appears to have deposited, partly at least, in open solution cavities, as is indicated by the botryoidal structure of the ore and by the presence in one of the tunnels of a small cave in the limestone, the walls of which are coated with manganese ore.

The source from which the manganese in the Pennsylvanian sandstone and conglomerate was derived cannot be clearly traced. But, since prior to the deposition of the Pennsylvanian rocks a period of erosion occurred, it is conceivable that during this erosion interval the older rocks of the region were deeply weathered and covered with a mantle of residual material. In this residual material any manganese that had been disseminated in the unweathered rocks would probably have become considerably concentrated in much the same way as the iron in the laterite deposits of warm moist regions of the present day. During the deposition of the Pennsylvanian rocks this residual material would be worked over and redeposited with the sandstone and conglomerate, the characteristic rocks of this period in New Brunswick.

Production and Development

Seven carloads are reported to have been shipped from the deposit to metallurgical companies at Welland, Ont., and at Sydney, N.S., with satisfactory results.

The deposit has been opened up at various points over a distance of 400 feet along the brook, by two open-cuts and a series of short tunnels, most of which are on the north side of the brook. Two tunnels on the south side have caved in. They showed red clay and manganese ore, but did not expose the character of the ore-body.

On the north side of the brook about 50 feet to the west of the larger of the two open-cuts, the contact of the overlying sandstone and conglomerate with the limestone swings suddenly to a lower level. This may be due to a fault with a small downthrow to the west or it may be due to an irregularity of the contact. Several of the western tunnels have been driven into these overlying beds of conglomerate, which are merely stained with manganese. Manganese-bearing limestone outcrops in the brook at a lower level opposite the most westerly tunnel. It is thought that a short distance west of the workings the overlying sandstone and conglomerate will occupy the whole of the brook valley and conceal any manganese deposits that may occur in the limestone beneath them. Since any ore lying west of the present workings would lie below the level of the valley bottom, it would here be necessary to sink shafts to test the quality of the ground.

To the north of the main workings on the north side of the brook, a series of diamond-drill holes have been put down through the strata overlying the limestone, but unfortunately the core recovery was not good. These holes, however, indicate that the surface of the limestone rises gently to the north of the brook. Many of the holes were not driven below the top of the limestone, as the possibility that manganese replacements might lie within the limestone was not considered.

Few outcrops occur to the east of the workings and no information could be gained as to the extent of the deposit in this direction.[1] At the bridge over Turtle creek the stream channel is floored by flat-lying Hillsborough conglomerate that lies below the limestone.

The most profitable method of developing the property would seem to consist of taking out the ore already in sight for 200 feet along the north side of the brook and slowly pushing the workings into the hill beneath the cover of conglomerate and surface material.

CANAAN RIVER

References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: "Bog Manganese Deposits, Upper North Branch, Canaan River, Westmorland County, N.B."

Mun. Res. Comm., Canada, Final Report, pp. 65-79 (1920).

Uglow's report contains plans, cross-sections, and a photograph of the bogs. The following description is derived from Uglow's report.

The deposits occur on the west bank of the upper north branch of Canaan river, Westmorland county. Other bog deposits occur on Canaan river and its upper north and middle north branches. The bogs are five in number and are about half-way between the Intercolonial and Transcontinental systems of the Canadian National railways. The nearest railway facilities are at Canaan Station on the old Intercolonial railway, about 4½ miles distant along a bush road that connects the bogs with Canaan Station. With a comparatively small expenditure of money this road could be made into a good truck road for use in the summer.

[1] Prospecting for manganese during the summer of 1932 has proved the presence of the limestone along the eastern side of Turtle Creek valley for a distance of about 1 mile south from Berryton. Indications of manganese occur in the upper part of the limestone near its contact with the overlying Pennsylvanian sandstone and conglomerate. Any bodies of manganese ore that might occur as replacements in the limestone should be discovered if the limestone were uncovered at regularly spaced intervals.

The ground on which the bogs are located slopes gently toward the river bottom with gradients varying from 5 to 12½ feet in 100 feet. The lower edges of the bogs are generally not more than 10 to 15 feet above the level of the river. The area is underlain by Carboniferous rocks.

The manganese bogs lie below the orifices of a series of mineral springs with which the manganese is genetically associated. The water from the springs has apparently deposited manganese dioxide through a process of oxidation or bacterial action, on top of the original surface of sand, gravel, or clay. The manganese deposits are, therefore, fan-shaped, with their narrow ends at the mouths of the springs and their thickest parts directly below the mouths. Laterally, and at the lowest parts, the manganese ore gradually pinches to nothing. The deposits are somewhat like blisters, which have pushed the soil upward, thus making room for themselves between the hard bottom and the grass roots.

The bogs, by which is meant the material between the grass roots and the foot-wall of sand, clay, or gravel, vary in thickness from less than a foot to upwards of 7 feet. Since the bog material has been deposited upon the old surface, it follows that where the old surface has depressions the bog material is generally thickest.

In some of the bogs the only manganese dioxide that can be observed occurs in a somewhat hard, compact layer immediately beneath the grass and tree roots. Below this layer, to the bottom of the bog, the material appears to consist entirely of brown peat varying in character from logs and roots of considerable thickness, scarcely affected by the carbonizing processes, to the finest woody residue which has been greatly altered by these processes. In this type the manganese and peaty beds are quite distinct, and there is an abrupt change at the contact. Occasionally a little manganese dioxide is also found below the peat, lying immediately on the foot-wall of the bog.

A partial analysis of a representative sample from the upper, compact manganese layer of such a bog gave:

	Per cent
Manganese	10·00
Iron	0·08
Moisture (at 110° C.)	76·22
Loss on ignition	7·86

This is equivalent to 62·81 per cent manganese and 0·50 per cent iron in the ignited ore.

The results obtained from a representative sample of the lower peaty layer of the same bog were:

	Per cent
Manganese	0·22
Iron	0·17
Moisture (at 110° C.)	84·41
Loss on ignition	12·74

Hence, the lower peaty part of this bog is considered as barren of ore.

In some of the other bogs, manganese dioxide occurs throughout the whole thickness of the bog. In places it is relatively pure, occurring by itself, whereas in others it is mixed with both hard and soft types of bog iron, and with peat. In this type there are no abrupt changes in the character of the material: everything is transitional.

The following table summarized the tonnages and average assay values. " Wet " ore is ore as it occurs in the bogs. " Dry " ore is the residue when wet ore is dried at 110 degrees centigrade. " Ignited " ore is the residue from dry ore after peaty matter, etc., has been burnt off. " Moisture " is the percentage of moisture in wet ore. " Loss on ignition " is the percentage loss in weight on ignition of dry ore. " Tonnage of dry ore " is obtained by deducting the moisture loss from the tonnage of wet ore. " Tonnage of ignited ore " is obtained by deducting the loss on ignition from the tonnage of dry ore.

Bog	Wet ore				Dry ore				Ignited ore		
	Tons	Mn, per cent	Fe, per cent	Moisture, per cent	Tons	Mn, per cent	Fe, per cent	Loss on ignition, per cent	Tons	Mn, per cent	Fe, per cent
No. 1.......	5,859·5	5·53	2·49	75·68	1,425·0	22·70	10·22	39·14	867·5	37·31	16·79
No. 2A.....	5,485·0	3·42	1·41	81·70	1,004·0	18·68	7·70	45·40	548·0	34·20	14·11
No. 2 B....	902·0	4·65	0·83	80·40	176·8	23·70	4·23	42·10	102·4	40·94	7·31
No. 3.......	1,218·0	4·49	0·61	76·55	285·7	19·15	2·59	53·92	131·7	41·55	5·62
No. 4.......	6,825·0	5·98	0·39	70·50	2,013·0	20·27	1·33	57·41	857·0	47·50	3·12
Total......	20,289·5	......	......	....	4,904·5	......	......	....	2,506·6	......	......
Averages...	....	5·01	1·305	....	....	20·71	5·40	....	....	40·45	10·49

The bogs have well-defined, hard, compact foot-walls from which, in most cases, the material can be readily separated by shovelling. The grass and the tree roots as a general rule lie upon the manganese layer and are not embedded in it. This makes stripping rather an easy problem. No boulders or pebbles have been found within the manganiferous zones. Wherever the manganese dioxide occurs isolated in relatively pure beds it can be readily separated from the underlying peat by shovelling. The deposits have gradients from 5 to 12½ per cent, which gives sufficient slope for drainage purposes.

The assays obtained by Uglow are not all given in Uglow's report, but are on file at the Mines Branch, Department of Mines, Ottawa. Those for bogs Nos. 1 and 2 are fairly numerous, and show that with increase of distance from the source springs there is a decrease in iron and an increase in manganese.

The assays show very clearly that the character of a bog ore of the dioxide type changes gradually with increase of distance from the source, from a relatively high iron and low manganese content to a relatively low iron and high manganese content. The explanation is that iron in solution oxidized to limonite more rapidly than manganese in solution oxidized to manganese oxides. Knowing the behaviour of these oxides, and the location of the source, and having only a few accurately located samples, it would be possible to arrive at a fairly definite conclusion in regard to the extent and location of the various parts of the bog, chiefly consisting of, respectively, bog manganese and bog iron.

ADAMSVILLE STATION

References: Crown Land Dept. of New Brunswick, Ann. Rept., No. 56, p. XXIV (1916).
Crown Land Dept. of New Brunswick, Ann. Rept., No. 55, p. XXI (1915).

Bog manganese occurs near Adamsville station on the Intercolonial railway, in Kent county.

The bog was mined in 1915 by the New Brunswick and Nova Scotia Mining and Development Company which produced in that year approximately 150 tons of mechanically dried ore. This ore was dried at the property and shipped to New York for smelting. An embargo was placed on the export of manganese in 1916 and as the company found no ready market in Canada operations ceased.

The rocks in the vicinity of Adamsville are probably of Carboniferous age. Several deposits of bog manganese occur and are described as follows, in the report on the Crown Land Department of New Brunswick. In every case the deposit is situated at and around a spring, which evidently has given rise to the deposit. In a large number of the deposits the springs are about 2 to 5 feet above the surrounding ground, giving a heavy deposit of relatively pure material immediately surrounding them and a thinner deposit of manganese ore, containing a higher quantity of peat in parts removed from the spring. All the deposits are shallow, varying usually from 1 to 3 feet in thickness and are underlain either by a hard, white sand or a grey clay. The following statement is based on the examination of some thirty deposits. The samples were dried at 212 degrees F.

—	Mn	MnO	Organic loss on incineration	Silica	Sulphur	Phosphorus
Average	27·62	43·90	37·21	9·53	0·54	0·05
Minimum	6·48	10·29	8·57	6·11	0·21	0·03
Maximum	49·64	78·92	72·04	33·24	0·72	0·07

From its nature the ore when first dug contains a large percentage of water, the moisture and volatile loss at 212 degrees F. being about 58 per cent with a range of from 42 per cent to 78 per cent.

JORDAN MOUNTAIN

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.
Uglow, W. L.: Notebooks, 1925.
Gwillim, J. C.: "Manganese in New Brunswick and Nova Scotia"; Mun. Res. Comm., Canada, Final Report, pp. 61, 62 (1920).
Bailey, L. W.: "The Mineral Resources of the Province of New Brunswick"; Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 50-52 (1899).

Minor References: Crown Land Dept. of New Brunswick, Ann. Rept., No. 58, p. 16 (1918).

Mines Branch, Department of Mines, Canada, Sum. Rept. 1909, p. 61.

Geol. Surv., Canada: Pub. No. 983, p. 96 (1907); Ann. Rept., vol. XV, pt. S, pp. 161, 162 (1907); Ann. Rept., vol. XIII, pt. S, p. 85 (1903); Ann. Rept., vol. XII, pt. S, p. 77 (1902); Ann. Rept., vol. X, pt. M, p. 50 (1899); Ann. Rept., vol. V, pt. S, p. 94 (1893); Rept. of Prog. 1878-79, pt. D, p. 24.

The Jordan Mountain manganese deposit is on the southern slope of Jordan mountain on the southwestern part of Mr. J. Tait's farm about 8 miles north of Sussex, Kings county. From Sussex, the property can be reached by the South Creek road to Newton, and thence west by the Jordan Mountain road.

Surface indications of a manganese deposit at Jordan mountain were known prior to 1878, but not until 1882 were the deposits discovered by F. W. Stockton of Sussex. The production from the mine was about 400 tons prior to 1887.[1] Except for very short periods of activity the property has probably been idle since that time. Some manganese ore was shipped in 1899, but the quantity is not stated.[2]

Bailey[3] furnishes the following information on the rocks in the vicinity. Jordan mountain is a rounded, well-timbered mountain 700 feet high, on the west side of Smith creek. In the vicinity of the workings rock outcrops are few. The main ore-body is conformable in strike and dip with an enclosing conglomerate of Lower Carboniferous age. The conglomerate and associated reddish brown shales are near the contact with the underlying Precambrian felsites and gneisses and the pebbles of the conglomerate may have been derived from these older rocks.

Smitheringale obtained from the dumps specimens of a breccia composed of sharply angular fragments of a reddish to grey, highly metamorphosed rock. Some of the cement of the breccia was mostly manganese oxide. This breccia is probably the conglomerate of early reports.

The property was developed by shafts and tunnels, nearly all of which are now inaccessible. Bailey, however, had access to the workings, and in regard to the occurrence of the ore stated that when he examined the occurrences the only working was a trench about 70 feet long and 10 to 12 feet deep. The sides of the trench showed shaly conglomerates dipping southeast at an angle of 70 degrees, whereas the base of the trench was chiefly occupied by the deposit of manganese, extending for a distance of about 65 feet, with an average thickness of about 6 feet. Approaching the ends of the cutting the ore deposit thinned out rapidly and alternated with the conglomerates; but the trench had not been opened sufficiently far to enable one to form a very accurate idea, either as to the extent or character of the deposit. Its appearance was that of a lenticular mass conformable to the bedding rather than that of a vein. In addition to the main body, small stringers of manganese oxide were observed penetrating the surrounding rocks for a distance of 20 or 30 feet and in some instances angular fragments of conglomerate were apparently cemented by the ore into a sort of breccia.

[1]Geol. Surv., Canada, Ann. Rept., vol. V, pt. S, p. 94 (1893).
[2]Geol. Surv., Canada, Ann. Rept., vol. XII, pt. S, p. 77 (1902).
[3]Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 50 (1899).

The ore is mostly fine-grained pyrolusite, in general of a massive character but also exhibiting crystalline bodies. Specimens collected by Smitheringale from the dumps show a mixture of psilomelane (?), manganite, pyrolusite, and hausmannite in a dense, fine-grained mass. Of these minerals manganite is the most plentiful, and both it and pyrolusite occur mostly as minute interlocking grains but also as small clusters of acicular crystals. Hausmannite occurs as small, isolated grains here and there through the ore mass. Barite was the only gangue mineral seen, but others may occur.

Where manganese oxides occur as a cement in the breccia the rock minerals have been partly replaced. In this type of ore, the proportion of ore to rock varies considerably, but the better ore contains over 50 per cent manganese oxides.

Two specimens of breccia cemented by ore were assayed at the Mines Branch, Ottawa, and yielded 24·23 per cent and 9·32 per cent manganese.[1]

Bailey quotes the following analyses of Jordan Mountain ore.[2]

—	Per cent	Per cent	Per cent
Manganese dioxide	86·08	....	....
Iron oxide	0·87	....	....
Silica	2·86	9·70	0·23
Manganese	....	52·88	57·37
Iron	....	1·18	....
Phosphorus	....	0·014	0·015
Sulphur	....	....	0·61

Bailey states that the rocks in the vicinity of the main ore-body are everywhere stained brown with manganese oxides, and that trial pits at several places in line with the main ore-body showed the presence of manganese.[3]

GLEBE MINE

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, p. 514 (1890).

Minor References: Mun. Res. Comm., Canada, Final Rept., p. 62 (1920).

Geol. Surv., Canada: Pub. No. 983, p. 95 (1907); Ann. Rept., vol. XV, pt. S, p. 161 (1907); Ann. Rept., vol. X, pt. M, p. 50 (1899).

The Glebe mine is on the farm of S. Boyles, 3 miles northeast of Markhamville and 8 miles southeast of Sussex, Kings county. Access to the mine may be had over the Sussex-Waterford road for 6 miles, then south along the Parlie Creek road for 1 mile, and then along a steep branch road for 2 miles.

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[1]Mun. Res. Comm., Canada, Final Rept., p. 62 (1920).
[2]Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 52 (1899).
[3]Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 51 (1899).

Local reports say that work at the Glebe mine stopped about 1882, but that before this it had been worked intermittently for fifteen years, resulting in a production of about 40 tons.

The rocks are nearly horizontal Carboniferous limestone and conglomerate overlying rocks presumably of Precambrian age. The ore occurs as nests and veinlets sparingly scattered through a massive to thin-bedded, greyish-weathering limestone that overlies a hard, flinty conglomerate. The ore minerals are dense and finely crystalline manganite and pyrolusite. Penrose states that the ore occurring as nodules and in thin layers follows the general direction of the bedding of the limestone.[1]

The workings consist of a number of shafts, 85 feet or less in depth, and an adit about 500 feet long. The adit is along the contact between the limestone and the underlying conglomerate, and the shafts go down to the same contact. Very little ore can now be seen in the workings.

MARKHAMVILLE MINE

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Bailey, L. W.: "The Mineral Resources of the Province of New Brunswick"; Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 43-49 (1899).

Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, pp. 507-511 (1890).

Ingall, E. D.: "Mineral Statistics and Mining in 1890"; Geol. Surv., Canada, Ann. Rept., vol. V, pt. S, pp. 93, 94 (1893).

Minor References: Mun. Res. Comm., Canada, Final Rept., pp. 60, 61 (1920). Mines Branch, Dept of Mines, Canada, Sum. Rept. 1909, p. 60. Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, pp. 158-161 (1907); Ann. Rept., vol. IX, pt. S, p. 80 (1898); Ann. Rept., vol. III, pt. S, p. 44 (1889); Rept. of Prog. 1878-79, pt. D, pp. 18, 24; Rept. of Prog. 1877-78, pt. D, p. 11; Rept. of Prog. 1870-71, pp. 65, 208, 224.

The above-mentioned reports by Bailey and Penrose contain cross-sections showing the mode of occurrence of the ore at the Markhamville mine, which is near the head of Hammond river, about 10 miles south of Sussex, Kings county. The workings are on the farm of Chas. D. Illsley.

The following history of manganese mining at Markhamville is taken from the reports of Bailey and Ingall listed above. It is reported that manganese was discovered at Markhamville by G. F. Matthew in 1862, and from this time until 1865 the discovery was worked under lease by Wm. Davidson of Saint John. The property was then acquired by the Queen Manganese Company or Victoria Manganese Company and under the management of Major A. Markham was operated until the autumn of 1889. The Queen Manganese Company then went into liquidation and in 1890 the Pope Manganese Company was formed with Major Markham as manager. Mining, however, ceased about 1895.

[1]Ark. Geol. Surv., Ann. Rept., vol. I, p. 514 (1890).

Bailey[1] says,

"The deposits first removed were superficial ones, consisting of ore enclosed, in the manner of pockets, in beds of clay, mingled more or less with gravel, and holding boulders of limestone. These deposits had a depth of 12 feet or more. Somewhat later, operations were extended to the underlying limestones but in these also the distribution was found to be most irregular, thus leading to great fluctuations in the output of successive years, as well as in the profits derived therefrom. In more than one instance an entire season would be occupied in profitless search, and operations would be upon the point of abandonment, when new and possibly richer deposits would be struck, thus prolonging, for a greater or less time, the life of the mine. Such finds, however, eventually become too rare to admit of continued expensive search, and about the year 1893 the mines were finally closed... The output, during the first twenty-three years of operation, varied from 500 to 1,500 tons per year, and the value, as delivered at Sussex, from $15 to $50 per ton."

The ore was hauled on wagons and sleighs 12 miles over steep grades to Sussex.

The ore is in Lower Carboniferous sediments in a valley between two ridges of Precambrian volcanic rocks. The Precambrian rocks on the northern ridge contain thin seams of manganese and, according to Bailey and Matthew, might well have been the source of the manganese in the Lower Carboniferous sediments.[2] The exact succession of the Carboniferous rocks is unknown, but the ore-bearing part is a limestone which is probably at the base of the series.

According to Penrose[3] the ore-bearing limestone is generally of a grey colour, but in some places is pink or buff and is associated with shaly strata. It contains veins of calcite in which occur occasional masses of pyrolusite. The thickness of the limestone varies considerably. In one place it is only 12 feet thick and in another it is 55 feet thick. It has been considerably distorted and is folded into small anticlines and synclines, but has a general northeasterly strike and a northwesterly dip. Surface decomposition has produced residual clay, and water circulation has developed a series of underground caverns and passages. The limestone extends for several miles down Hammond river, but only locally does it contain workable manganese deposits.

Manganese ore occurs in the residual clay and in the limestone. In the limestone some manganese occurs in calcite veins, but according to Penrose.[4]

" . . . . . the principal ore deposits are lenticular bodies interstratified with the limestone. These occur either as irregular pockets, or as flat layers, more or less continuous for considerable distances and becoming thin and thick at intervals. In some places such deposits widen into pockets from which several hundred tons of ore have been taken, and in one opening 3,000 tons are said to have been mined. Though in places the pockets do not always adhere strictly to the bedding of the rock, yet in a general way they follow it. Sometimes veins and pockets cut directly across the bedding, but these are generally smaller than the others and are probably due to a secondary chemical action by which they have been derived from the bedded ores . . . . The ore that was originally in the part of the limestone which has decayed, is now found buried in the clay . . . . . Such deposits are rarely more than from 8 to 20 feet in thickness, but the ore in them is cheaply worked and they

[1]Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 44 (1899).
[2]Geol. Surv., Canada, Rept. of Prog. 1870-71, p. 65.
[3]Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, p. 508 (1890).
[4]Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, pp. 508, 509 (1890).

have supplied a large part of the output of the Markhamville mine. Frequently the decomposition of the limestone has spread downward more rapidly along the outcrop of a body of ore than elsewhere, causing somewhat abrupt hollows filled with residual clay and manganese ore, and containing in the bottom the outcrop of the ore in situ in the rock."

Manganese ore also occurs in the solution cavities and passages in the limestone. Where these cavities have encountered bodies of manganese ore their floors are covered with loose ore fragments. Kidney-shaped masses of glossy black limonite also occur in the caves.

Smitheringale collected specimens from the mine and noted psilomelane (?), pyrolusite, manganite, hausmannite, braunite, limonite, hematite, calcite, and barite. The braunite occurs as dense, finely crystalline, nodular or vein-like masses, or as more irregular replacements in limestone. Some of the irregular replacement bodies show a colloform structure, and small pyramidal crystals in the various bands are arranged with random orientation. Manganite, pyrolusite, and hausmannite occur in veins and nodular masses in the limestone. Pyrolusite appears to be an alteration product of the other manganese minerals. The limonite and hematite in the limestone occur in some places by themselves, and in some places limonite occurs with manganese ore, either intermixed with it or as thin films between manganese ore and limestone.

Bailey[1] says that the total production of manganese ore from Markhamville probably exceeds 23,000 tons. He also gives the following table of exports of manganese ore from New Brunswick from 1868 to 1894. This can be taken as being practically the production of the Markhamville mine, as nearly all the ore of New Brunswick came from this mine.

Exports of Manganese Ore from New Brunswick, 1868-1894

	Tons		Tons
1868	861	1884	469
1869	332	1885	1,607
1870	146	1886	1,377
1871	954	1887	839
1872	1,075	1888	1,094
1873	1,031	1889	1,377
1874	776	1890	1,729
1875	194	1891	233
1876	391	1892	59
1877	785	1893	10
1878	520	1894	45
1879	1,732		
1880	2,100	Total	23,024
1881	1,504		
1882	771		
1883	1,013		

The workings at the Markhamville mine consist of a large number of open pits and many underground passages. They are now mostly caved or otherwise inaccessible.

Two main classes of ore were recognized in mining, "chemical ore" which was high-grade pyrolusite ore and was shipped to Boston, and "metallic ore" or "furnace ore" which consisted of ore below a chemi-

[1]Bailey, L. W.: Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 44-48 (1899).

cal grade and which was shipped to England. Bailey[1] says, "In preparation for market, the better class of ores, known locally as high-class ores, were first crushed, then washed, and finally sized in screens, to be afterwards loaded in old petroleum barrels containing something over 1,000 pounds each . . . . . The lower grades, ... were shipped without special treatment."

Denis[2] says that before the mine was abandoned the ground was prospected carefully and diamond drilled. Gwillim,[3] however, says, "All the same there are in the vicinity untouched portions of the ore-bearing formation which potentially carry manganese."

QUACO HEAD

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Uglow, W. L.: Notebooks, 1925.

Ingall, E. D.: "Mineral Statistics and Mining in 1890"; Geol. Surv., Canada, Ann. Rept., vol. V, pp. 94, 95 (1893).

Penrose, R. A. F.: "Manganese"; Ark. Geol. Surv., Ann. Rept., vol. I, pp. 511-514 (1890). This report includes a geological cross-section at Quaco head.

Bailey, L. W.: Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 52-54 (1899). This report simply quotes Penrose's report.

Minor References: Geol. Surv., Canada: Pub. No. 983, pp. 96, 97 (1907); Rept. of Prog. 1878-79, pt. D, pp. 18-24; Rept. of Prog. 1870-71, p. 224.

The Quaco Head manganese deposit is in the cliffs that form the southeastern extremity of Quaco head on the north shore of the bay of Fundy. The deposit is about 2 miles south of St. Martins, St. John county. Manganese deposits were known at Quaco head prior to 1870 and were worked in a small way until 1889. Several hundred tons of ore are said to have been mined. In 1889 the property was acquired by the Brunswick Manganese Company who began a more ambitious program of development. No records of production by this company are available and possibly no ore was shipped.

The cliffs at Quaco head are 100 feet or more in height. At high tide the base of the cliffs is immersed, but at low tide a gravel beach is exposed. The rocks forming the promontory dip steeply so that a good vertical section of the rocks can be seen from the beach. Penrose[4] says,

> "The rocks are greatly disturbed and have been much shattered and broken by igneous intrusions. They now stand at steep angles, sometimes almost vertically, exposing in different parts of the headland areas of limestone, shale, and coarse conglomerate. Masses of igneous material protrude into these beds at different points, and on either side of the headland are beds of Triassic sandstone and fine conglomerate lying unconformably on the upturned edges of the older rocks."

Uglow examined the deposit in 1925, and in his notebook he has indicated that he considers the "igneous intrusion" of Penrose as argillite breccia or as felsite breccia older than the rocks with which they are

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[1] Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 49 (1899).
[2] Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1909, p. 60
[3] Mun. Res. Comm., Canada, Final Rept., p. 61 (1920).
[4] Ark. Geol. Surv., Ann. Rept., vol. I, p. 512 (1890).

associated. Smitheringale examined the occurrence in 1927 and is of the opinion that the rocks once considered as intrusive are really of volcanic origin and are older than the Carboniferous limestone.

In regard to the manganese deposits, Penrose[1] says,

"The manganese occurs as nodules and irregular discontinuous veins, in both the shale and the limestone, though the larger quantities are in the former. The nodules vary from a fraction of an inch to several inches in diameter, and the thickness of the veins is equally variable. The disturbed character of the rocks renders it somewhat difficult to determine the thickness of the main ore-bearing bed, but it is probably not over 30 feet, though smaller quantities of manganese are found in the rocks on either side. The ore is scattered through this thickness in very variable quantities. The amount of commercially available ore at Quaco head is small."

In regard to the manganese deposits, Smitheringale says that the manganese minerals occur mostly in a sheared, shaly rock, which has been so severely crushed that it is a crumpling mass of rhomboidal fragments. The ore occurs in this rock as isolated nodules varying from bodies the size of an egg to masses 2 feet in diameter. The ore is mostly psilomelane and manganite or "hard" ore, and the larger pieces have the same rhomboidal cleavage as the containing rock. Some of the ore is porous and honeycombed, some fragments of manganese oxides occur in the conglomerate member. A white, thinly laminated limestone contains irregular veinlets of manganese oxides. The minerals in the ore are psilomelane, pyrolusite, manganite, barite, and calcite. The pyrolusite and manganite occur either as interlocking crystalline grains or as small, acicular crystals lining vugs within the ore.

Penrose[2] quotes the following analyses of the better grades of ore from Quaco head.

—	Per cent	Per cent
Manganese peroxide (pyrolusite)	71·54	65·00
Ferric oxide	2·19	1·75
Calcium	Trace	Trace
Phosphorus	0·02	0·04
Sulphur	0·00	0·00
Insoluble silicates	8·37	6·66
Manganese	58·20	57·15
Iron	1·53	1·23

NORTH RENOUS

Reference: Wright, W. J.: "Notes on Some Manganese Deposits of New Brunswick"; Manuscript written in 1931.

The following information was obtained from the manuscript report by Wright.

[1] Ark. Geol. Surv., Ann. Rept., vol. I, pp. 512, 513 (1890).
[2] Ark. Geol. Surv., Ann. Rept., vol. I, p. 513 (1890).

The North Renous manganese deposits are on the farm of E. Singleton on the north side of Renous river at North Renous. The main highway crossed the farm about 500 yards from the deposits.

It has long been known that bog manganese occurs in the vicinity and three deposits have now been discovered. Each of the two smaller has been drained by a trench, but the largest has not been opened up. Each of the two small deposits is 100 feet in diameter, 5 feet thick in the centre, thins out towards the edges, and is covered by sod and small clumps of shrubs. The largest deposit is 900 feet long and 300 feet wide. An area about 150 feet square in the eastern part of it appears to be covered with about 4 feet of bog manganese, but the rest of the deposit seems to be very shallow.

TETAGOUCHE

Main References: Smitheringale, W. V.: "The Manganese Deposits of the Maritime Provinces, Canada"; Manuscript report written in 1928.

Young, G. A.: "Bathurst District, New Brunswick"; Geol. Surv., Canada, Mem. 18E, p. 77 (1911).

Bailey, L. W.: "The Mineral Resources of the Province of New Brunswick"; Geol. Surv., Canada, Ann. Rept., vol. X, pt. A, p. 97, pt. M, pp. 42-43 (1899).

Minor References: Geol. Surv., Canada: Sum. Rept. 1909, p. 224; Ann. Rept., vol. XV, pt. S, p. 158 (1907); Rept. of Prog. 1879-80, pt. D, pp. 24, 25, 45.

Gesner, A.: "Report on the Geological Survey of the Province of New Brunswick", p. 84 (1843).

The Tetagouche manganese deposits are near Tetagouche falls on Tetagouche river, 9 miles west of Bathurst, Gloucester county.

These deposits were the first to attract attention to the possibility of mining manganese in New Brunswick. They were worked for a short time prior to 1843 by the Gloucester Mining Association which made a shipment of 125 tons of ore to England where it sold for £1,000.[1] The ore could not be mined at a profit and the property has not since been operated.

The ore consists of quartz veins containing manganite in slates of Ordovician age. Young[2] says,

> "At its outcrop on the steep river bank, the vein is seen in places to be at least 13 feet wide, to be nearly vertical, and to be accompanied by roughly parallel, narrow veins. The quartz is coarse, and white in colour; it forms most of the vein, the manganite occurring in narrow seams, and small patches or aggregates of plates, or in semi-detached, imperfect crystals or fine grains. The vein is irregular in outline, holds inclusions of country rock, and is much fractured. From information gained from nearby residents, it is believed that during mining operations solid or nearly solid ore was found to occur in pockets."

Bailey[3] states that pyrolusite and psilomelane occur as narrow veinlets and as films along joints in the slates, and that some of the veins were as wide as 8 inches. Ells[4] states that the red slates contained nodules of manganite, but attempts to mine the material were not successful.

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[1]Gesner, A.: "Report on the Geological Survey of the Province of New Brunswick," p. 84 (1843).

[2]Geol. Surv., Canada, Mem. 18, p. 77 (1911).

[3]Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 43 (1899).

[4]Geol. Surv., Canada, Rept. of Prog. 1879-80, pt. D, p. 24.

The workings consist of numerous pits on both sides of the river, a shaft, and a tunnel.

	Location	Description	References
112	Albert co., east side of Salisbury bay	Manganese ore occurs near contact between Lower Carboniferous and Triassic rocks. The deposit was worked by the Queen Mining Company prior to 1878	Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 54 (1899). Geol. Surv., Canada, Rept. of Prog. 1878-79, pt. D, pp. 18, 24. Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. D, p. 12
119	Albert co., near Harvey.......	A bed of bog manganese.......	Geol. Surv., Canada, Ann. Rept., vol. X, pt. S, p. 125 (1899)
120	Albert co., about 1 mile west of Hopewell	Small deposit of manganese ore in hard grey sandstone near contact between Millstone Grit and Lower Carboniferous rocks. The deposit was worked out prior to 1885	Geol. Surv., Canada, Ann. Rept., vol. I, pt. E, p. 18 (1886). Geol. Surv., Canada, Rept. of Prog. 1878-79, pt. D, p. 24
121	Albert co., near Hillside post office, 5 miles southeast of Elgin	Manganese ore occurs as float near the contact between Lower Carboniferous and pre-Silurian rocks	Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 54 (1899). Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. D, p. 11
122	Albert co., at western base of Shepody mountain on Sawmill creek	Bog manganese...............	Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, p. 47 (1899)
123	Westmorland co., about 2 miles northwest from Petitcodiac station	Manganese vein 1 inch thick occurs near the contact between Lower Carboniferous limestone and gypsum	Geol. Surv., Canada, Rept. of Prog. 1878-79, pt. D, p. 24
124	Westmorland co., 4½ miles west of Petitcodiac. On southeast side of Holmes brook	Pyrolusite occurs in joints in Carboniferous limestones, sandstones, and conglomerates which strike northeast and dip steeply southeast. Development consists of open-cuts and a shaft 40 feet deep	Smitheringale, W. V.: manuscript
127	Kings co., Pollet lake.........	"A small quantity of manganese ore is being mined and shipped at Pollet lake"	Crown Land Dept. of New Brunswick, Ann. Rept., No. 49, 1909, p. XXVII

	Location	Description	References
129	Kings co., Hillsdale post office.	Manganese ore occurs as float..	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 162 (1907). Geol. Surv., Canada, Rept. of Prog. 1878-79, pt. D, pp. 18, 24
133	St. John co., Henry lake.......	Surface indications of manganese reported	Geol. Surv., Canada, Rept. of Prog. 1878-79, pt. D, p. 24
134	Northumberland co., east bank of McKay brook on north side of Northwest Miramichi river, 6 miles above Newcastle	Bog manganese occurs near springs	Wright, W. J.: "Notes on some Manganese Deposits of New Brunswick"; Manuscript
136	Northumberland co., Upper Blackville	Bog manganese occurs in an area 150 feet in diameter	Wright, W. J.: "Notes on Some Manganese Deposits of New Brunswick"; Manuscript
137	Northumberland co., Doaktown	Bog manganese occurs.........	Wright, W. J.: "Notes on Some Manganese Deposits of New Brunswick"; Manuscript
138	Northumberland co., on north branch of Southwest Miramichi river, 12½ miles above forks	Bog manganese	Geol. Surv., Canada, Ann. Rept., vol. I, pt. GG, p. 58 (1886)
140	Sunbury co., near Lincoln.....	Bog manganese..............	Geol. Surv., Canada, Rept. of Prog. 1882-4, pt. GG, p. 47. Geol. Surv., Canada, Ann. Rept., vol. I, pt. GG, p. 58 (1886)
141	York co., parish of Douglas, ½ mile from Jones forks	Bog manganese occurs as blackish brown nodules in soil. Specimen assayed 27·04 per cent MnO_2	Geol. Surv., Canada, Ann. Rept., vol. XIII, pt. R, p. 62 (1903)
142	York co., Fredericton........	Bog manganese occurs in a gravel bank	Geol. Surv., Canada, Rept. of Prog. 1882-4, pt. GG, p. 47
143	York co., Queensbury.........	Bog manganese..............	Geol. Surv., Canada, Rept. of Prog. 1882-4, pt. GG, p. 47. Geol. Surv., Canada, Ann. Rept., vol. I, pt. GG, p. 58 (1886)

	Location	Description	References
144	Charlotte co., Lynfield........	Dark brown mixture of bog manganese and iron oxide, 18 feet thick, was found underneath trap rock in the excavation of a well	Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 120, 121 (1899)
145	Carleton co., 3 miles north of Glassville	Black, powdery manganiferous material occurs in surface joints in argillite. Opened up by pits and trenches	Wright, W. J.: "Notes on Some Manganese Deposits of New Brunswick"; Manuscript report

PRINCE EDWARD ISLAND

NORTH CAPE

Reference: Ells, R. W.: Geol. Surv., Canada, Rept. of Prog. 1882-4, pt. E, p. 13.

The above-mentioned report refers to manganese as occurring at North cape at the north end of Prince Edward Island. The report states: "Some of these (sandstones and shales) are so cemented by manganese as to resemble at first sight solid beds of that mineral."

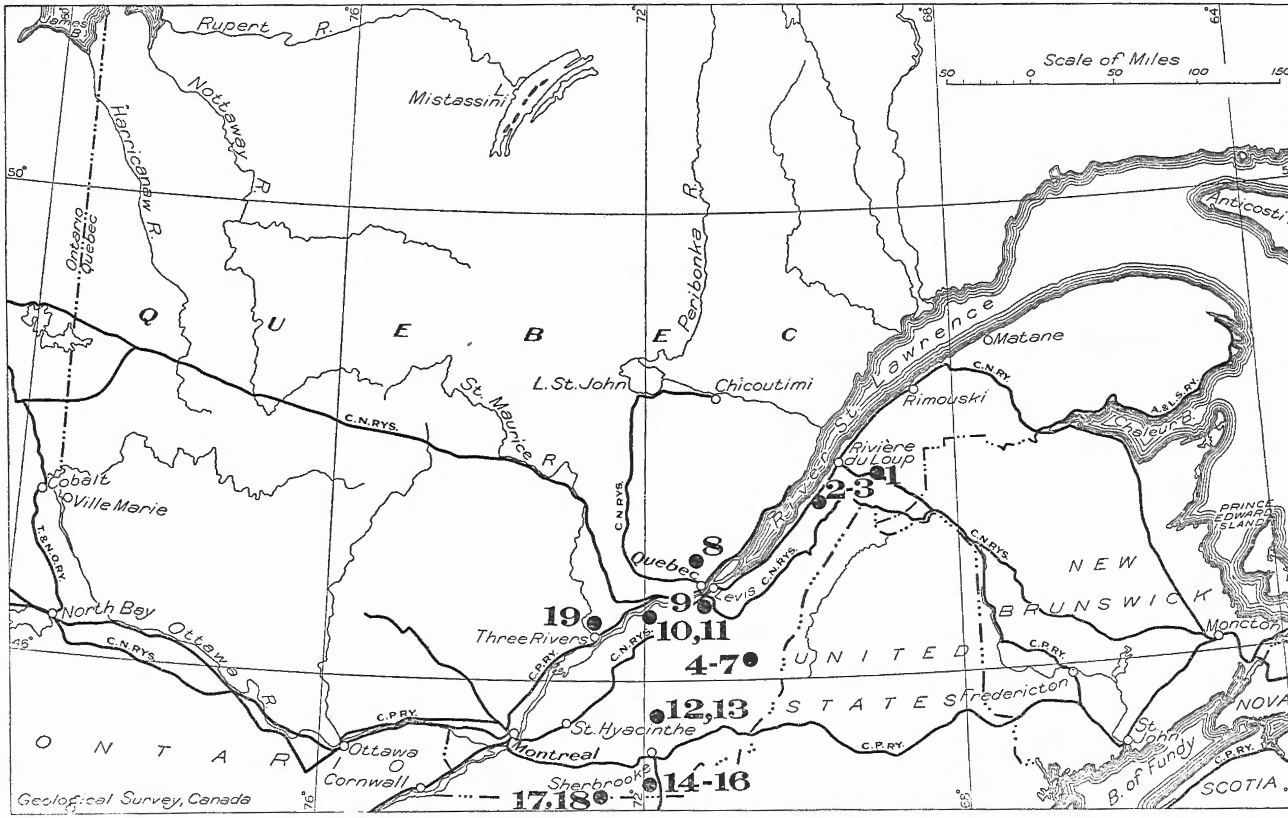

Figure 2. Index map showing location of manganese deposits in Quebec. (*See* page 97 for locality names.)

Explanation of Figure 2 (Page 96)

The localities indicated by numbers on Figure 2 are as follows:

1. LaPlaine
2. Kamouraska seigniory
3. Ste.-Anne-de-la-Pocatière
4. St. Mary seigniory
5. St. Joseph seigniory
6. Aubert-Gallion
7. Tring township
8. Quebec
9. Lauzon township
10. St. Sylvestre parish
11. Gaspe seigniory
12. Cleveland township
13. Cleveland township
14. Stanstead
15. Stanstead
16. St. Mary seigniory
17. Bolton township
18. Sutton township
19. St. Maurice

QUEBEC

The only recorded occurrences of crystalline manganese oxide in Quebec are those of the Magdalen islands in the gulf of St. Lawrence. Many small deposits of bog manganese have been recorded, but have, apparently, no commercial importance. A few tons of manganese ore have been shipped and represent the only mining for manganese done in the province. Logan[1] states that in the Eastern Townships some of the sedimentary rocks contain enough manganese to weather black.

MAGDALEN ISLANDS

Main References: Dept. of Colonization and Mines of Quebec, 1904, pp. 25, 26. Dept. of Lands, Mines, and Fisheries of Quebec, 1903, pp. 69-73.

Minor References: Geol. Surv., Canada: Ann. Rept., vol. XV, pt. S, pp. 166, 167 (1907); Rept. of Prog. 1879-80, pt. G, pp. 4, 10, pt. H, p. 18.

The following information is taken from the report of the Department of Lands, Mines, and Fisheries of Quebec for 1903, pages 69 to 73. The manganese oxides pyrolusite and manganite occur on several of the islands, but are reported mostly from Amherst island, Allright island, Grosse île, and Grindstone island. Prior to 1903 several tons of pyrolusite were shipped from an excavation on Grindstone island. The ore occurred near the contact between diabase and red sandstone. The rock of the island is mostly sandstone intruded by basic igneous rocks. In the report referred to the belief is expressed that the manganese existed in the rocks as a carbonate and was changed to oxides by chemical action accompanying igneous intrusion.

In 1904 the deposits were controlled by the Magdalen Island Company which supplied the following assays, appearing in the report of the Department of Colonization and Mines of Quebec, 1904, pages 25, 26.

—	Grindstone Island ore	Etang-du-Nord ore		Amherst Island ore	Locality not stated
Manganese	50·36	56·56	49·32	51·29	64·62
Iron	10·62	0·82	1·44	3·89	....
Silica	1·62	0·70	5·84	3·96	1·40
Phosphorus	0·004	0·068	0·068	0·029	None
Oxide of alumina and iron	....	....	....	....	1·55
Moisture	....	....	....	....	0·80
Oxygen by difference	....	....	....	....	31·63

[1]Geol. Surv., Canada, "Geology of Canada," 1863, p. 508.

Bog Manganese in Quebec

	Locality	Character and extent	References
1	Temiscouata county, seigniory of Cacouna, village of La-Plaine	Nodules of manganese in sand. Bed is a few yards in diameter and 4 to 5 inches thick	Geol. Surv., Canada, Rept. of Prog. 1863, p. 752
2	Kamouraska co., siegniory of Kamouraska	Deposit of mixed bog iron and manganese. Area is 30 by 300 paces and thickness is 6 to 8 inches	Geol. Surv., Canada, Rept. of Prog. 1866-69, p. 140
3	Kamouraska co., seigniory of Ste.-Anne-de-la-Pocatière, ¾ mile southeast of the church	Bed of bog manganese under a cultivated field. Analysis gives 38 per cent MnO_2. Extent not known	Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 113 (1891). Geol. Surv., Canada, Rept. of Prog. 1863, p. 752
4	Beauce co., third concession of the seigniory of St. Mary	Earthy, impure oxide of manganese in small fissures in slate	Geol. Surv., Canada, "Geology of Canada", 1863, p. 730
5	Beauce co., seigniory of St. Joseph, 1 mile west of Chaudière river	Earthy oxide of manganese occurs with copper, quartz, and chlorite in small fissures in slate	Geol. Surv., Canada, "Geology of Canada", 1863, p. 731
6	Beauce co., seigniory of Aubert-Gallion, on west bank of Chaudière river opposite the mouth of Famine river	Earthy, nodular masses in a deposit 2 to 4 inches thick. Analysis gives 20 per cent MnO_2. Deposit extends ½ mile along Chaudière river	Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 113 (1891). Geol. Surv., Canada, Rept. of Prog. 1863, p. 752
7	Beauce co., Tring tp., near eastern limit of the township along the road from Lambton to St. Francis	Earthy, nodular masses and small patches. Analysis gives 25 per cent MnO_2. The deposit is 1 foot or less thick	Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 113 (1891). Geol. Surv., Canada, Rept. of Prog. 1863, p. 752
8	Quebec co., near Quebec city on St. Louis road	Bed of black, porous masses of manganese in sand. Area is 60 by 5 yards. Bed is 1 foot thick in the centre and thin at the edges	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 167 (1907). Geol. Surv., Canada, Rept. of Prog. 1863, p. 752.
9	Levis co., Lauzon tp., 1 mile east of the line between Lauzon and St. Antoine tps. and 2 miles south of the St. Lawrence	Bog manganese in a ploughed field. An acre or more in extent	Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 113 (1891). Geol. Surv., Canada, Rept. of Prog. 1863, p. 752
10	Lotbinière co., St. Sylvestre par., 9th lot on the St. Charles range	Bog manganese in 3 places each about 15 paces in diameter and 2 to 6 inches thick	Geol. Surv., Canada, Rept. of Prog. 1863-66, p. 45
11	Lotbinière co., St. Sylvestre par., seigniory of Gaspe, ½ mile southwest of the St.-Apollinaire church	Bed of manganese 20 feet across and 6 to 9 inches thick	Geol. Surv., Canada, Rept. of Prog. 1863-66, p. 45
12	Richmond co., Cleveland tp., lot 16, range XIII, in a ditch west of the Danville-Richmond road	Concretionary nodules mixed with clay in a deposit 7 yards long and 3 to 12 inches thick	Geol. Surv., Canada, Rept. of Prog. 1863-66, p. 45

Bog Manganese in Quebec—Concluded

	Locality	Character and extent	References
13	Richmond co., Cleveland tp., lot 6, range XIV	Specimen of very low-grade bog manganese gave on analysis less than 16 per cent MnO_2	Geol. Surv., Canada, Rept. of Prog. 1876-77, p. 476
14	Stanstead co., Stanstead tp., lot 24, range IV	Nodular masses in sand.......	Geol. Surv., Canada, Rept. of Prog. 1863, p. 752
15	Stanstead co., Stanstead tp., lot 9, range X	Patches or bodies 6 to 9 feet in diameter and 1 foot thick in the centre, consisting of nodular masses of manganese in sand. Patches extend over 20 acres. Analysis gives 37 per cent MnO_2	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 167 (1907). Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 113 (1891). Geol. Surv., Canada, Rept. of Prog. 1863, p. 752. Geol. Surv., Canada, Rept. of Prog. 1847, pp. 69-71
16	Stanstead co., seigniory of St. Mary at junction of Frampton road with that between ranges II and III	Bog manganese giving on analysis 30 per cent MnO_2 is in an area several yards in diameter and up to 2 feet thick	Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 113 (1891). Geol. Surv., Canada, Rept. of Prog. 1863, p. 752
17	Brome co., Bolton tp., in lot 20 or 22, range XII	Earthy manganese resting on clay slate and filling interstices in the slate. Analysis gives 26 per cent MnO_2. Deposit is several hundred square yards in area and 3 to 6 inches thick	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 167 (1907). Geol. Surv., Canada, Ann. Rept., vol. IV, pt. K, p. 113 (1891). Geol. Surv., Canada, Rept. of Prog. 1863, pp. 507, 752. Geol. Surv., Canada, Rept. of Prog. 1847, pp. 69-71
18	Brome co., Sutton tp..........	Specimen of ferruginous dolomite contained 7·65 per cent manganese carbonate	Geol. Surv., Canada, "Geology of Canada," 1863, pp. 508, 613. Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. G, p. 38
19	St. Maurice co., near St. Maurice	Bog iron and bog manganese intermixed	Geol. Surv., Canada, Rept. of Prog. 1863, p. 507

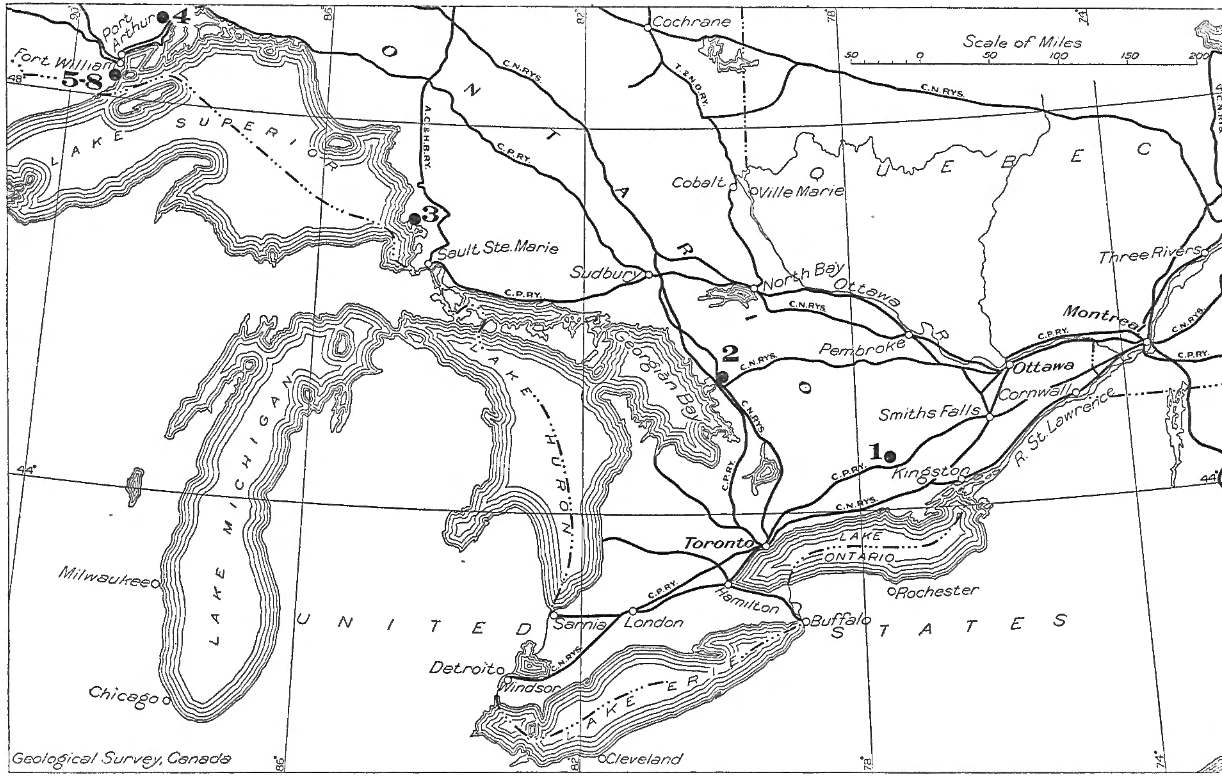

Figure 3. Index map showing location of manganese deposits in southern Ontario: 1, Madoc; 2, Parry Sound; 3, Batchawana bay; 4, Pearl; 5, McKellar island; 6, Silver islet; 7, Gunflint lake; 8, Sand lake.

ONTARIO

PEARL

By T. L. Tanton

Small deposits of manganese have been found about 30 miles northeast of Port Arthur. These occur at three localities in concession III, McTavish township, between 2 and 2¾ miles north of Pearl on the Canadian Pacific railway, from which station they may be reached by a trail.

The original discovery in this vicinity was made in 1926 by Mr. Fred Sanderson of Nipigon. In 1931, Mr. Alexander Mills, acting on information supplied by an Indian who had accompanied Mr. Sanderson at the time of his discovery, found manganese deposits in lots 3 and 4, concession III, McTavish township, and staked a block of ten claims in lots 3, 2, and 1, concession III, for Messrs. J. C. Dobie of Port Arthur and N. M. Patterson of Fort William, and associates. Development work in July, 1931, consisted of a few feet of stripping adjacent to the exposures.

In this region there are hills and ridges of early Precambrian granite rising 300 feet above the lowlands in which granite is overlain by patches, up to a few square miles in extent, of nearly flat-lying sediments of the Sibley series (late Precambrian). These rocks are intruded by diabase dykes. Pleistocene drift occurs as a mantle of irregular thickness over the area.

The most northerly occurrence of manganese is in the northeast quarter of lot 3, concession III, McTavish township. Here there is an inferred fault trending northeast in a drift-covered zone 50 feet or more wide. On the southeast side of this zone there is a cliff of Sibley conglomerate, and on the northwest side a steep slope on which is an exposure a few yards wide of a chert rock of the Sibley series, about 10 feet thick, unconformably overlying a large mass of granite that rises to the northwest in a high hill. In the chert rock adjacent to the drift-covered depression there is a shatter zone about 2 feet wide. Some of the fissures in it are cemented with quartz and one is occupied by a vein rich in manganese. This vein has an average width of 6 inches and an exposed length of 10 feet. It strikes north 25 degrees east and dips steeply towards the northwest. The vein pinches out towards the north, but apparently continues under the drift towards the southwest. Where last seen it is 8 inches wide.

The vein consists almost entirely of massive and finely crystalline black manganese minerals, identified by E. Poitevin of the Geological Survey as an intimate association of braunite and psilomelane. Locally in the vein there are small crystalline aggregates of barite and minor amounts of quartz.

A sample taken across the complete width of the vein was analysed by R. J. C. Fabry in the laboratories of the Geological Survey and the results follow.

Mn_2O_3	41·65
MnO	44·22
SiO_2	7·04
Fe_2O_3	0·70
Al_2O_3	0·14
TiO_2	None
CaO	1·48
MgO	0·14
Na_2O	0·64
K_2O	0·48
H_2O above 110°C	2·00
H_2O below 110°C	0·48
BaO	0·42
S	0·40
P_2O_5	0·36
Totals	100·15
Less oxygen equivalent of sulphur	0·36
	99·79

The second occurrence is in the southwest quarter of lot 3, 50 chains south of the first. Here, on the east side of a southerly flowing creek, there is a cliff of conglomerate 12 feet high. Between 6 and 8 feet from the top of the cliff is the manganese-bearing layer, a 2-foot bed in which many of the pebbles and sand grains are cemented by an intimate association of white barite, braunite, and other manganese minerals concentrated in streaks and irregularly shaped masses. The more common cementing material is fine-grained calcite. This layer has been traced along the cliff for 20 feet and is exposed in a boulder 15 feet in diameter that lies in the creek below the cliff.

The third occurrence of manganese is in the northwest quarter of lot 4, concession III, about ¼ mile south of the second occurrence. In the drift at this locality a few boulders, as much as 6 feet in diameter, of Sibley conglomerate, contain concentrations of manganese minerals as cementing material arranged as in the last-mentioned occurrence. The manganese-bearing part of the boulders measures 2 feet or less across the bedding. At one place a trench 11 feet long has been dug to a depth of 2 feet through the drift, exposing conglomerate in place, but where uncovered the cementing material consists of fine-grained calcite only. Selected material from a boulder has been found to contain, on analysis, 35 per cent manganese.

The vein deposit is a precipitate from solutions that probably rose along the fissures from an original mineralizing source at depth. The presence of diabase dykes in the vicinity suggests that the mineralizing source may have been the deep-seated magma from which the intrusives came. Previously known occurrences of manganese in this region, as, for example, in the vein at Silver islet, are believed to be genetically related to the diabase intrusives. The manganese deposits that occur as cement in the conglomerate were probably precipitates from manganese solutions of magmatic origin that came up along faults and spread laterally in porous layers intersected by the fissures; these mineralized solutions locally replaced limy material that had imperfectly cemented the conglomerate.

The deposits as exposed are of ore quality and it is possible that they extend for many yards beyond the known exposures. It is possible that wider veins and thicker beds, similarly mineralized, may be found in and adjacent to faults in the area. It would be necessary to find deposits in veins or layers much larger than those known in order to furnish sufficient tonnage of ore for profitable mining.

Other Manganese Occurrences in Ontario

	Location	Description	References
1	Hastings co., Madoc tp., lot 4, range V	Wad occurs in a ploughed field	Geol. Surv., Canada, Rept. of Prog. 1863-6, p. 107
2	Parry Sound district..........	Granite and pegmatite contain spessartite, a manganese-bearing garnet	Geol. Surv., Canada, Sum. Rept. 1921, pt. D, p. 60
3	Lake Superior, Batchawana bay, near southwest end of Upper Canada Mining Co. location. Not far from the shore	Manganite with quartz, calcite, and fluorspar occur in closely spaced stringers in a reddish lava flow. The whole makes a deposit 50 to 60 feet wide striking north. A specimen assayed 60 per cent MnO_2	Geol. Surv., Canada, "Geology of Canada," 1863, p. 751
5	Lake Superior, McKellar island	Argentiferous rhodochrosite occurs	Ont. Bureau of Mines, Rept. No. 2, p. 187 (1892)
6	Lake Superior, Silver islet.....	Manganese-bearing dolomite occurs and rhodochrosite is reported in silver-bearing veins	Ont. Bureau of Mines, Rept. No. 16, pt. 11, p. 48 (1905)
7	Lake Superior, Thunder Bay district, Gunflint lake	Manganese occurs in iron ore...	Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 168 (1907)
8	Pigeon River district, Sand lake Lake of the Woods, Big Stone Bay region, Golden Gate mine	Manganese occurs dispersed and in pockets in iron ore Pyrolusite reported in silver-bearing vein	Ont. Bureau of Mines, Rept. No. 2, p. 69 (1892) Ont. Bureau of Mines, Rept. No. 7, p. 112 (1897)

MANITOBA

NORTHWEST OF ROSEISLE

Reference: Wallace, R. C.: "The Mineral Resources of Manitoba", p. 37 (Winnipeg, 1927).

"Four miles northwest of Roseisle, on the northeast quarter of sec. 36, tp. 6, range 8, W., an occurrence of manganese has been discovered recently. It has been apparently deposited by springs issuing from the Pembina hills in the form of hydrous oxides, probably manganite and psilomelane, or wad. The manganese is found in the low swampy land at the base of the escarpment, partly overlain by 1 or 2 feet of soil and partly on the surface. Considerable proportions of limonite invariably accompany it. Insufficient work has been done to determine the economic possibilities of the deposit. An analysis of the best material showed: Mn. 26·96, Fe 13·11".

ALBERTA

NORTH FORK OF WILLOW CREEK

Reference: Ingall, E. D.: Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 168 (1907).

Manganese is reported to occur in tp. 5, range 1, W. 4th mer., on the north bank of the north fork of Willow creek. The manganese is said to occur in pockets in a honeycombed formation 4 or 5 feet thick composed of clay and sand. The deposit as a whole is estimated to contain 5 per cent manganese.

NORTHWEST TERRITORIES

NASTAPOKA ISLANDS

References: Bell, R.: "Report on an Exploration of the East Coast of Hudson's Bay"; Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. C, pp. 21, 22.
Low, A. P.: Geol. Surv., Canada, Ann. Rept., vol. XIII, pt. DD, pp. 9, 17-31, pt. D, p. 51 (1903).
Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 167 (1907).
Geol. Surv., Canada, Repts. of Prog.: 1875-76, p. 324; 1877-78, pt. G, pp. 46, 47.

The Nastapoka islands are a chain of islands extending for 120 miles along and close to the east coast of Hudson bay. They are formed of late Precambrian sediments with flows and sills of diabase, and dip seawards at low angles. The upper part of the sedimentary series is a siliceous "iron formation" consisting of several persistent zones, the upper of which is characterized by the presence of 20 to 50 per cent of ankerite in grains, in small patches, and in thin seams along the partings of the sediments. This carbonate according to Bell carries manganese, and a specimen analysed held:

	Per cent
Ferrous carbonate	52·70
Manganese carbonate	24·64
Calcium carbonate	Trace
Magnesium carbonate	11·81
Insoluble	10·94

On Flint island, Low states he saw fragments, 8 to 10 inches wide, of a quartz vein holding about 50 per cent manganiferous siderite. The vein could not be found, but the fragments indicated it was narrow.

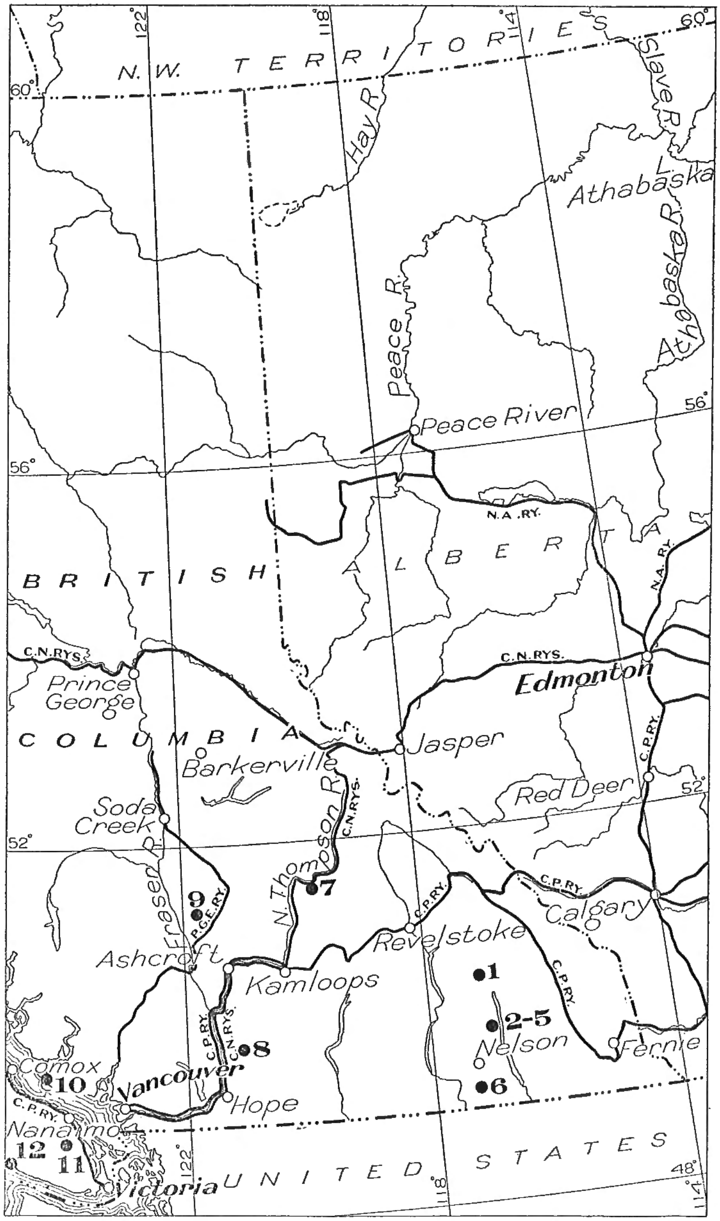

Figure 4. Index map showing location of manganese deposits in southern British Columbia: 1, Sproat mountain; 2, Manganese group; 3, Harp group; 4, Contact claim; 5, Nelson; 6, Ymir; 7, Birch island; 8, Boston Bar creek; 9, Clinton; 10, Texada island; 11, Cowichan lake; 12, Vargas island.

BRITISH COLUMBIA

SPROAT MOUNTAIN

Reference: Bancroft, M. F.: "Lardeau Map-area, B.C."; Geol. Surv., Canada, Sum. Rept. 1921, pt. A, p. 111.

Sproat mountain is 6 miles north of Arrowhead near the head of upper Arrow lake.

"Carbonates that show on weathering a considerable content of manganese occur in grey quartzites bordering a body of serpentine rock on the west slope of Sproat mountain. 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. The ground in this locality was staked several years ago for asbestos, which occurs in the altered serpentine rock.

Several small open-cuts have been made showing the character of the manganese ore. Samples taken from the surface this season by the writer 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 in composition, others nearer to mangancalcite or mangansiderite. The specific gravity varies from 3·30 to 3·40, and the optical properties indicate that the material is not of uniform composition. About 20 per cent of the material is unattacked by hydrochloric and nitric acids. The microscopic residue appears to be a quartz. A few quartz crystals coated with manganese oxides appear encrusted on one of the specimens.

The hydrous manganese oxides coating the carbonates are admixed with certain quantities of limonite. It is evident that the manganese oxides were derived from the transformation of the carbonates'."

MANGANESE GROUP

By C. E. Cairnes

References: Bancroft, M. F.: Geol. Surv., Canada, Sum Rept. 1917, pt. B, pp. 30-33.
Ann. Repts., Minister of Mines, B.C.: 1917, pp. 156, 185; 1918, pp. 160-161; 1919, facing 120 (two illustrations "Curle's Manganese Deposit, Kaslo").
Nash, A. D.: Private report.

The Manganese group, comprising Manganese and Manganese No. 1 Crown-granted claims and the Manganese Nos. 2, 3, and 4 and Cantan claims held by location, is on the lower eastern slope of Kaslo Creek valley about 2 miles above Zwicky and 7 miles by rail from Kaslo. The property was staked in July, 1917, and is owned by A. J. Curle, Kaslo, B.C. It is traversed by the Kaslo-Nakusp branch of the Canadian Pacific railway and by the new highway between Kootenay and Slocan lakes.

Records of production are incomplete, but are stated by Mr. Curle to include over 1,000 tons, of which between 850 and 900 tons are credited to operations by Col. F. B. Millard of Spokane who had a lease and bond on the property in 1918. This ore was shipped to Carnegie Steel Company, Evanston, Ill., and is stated to have carried between 45 and 50 per cent metallic manganese. Later, in 1918, Curle shipped one carload, about 50 tons, to Trail and another carload to the Bilrowe Alloys Company, Tacoma. A sample lot of 30 tons extracted in 1917 from an area of 684 square feet averaged 43 per cent metallic manganese.

The property extends from the bottom of Kaslo Creek valley easterly over a series of benches and up the steeper valley slopes to an elevation of about 1,600 feet above Kaslo creek. In the valley bottom and up the slope to a maximum height of about 400 feet, the underlying rocks are platy to slaty, black or rusty-weathering argillites of the Slocan series dipping at about 65 degrees southwest. These rocks are underlain on the east by greenstones of the Kaslo series, which occupy the slope to a height of between 900 and 1,000 feet above Kaslo creek. East of the volcanics is a band about 1,500 feet wide of underlying sedimentary rocks of the Milford group. East of the band of sediments, the Kaslo series is repeated by reason of a fold and extends from the upper limits of the property to the summit of Blue ridge.

Overlying the solid formations and concentrated particularly on the lower slopes is an irregular but mostly heavy accumulation of Glacial and post-Glacial drift from which the succession of terraces or benches have been carved. The manganese deposits occur in the drift.

The manganese deposits that have been developed to date occur chiefly on Manganese and Manganese No. 1 claims and mostly occupy a single bench at an elevation of about 375 feet above the railway. Other occurrences have been noted at lower and at somewhat higher elevations, but to date either have not proved economically important or have not been sufficiently investigated to permit pronouncing upon their possibilities.

These deposits consist of different forms of wad or bog manganese interstratified with, but generally fairly distinct from, varying proportions of hydrous iron oxides, calcareous tufa or sinter, and layers of clayey subsoil. The developed deposits occupy two principal areas, one on each of the two claims mentioned above. These areas are of irregular outline, that on Manganese claim covering about 5½ and that on Manganese No. 1 claim over 2½ acres, respectively. Within these areas the bog manganese varies from less than an inch to 3 feet in thickness. Production to date has come entirely from the more extensive area on Manganese claim and has exhausted most of the higher grade material.

The deposits have formed in swampy ground fed by mineral springs charged with carbonic acid and carrying manganese, lime, and iron. On reaching the surface in the swampy areas, the carbon dioxide of the spring waters partly escaped and the contained manganese and iron carbonates were precipitated and almost immediately oxidized to form hydrous oxides. In much the same way the lime carbonate was, on escape of the excess carbonic acid gas, deposited to form sinter deposits of calcareous tufa. Due to differences in the relative solubilities of these different substances and to variations in local conditions, the tendency has been for each to form more or less separately from the others.

The various types of wad in these deposits have been classified by Bancroft as follows: (1) unconsolidated wad forming the surface soil, in places covered by a thin layer of wood ash due to forest fires; (2) layers of partly consolidated wad associated with other deposits; (3) hummock-like deposits, formed near mineral springs, having abrupt lateral limits; and (4) nodules and concretions of wad in beds of unconsolidated detrital material, the manganese content in the form of nodules being due to admixture consequent upon mechanical disintegration, transportation, and deposition of debris through surface erosion, and in this surface waste, manganese oxide, chemically precipitated, acts as a cement, binds together portions of the detrital material, coats pebbles, forms concretions about organic remains, and exhibits all degrees of dissemination.

Of these types, No. 2, "layers of partly consolidated wad", forms the highest grade material but occurs in relatively small proportion to type No. 1, "unconsolidated wad", which is the material of principal economic interest. Analyses of both types are given below. Type No. 2 has a porous, clinkery appearance much resembling that of coke. Type No. 4 is quite different in character, being composed largely of foreign matter including sand and pebbles. A large specimen of such material obtained from a stratum 6 inches thick occurring at a depth of several feet in partly consolidated bench materials was assayed by the Mines Branch, Ottawa, and found to carry 10·06 per cent metallic manganese.

An estimate of the amount of wad in the deposit of Manganese No. 1 claim was made by the writer. It has an area of 2·58 acres. Very many holes had been sunk by Mr. Curle to the bottom of the deposit and some one hundred and seventy-seven of these were sampled and the samples combined to form two large composite samples, one of the soft, unconsolidated wad and the other of the so-called "high-grade" or partly consolidated material. The one hundred and seventy-seven holes, though irregularly spaced, were regarded as representing a fair average of the whole deposit. In these holes the wad has a thickness varying from less than an inch to 33 inches and averages 13 inches of unconsolidated material (*See* Analysis A). The more consolidated wad was only found in fifty-three of the holes and was roughly estimated to form one-tenth of the total amount of the unconsolidated wad (*See* Analysis B). Assuming that 1,000 cubic feet weighs 18·56 tons, it was calculated that the amount of unconsolidated material within the surveyed area amounted to about 2,270 short tons and that the amount of high-grade present would bring the total tonnage up to nearly 2,500. Wad has been found at a number of places close to but outside of the surveyed area, but has not been sufficiently investigated to permit any estimate of tonnage. On the other hand the estimate of 2,500 tons does not represent available tonnage within the area surveyed, as in the first place the material is capable of practical excavation only where it has a reasonable thickness and, in the second place, there would doubtless be a very considerable waste in actual operations.

The other principal deposit occurs on Manganese claim and is the one that has supplied production to date. It has not been entirely exhausted, though most of the better-grade material has been removed. No estimate of the remaining tonnage was made, but Mr. Curle is of the opinion that between 700 and 800 tons are still left and that this would probably average 30 per cent manganese.

Aside from these two main occurrences, there is a showing of wad on the slope of the lowest terrace above the railway on Manganese claim where some high-grade consoldater wad overlies bouder clay and is capped by several feet of calcareous tufa.

The following analyses by A. Sadler of the Mines Branch are of the composite samples of unconsolidated (A) and consolidated (B) wad mentioned in a previous paragraph.

—	A	B
Mn	(31·57)	50·10
MnO_2	49·94	(79·25)
SiO_2	12·03	....
Fe_2O_3	3·75	0·76
P_2O_5	0·21	....
NiO	0·22	....
CO	0·013	....
CaO	3·40	....
MgO	0·72	....
S	0·045	....
CO_2	6·44	....
H_2O (+ 105°)	10·80	....
Insoluble	....	2·57

From these analyses it will be seen that the wad of sample A, representing the bulk of the deposit on Manganese No. 1 claim, is low grade, carrying an abundance of impurities of which lime and magnesian carbonates, iron (limonite), and silica (probably chiefly quartz) are the most abundant. Wad carrying such a low percentage of manganese would be of doubtful commercial value unless some method of concentration be adopted or, in excavation, care be constantly taken to extract only the better-grade material. Sample " B " on the other hand is high-grade ore and is readily separated from the lower-grade material. The possibilities of these deposits depend, of course, on the market price of manganese, and cost of production. The chance of developing a larger tonnage by further explorations seems reasonably good and transportation facilities are exceptionally convenient.

On the Manganese No. 4 claim, of the Manganese group, at an elevation of about 1,600 feet above the railway, near the upper contact of a belt of sediments of the Milford group with greenstones of the Kaslo series, there is an open-cut 60 feet long, in altered, banded, quartzitic, and argillaceous sediments; it exposes an irregular zone conforming in its northwesterly strike with that of the sediments, in which lenses of barren-looking quartz occur and in which the sediments across a width of several feet are weathered brown, dark brown, and black as a result of the decomposition of contained iron and manganese minerals. The sediments are chiefly quartzitic types carrying varying proportions of black and reddish oxides and, locally, abundant grains of a manganiferous garnet (spessartite?) that are commonly surrounded by rims of black manganese oxide. Most specimens show an abundance of tiny crystals, commonly diamond shaped and possessing high relief, of another manganese mineral, probably either braunite or hausmannite. A general sample of this manganiferous deposit was taken by Mr. Curle who reports that the assay returns gave 14·08 per cent manganese, 15·3 per cent iron, and 38·64 per cent silica.

The source of the bog manganese on Manganese and Manganese No. 1 claims may be referred with some confidence to rock formations traversed by the streams draining the slopes of the Blue ridge to the east of the property. These slopes are underlain chiefly by greenstones of the Kaslo series and this series has, in earlier accounts, been regarded as the source from which the iron, calcium, and manganese have been obtained to be deposited later as limonite, calcareous tufa, and wad. This interpretation can hardly be entirely correct since the Milford sediments also outcrop on the Blue Ridge slope and manganese occurs in at least one zone within these sediments. That the deposition of wad near the valley bottom must have been in progress for a considerable time is indicated by the amount of material at the surface and the fact that thin deposits have also been found interstratified with underlying bench materials. The swampy conditions that permitted the accumulation of wad have disappeared since the removal of the protective covering of forest vegetation. Elsewhere in the lower course of Kaslo valley swampy conditions still exist on a small scale and in the vicinity of springs a rapid accumulation of iron oxides and calcareous tufa is taking place. At one locality about a mile from the wad deposits, and on the same side of the valley, the tufa so forming carries some manganese.

HARP GROUP

By C. E. Cairnes

Reference: Bancroft, M. F.: Geol. Surv., Canada, Sum. Rept. 1917, pt. B, p. 30. Ann. Rept., Minister of Mines, B.C., 1918, p. 161.

Manganiferous deposits occur on the Harp group, owned by W. J. Murphy of Kaslo and situated less than a mile east of and about 350 feet above Zwicky. On this property some work has been done on a series of quartz veins. They occur in sedimentary rocks or along contacts of the sediments with greenstone schists, and strike northwest to north and dip steeply west in conformity with the attitudes of the enclosing strata. They consist of vitreous to smoky quartz with considerable sericite, impregnated with varying amounts of pyrrhotite, pyrite, and chalcopyrite.

One vein explored by surface work and a short adit has attracted attention since the wall-rocks, particularly on the foot-wall side, carry abundant pink rhodonite, in lens-like masses associated chiefly with abundant finely crystalline calcite or other carbonate, quartz, and secondary manganese oxides. The foot-wall rock of this vein is chiefly a greenish schist forming a belt about 2 feet wide enclosed in sedimentary rocks. The hanging-wall is a banded quartzitic argillite composed chiefly of quartz and a manganiferous garnet which is partly altered to oxide of manganese. The rhodonite-bearing greenish schist much resembles a siliceous limestone and is composed of quartz, calcite, a little garnet, considerable graphite (or pyrolusite), and abundant rhodonite, the latter occurring in masses, streaks, and disseminations, in places having a width of several inches. The origin of this rhodonite is somewhat obscure, but it appears to have developed by either hydrothermal or thermal metamorphism of some primary manganese mineral, possibly rhodochrosite.

A considerable amount of float similar to this rhodonite-bearing rock has been found at a number of points along the slope of the hill to the north of this property.[1] These blocks of float are commonly partly coated with manganese oxide and some carry quite a little graphite (or pyrolusite) smeared along fracture planes. Aside from the abundant rhodonite, the composition of these float boulders and of the specimens from the Harp group much resemble the siliceous limestone forming part of that heavy belt of limestone situated near the base of the Milford group and conspicuously exposed in bluffs above the railway and highway about 2 miles southeast of Zwicky. The same limestone belt is believed to extend through the Harp group is not a vein mineral but that it is secondary after some limestone were noticed, and may also form part of the body of Milford rocks exposed on Manganese No. 4 claim of the Manganese group. In places this limestone carries considerable graphite and was also observed to carry occasional small, pinkish, fine-grained masses of some mineral much resembling either rhodonite or rhodochrosite. The inference from such associations and resemblances is that the rhodonite as developed on the Harp group is not a vein mineral but that it is secondary after some primary manganese mineral, probably rhodochrosite, deposited during the formation of these siliceous limestones and, subsequently, by metamorphic processes, involving probably reactions with hydrothermal solutions, transformed to rhodonite and, to a lesser degree, manganese-bearing garnet. Similarly the manganese content of other sedimentary rocks such as occur on the Harp group and on the Manganese No. 4 claim has probably developed from primary manganese carbonate deposited with the sediments and subsequently altered to constituents now found in these rocks.

CONTACT (BLACK PRINCE) CLAIM

By C. E. Cairnes

The Contact claim, formerly known as the Black Prince, is the property of A. J. Curle, Kaslo, B.C. It is on the lower southwestern slope of Kaslo Creek valley about 14½ miles by rail from Kaslo and 200 feet above the railway.

Interest in this property is centred on the mineralization of a belt of limestone about 150 feet thick, striking north 35 degrees west and dipping southwest at 45 or 50 degrees. The limestone is a member of the Slocan series and on this property is interbedded with shaly and slaty, dark grey to brownish, argillaceous rocks. These sediments are intruded within a few hundred feet of the workings by at least one porphyritic body of uncertain, but apparently small, dimensions. The limestone bed appears to be continuous to the northwest with a heavy stratum exposed near the mouth of Lyle creek, and is probably the same bed as that encountered still farther northwest in the underground workings at Whitewater Deep mine.

[1]Mr. A. J. Curle, of Kaslo, B.C., reports that an analysis of a specimen of this rhodonite gave 27·43 per cent manganese, whereas theoretically pure rhodonite ($MnSiO_3$) would carry 42 per cent. A specimen examined by E. Poitevin of the Geological Survey was reported by him as being "Calciferous rhodonite, that is, rhodonite impure due to the presence of calcium and iron carbonate."

On the Contact claim this limestone has been extensively replaced, particularly along the hanging-wall side, by manganiferous siderite which is extensively oxidized near the surface and carries here and there a little sulphide mineralization including galena, blende, and pyrite.

The workings include two adits and a great deal of surface trenching and stripping. This work has been designed chiefly to investigate the extent and character of the mineralization along the hanging-wall side of the limestone belt and has been sufficient to prove the continuity of a body of more or less oxidized spathic iron over a distance of at least 200, and probably more than 600, feet. Its thickness where most closely investigated, above and to the west of the underground workings, would average at least 20 feet and in one trench it is reported that this spathic body has widened to 90 feet. The adits are 50 feet apart vertically. The upper one, 170 feet long, encounters the spathic body near the portal and the lower one has intersected it near the face, 170 feet from the portal. An open-cut along the foot-wall of the limestone has disclosed very similar mineralization across a width of 30 feet, but the linear extent of this body has not been investigated.

These discoveries have attracted attention partly because of the size and manganiferous character of the siderite deposits and partly because of the possibilities which associated lead and zinc minerals afford. At the surface the spathic iron has been largely altered to oxides of iron and manganese (analysis No. 2), but at a depth of a few feet (as indicated by analysis No. 1), this alteration is comparatively slight. The following analyses by the Mines Branch, Ottawa, illustrate the character of the siderite as exposed at the surface and in the upper adit.

—	No. 1	No. 2	No. 3
Mn	10·03	(12·15)[1]	8·36
MnO	....	None	....
MnO_2	(15·86)	19·23	(13·22)
SiO_2	....	8·04	....
Fe_2O_3	43·56	59·93	62·66
P_2O_5	....	0·11	....
NiO	....	None	....
CoO	....	None	....
CaO	4·20	0·42	None
MgO	2·62	0·08	0·20
S	....	0·10	....
CO_2	36·30	0·76	....
H_2O (+ 105° C.)	....	8·92	....

No. 1. Sample of only slightly oxidized manganiferous siderite from the face of No. 1 adit.
No. 2. Sample of oxidized manganiferous siderite taken across a width of 15½ feet exposed in a trench above the portal of the upper adit.
No. 3. Composite sample of oxidized manganiferous siderite taken from several trenches in vicinity and west of the underground workings.

[1] Figures in brackets have been calculated from the analyses.

From analysis No. 1, A. Sadler of the Mines Branch has calculated the composition of the less altered siderite in terms of the carbonates that compose it, as follows:

	Per cent
Iron carbonate	63·20
Lime carbonate	7·49
Magnesian carbonate	5·47
Manganese carbonate	20·98

BIRCH ISLAND MANGANESE DEPOSITS

References: Ann. Rept., Minister of Mines, B.C., 1930, p. 193.
Ann. Rept., Minister of Mines, B.C., 1929, p. 224.

Manganese occurs on the Smuggler group of mineral claims on the south side of North Thompson river at Birch island. The manganese occurs as oxides mixed with soil and vegetation and is referred to in reports as a subsoil from 3 to 8 feet deep. Pits have been dug in the deposit. The manganese has probably been deposited from springs. Higher on the hillside altered rocks at the contact between sediments and granite contain some manganese-bearing minerals and may have been the source of the manganese oxides.

CLINTON

Reference: Reinecke, L.: "Mineral Deposits Between Lillooet and Prince George"; Geol. Surv., Canada, Mem. 118, p. 95 (1920).

The only description of the Clinton manganese deposit is contained in the above-mentioned report by Reinecke who visited the occurrence in 1918. Reinecke states that the claim is some 10 miles northeast of Clinton. The deposit occurs on one of the foothills of Marble mountains about 2 miles north of Clinton creek and may be reached by an old trail from Clinton. The owner in 1918 was W. Murray of New Westminster, B.C. Shortly after 1918 the claim was allowed to lapse. The ores were seen in an open-cut 38 feet long by 4 feet wide and from 5 to 7 feet deep, on the east slope of a hill some 100 feet below its summit. For several hundred yards on all sides of the open-cut, the rock is drift covered. The ore occurs in argillites and quartzites of the Cache Creek series. The following, ascending section was seen in the open-cut: (a) thin-bedded, siliceous argillite in ¼- to ¾-inch beds, 12 feet; (*b*) bluish grey, dense quartzite cut by quartz stringers and impregnated in an irregular manner with black manganese, 20 feet; (*c*) greenish white beds of quartzite 1 to 2 inches thick, 4 to 5 feet. The general strike of the beds is north 55 degrees west, dip 40 degrees to 70 degrees to the southwest.

The ore minerals are psilomelane, manganite, and pyrolusite. A fault occurs between zones (*a*) and (*b*) accompanied by much alteration of the rock to clay, in which the best ore seems to lie. Stringers of quartz cut across the bluish grey quartzite of zone (*b*) and they are accompanied by nodules and irregular masses of the black ore. The ore is also concentrated near fracture planes where the rock is in many places altered to clay. A few stringers of ore occur in zone (*c*), but most of the ore is in the lower 15 feet of zone (*b*).

The ore seems to have been introduced into the quartzite with the quartz veins and to have impregnated the country rock in an irregular manner. It has been enriched in places by leaching away of the country rock by surface waters.

Reinecke took a sample representing the first 4 feet of the wall from the floor of the open-cut upwards, and across the lower 15 feet of zone (*b*). The result of an assay of this sample by F. W. Baridon was as follows:

	Per cent
Manganese	7·57
Silica	82·57
Phosphorus	0·018

The high percentage of silica is due as much to the country rock included in the sample as to quartz gangue. The ore is too low in manganese and much too high in silica to be of commercial value.

COWICHAN LAKE

References: Mackenzie, G. C.: "Manganese"; Mun. Res. Comm., Canada, Final Rept., pp. 90-95 (1920).
Ann. Repts., Minister of Mines, B.C.: 1920, p. 24; 1919, pp. 237, 238; 1918, pp. 296-298.

Photographs of the outcrop of the manganese ore on the "Hill 60" group of claims are included in the report of the Munition Resources Commission and also in the report of the Minister of Mines of British Columbia for 1918. Plans showing the location of manganese assay samples are given in the report of the Munition Resources Commission and also in the report of the Minister of Mines of British Columbia for 1919.

Three groups of claims, the Hill 60, Cottonwood, and Black Prince have been staked on manganese deposits on the northeast side of Cowichan lake, Victoria mining division, Vancouver island. The mineral deposits are several miles from the lake and are in a line parallel to the northeast shore. The Hill 60 group is east of the foot of Cowichan lake. The Cottonwood group is 12 miles northwest and is east of the centre of the lake. The Black Prince group is 12 miles northwest of the Cottonwood group and is north of the north end of the lake.

The general geology of southern Vancouver island was studied some years ago by Clapp.[1] The map that accompanies Clapp's report shows that the rocks in the vicinity of Cowichan lake are chiefly members of the Vancouver volcanics. Northeast of the lake is a northwesterly-trending band several miles wide of metamorphosed sedimentary and volcanic rocks known as the Sicker series. The Sicker series and the Vancouver volcanics are part of the Vancouver group of formations and are probably of Jurassic or Triassic age. Stocks and small batholiths of granodiorite

[1]Clapp, C. H.: "Southern Vancouver Island"; Geol. Surv., Canada, Mem. 13 (1912).

intrude the Vancouver group in several places in the vicinity of Cowichan lake. Clapp states that the sedimentary part of the Sicker series contains, among many other rock types, bands of cherts and jaspery magnetite schists. These are grey to reddish, fine-grained, stratified rocks.

The manganese deposits at Hill 60 and Black Prince groups are in cherty quartzites and are distinctly bedded rocks, pink to red in colour. The Cottonwood group may be in similar rocks but has not been described. Rhodonite, which is pink, occurs in the cherty quartzite near the manganese deposits, and is probably the cause of the pink colour of the rock. The cherty quartzite may be similar in many ways to the cherts and jaspery magnetite schists described by Clapp, and it is quite possible that some of the strata seen by him are manganiferous. The strike of the cherty quartzite band is north 50 degrees west to north 70 degrees west and the dip is at variable angles southwestward. Although the manganiferous beds of quartzite at the Hill 60 and at the Black Prince groups of claims have not been proved to be one and the same bed, they are probably the same bed or similar parallel beds at approximately the same geological horizon.

Hill 60 Group

The Hill 60 group is 5 miles east of the foot of Cowichan lake and 2,000 feet above sea-level, near the summit of a low mountain. A wagon road connects the property with the Cowichan Lake extension of the Esquimalt and Nanaimo railway. The property has been idle for a number of years so the road is in disrepair, and as several logging roads have been constructed recently in the vicinity, the roads may be confused.

The Hill 60 manganese deposit was discovered and staked in 1918. In 1919, ownership of the property was acquired by the British Columbia Manganese Company, Limited. This company commenced mining immediately and mined 530 tons in 1919 and 587 tons in 1920.[1] The ore was shipped to the Bilrowe Alloys Company in Tacoma, Wash., U.S.A., the first shipment averaging 50 per cent manganese and about 19 per cent silica,[2] and the second over 50 per cent manganese and less than 20 per cent silica.[3] The ore-shoot was mined out in 1920 and although some exploration was carried out in search of other ore-bodies, none was found large enough to warrant resumption of mining. The property has remained idle since 1920.

The rocks in the vicinity are quartzites of the Sicker series. A diorite stock outcrops about half a mile away. The quartzites show ill-defined bedding which strikes north 70 degrees west and dips steeply south. The ore-shoot was contained in a bed of pink, cherty quartzite, commonly stained black on the surface, and containing narrow beds of black manganese oxides. Thin sections of the rock show that rhodonite is plentiful, so the pink colour of the bed is probably due to this. The quartz grains in the quartzite contain clouds of minute inclusions which may be garnets

[1]Personal communication from J. D. Galloway, Provincial Mineralogist of British Columbia.
[2]Ann. Rept., Minister of Mines, B.C., 1919, p. 237.
[3]Ann. Rept., Minister of Mines, B.C., 1920, p. 24.

but which could not be identified with certainty. The ore-body is cut by a green lamprophyre dyke 2 feet wide and the dyke has been offset 6 feet by a later fault.

The ore-shoot was about 20 feet wide at the surface, 40 feet long, and 30 feet deep, and was simply a hard, black body enclosed on the sides by quartzites and grading at the ends into reddish, rhodonite-bearing, cherty quartzite. Mackenzie, who examined the property before the ore was mined, says, " The ore consists mainly of a mixture of hard, compact oxides of manganese grading from highly siliceous material along the walls containing less than 40 per cent metallic manganese to a relatively pure oxide at the centre of the body containing over 48 per cent metallic manganese." [1] The bottom of the ore-shoot was wedge-shaped, whereas the ends interfingered with quartzite. Narrow bands of black manganese oxides a few inches to 2 feet wide extend along the strike of the rhodonite-bearing bed, but no other ore-shoot has been found. Rhodonite is plentiful in the leaner parts of the ore-body. The dyke does not contain rhodonite but does contain narrow films of manganese oxides and is in all likelihood later than the rhodonite but earlier than some of the manganese oxide. The minerals in the ore have not been identified, but psilomelane is probably the chief ore mineral.

Twenty-five analyses of the ore and a plan showing their location are given on page 95 of the report by the Munition Resources Commission. The highest-grade sample contained 57·15 per cent manganese, 10·04 per cent silica, 0·87 per cent iron, 0·047 per cent phosphorus, and 0·085 per cent sulphur. The average analysis is 43·78 per cent manganese, 23·28 per cent silica, 1·55 per cent iron, 0·064 per cent phosphorus, and 0·10 per cent sulphur. Moisture or water is not recorded in the analyses, but on page 90 of the same report it is stated that a sample of highly oxidized ore contained 2·5 per cent water.

Cottonwood Group

The following statements are from page 92 of the report by the Munition Resources Commission. These three claims are situated near the headwaters of Cottonwood creek which enters Cowichan lake about half-way along its north shore. They comprise 120 acres on which the manganese zone has been prospected to some small extent, but no development work accomplished. These claims were not examined, but it is understood that though possessing potential value the outcrops of ore are not as good as those on the Hill 60 group.

Black Prince Group

The Black Prince group is 7 miles north of the north end of Cowichan lake, near the headwaters of Shaw creek. The manganese occurs as narrow black bands in a bed of cherty quartzite which is very similar to and may be the same bed as that exposed on the Hill 60 group. The strike of the bed is north 50 degrees west and the dip is 30 degrees southwest. Accord-

[1] Mun. Res. Comm., Canada, Final Rept., p. 91 (1920).

ing to the Annual Report of the Minister of Mines, B.C., 1919, page 298, the ore appears to be in part of a residual character and in part fills a fissure. Analyses of the deposit over a width of 47 feet are quoted in the report of the Munition Resources Commission. The manganese content varies from 23 to 40 per cent and the silica from 30 to 57 per cent. Samples consisting of 430 pounds of the material were tested in the ore dressing laboratories of the Department of Mines, Ottawa, and it was discovered that ordinary specific gravity methods of separation would not liberate a commercial product. The report on the mill test is included in the report of the Munition Resources Commission.

In the case of the Hill 60 group it is probable that the ore resulted from the concentration of manganese from manganese-bearing rock through the solution and removal of the non-manganiferous parts of the rock, and also by replacement. The rocks of the area were originally siliceous sandstones containing one or more highly manganiferous beds. Through intense regional metamorphism the sandstones were changed to quartzites and the manganese became crystallized into manganese silicates such as rhodonite. On exposure to the forces of oxidation and solution the manganese silicates were broken up, the silica carried away in solution, and the manganese left in part as a residual deposit. The manganese is not entirely residual in origin as some would be carried in solution and deposited below in fractures, as in the lamprophyre dyke, or by the replacement of other rocks or minerals. Except for deposits of wad, manganese ore deposits will, probably, be found only in the manganese-bearing rock.

In the Annual Report of the Minister of Mines of British Columbia for 1918 it is stated that,

> "Sufficient work has not yet been done to determine whether the deposits of manganese ore are residual or whether they occur as replacement deposits in the jasperized rock and occupy fissures in the sheared portion of the belt of rocks. The latter theory would appear, from the conditions at present shown by the shallow work that has been done, to be the more tenable, and if such prove to be the case it is reasonable to presume that the ore deposits may possibly maintain continuity to some considerable depth, as the shearing movement appears to be widespread and deep-seated." [1]

In regions where climatic conditions have been favourable for the formation of manganese oxides for a considerable period of time fairly deep deposits result, but nevertheless they will be clearly linked up with the surface. Where glaciation has removed most of the pre-glacial products of oxidation, as it has in Canada, no deep residual manganese deposits are to be expected.

The origin of the Black Prince and Cottonwood deposits is probably similar to that of the Hill 60 deposit.

The bed of rhodonite-bearing quartzite is probably the source of the manganese ore, the deposits are most likely the result of weathering and solution and if so will be restricted rather closely to the surface. Manganese ores then will be found only in manganese-bearing rocks and will not

[1]Ann. Rept., Minister of Mines, B.C., 1918, pp. 296-297.

extend far below the surface. It is quite likely, however, that several manganese deposits occur along the outcrop of the rhodonite-bearing bed of quartzite and some of these may be large enough for profitable mining.

VARGAS ISLAND

Reference: Dolmage, V.: "West Coast of Vancouver Island between Barkley and Quatsino Sounds"; Geol. Surv., Canada, Sum. Rept. 1920, pt. A, p. 22.

The Vargas Island manganese deposits have been described only by Dolmage. His report is quoted below in full.

"On Vargas island, about 2 miles inland from the north shore, a deposit containing considerable manganese was recently discovered by Mr. Hovelaque of Clayoquot. As yet only a small amount of work has been done, and the highest assays obtained showed not over 15 per cent manganese which is much too low to be considered of economic value.

The deposit occurs less than 50 feet above sea-level in a low swampy area underlain by a band of cherty, ferruginous tuffs of the Vancouver group, which have been sheared and slickensided, and are strongly weathered to a depth of 10 feet or more. The weathered rocks contain much limonite, and some pyrolusite which forms films on the shear planes.

The area underlain by the sheared tuffs is quite extensive, and future work may disclose areas having sufficiently high proportions of manganese to enable it to be mined at a profit. The deposit is interesting because it is the first discovery of this metal on the west coast."

Manganese Occurrences in British Columbia

	Locality	Character and extent	References
5	Free Silver group of claims, Nelson mining division	A shipment of several hundred pounds of manganese ore is reported to have been sent to Nelson for use in the French electrolytic zinc process	Ann. Rept., Minister of Mines, B.C., 1915, p. 155
6	Ymir district, Nelson mining division	Thin films of manganese oxide occur in quartz veins in the Nelson granite	Geol. Surv., Canada, Mem. 94, p. 57 (1917)
8	Four miles east of mouth of Boston Bar creek between Cedar creek and Coquihalla river, Yale mining division	Manganese deposit reported...	Geol. Surv., Canada, Sum. Rept. 1920, pt. A, p. 38
10	Prescott mine, Texada island, Nanaimo mining division	Magnetite of the Prescott mine contains 0·08 per cent manganese	Geol. Surv., Canada, Mem. 58, p. 84 (1914)
	Prosperity group of mineral claims, Portland Canal mining division	Manganese occurs in the oxidized outcrop of metalliferous ore deposits	Geol. Surv., Canada, Mem. 159, p. 60 (1929)
	Silver Bell group of claims, Nass River mining division	The oxidized part of a mineralized rock contains 3·5 per cent manganese	Ann. Rept., Minister of Mines, B.C., 1918, p. 72
	Humming Bird claim, Omineca mining division	Pyrolusite occurs in the oxidized outcrop of a mineral deposit	Geol. Surv., Canada, Sum. Rept. 1908, p. 45
	Owen Lake mine, Owen lake, Omineca mining division	Rhodochrosite is a common gangue mineral in a metalliferous deposit	Geol. Surv., Canada, Sum. Rept. 1929, pt. A, p. 77

YUKON

Reference: Cockfield, W. E.: "Silver-lead Deposits of the Keno Hill Area, Mayo District, Yukon"; Geol. Surv., Canada, Sum. Rept. 1920, pt. A.

Manganese is present in some of the silver-lead veins at Keno Hill.