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THE MANGANESE OCCURRENCES OF THE MARITIME PROVINCES, CANADA.

by

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THE MANGANESE OCCURRENCES OF THE MARITIME PROVINCES, CANADA.

CHAPTER I

I INTRODUCTION

In 1925 Dr. W. L. Uglow investigated the manganese occurrences of the Maritime Provinces but due to his untimely death in 1926 the report was not completed. In 1927 the Geological Survey of Canada commissioned the present writer to re-examine the deposits and complete the work initiated by Dr. Uglow. To this end the summer months of June, July, and August, 1927, were spent in visiting the various localities in Nova Scotia and New Brunswick in which manganese has been reported as occurring and gathering data relating to their occurrence and economic aspect.

II ACKNOWLEDGMENTS

Acknowledgment is freely made of access to the notes of Dr. Uglow, compiled during 1925 on the manganese occurrences, and these were of no little value to the writer during his investigation. Thanks are due to Mr. Flynn,

Department of Natural Resources, Halifax; Dr. Lavers, New Ross; Mr. Graham, Registrar of Deeds, Windsor; Mr. A. Parons, M.P.P., Walton; Mr. W. F. Stephens, Tennycape; Mr. R. E. Chambers, New Glasgow; Mr. G. Ross, Sydney; Mr. Bligh, Hillsboro; Professor M. F. Bancroft, and W. A. Bishop, Wolfville; and Mr. W. E. McMullen, Inspector of Mines, Frederickton, for the assistance and information which they gave the writer during his field work. Thanks are equally due to the inhabitants of the various localities; their courtesy and hospitality were greatly appreciated.

The assistance and cooperation of the various members of the Department of Geology, Mass.Inst.Technology, during the laboratory investigation are acknowledged with thanks. Facilities for obtaining the X-ray spectra photographs were obtained through the kindness of Professor J. T. Norton, Department of Physics.

The writer is truly grateful for the guidance and council of Doctor Waldemar Lindgren, Department of Geology, Mass.Inst.Technology, under whom this thesis was written.

III HISTORICAL SKETCH

Since early Egyptian time manganese ore has been used in glass making. Long considered a variety of magnetic iron ore, it was not until 1740 that Pott demonstrated that it formed a series of salts distinct from those of iron. The existence of the metal was not known until about 1774 and when first isolated by Gahn it was called "magnesium" because it was obtained from a compound known as "magnesia niger" (manganese peroxide or dioxide); in 1808 Wilkinson obtained an English patent for the use of manganese and manganiferous ores for producing a superior grade of pig iron and the name was arbitrarily changed to "manganese".

Until the close of the eighteenth century the principal commercial use of manganese was decolorizing glass and coloring glass and pottery. About 1785 Berthollet used it as a bleaching agent and its use in making chlorine became extensive.

Experiments by Heath in 1839 showed that the properties of wrought and cast steel derived from low grade ores were greatly improved by the addition of manganese; the product being more malleable and easily welded. It was first added as a mixture of manganese oxide and coal tar.

After the perfecting of the Bessemer process in steel manufacture it was found that the method eliminated the carbon content and produced wrought iron. Mushet in 1856 used an alloy of iron, manganese and carbon, essentially spiegeleisen, which when added in a molten state to the final product of the Bessemer converter recarbonized the steel to the required amount, offset to some extent the bad effects of phosphorus and sulphur and reduced the amount of iron oxide formed during the "blow".

"Ferro-manganese, containing 25 to 30 per cent manganese, was first prepared for commercial use in 1865 by Henderson, followed closely by Prieger who produced an alloy with 75 per cent manganese. The Terre Noir Company improved upon these earlier processes and to them we owe the first commercial production of rich and cheap ferro-manganese."

"The first successful experiments and tests of ferro-manganese steel were made by R. A. Hadfield, Sheffield, England which were published in 1888".(1)

IV SOURCES OF MANGANESE

The commercial sources of manganese are principally the oxides of the metal and also the carbonate; manganiferous iron and silver ores; and a by-product obtained from the roasting of manganiferous zinc ores also add a small amount annually.

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(1) E.C.Harder, Bull.427, U.S.Geol.Survey, 1910, p.244.

V CHEMISTRY AND PROPERTIES OF MANGANESE (1)

Manganese occurs in group VII of the Periodic Table and is the only member of sub-group (a). Its analogy to the halogene family is through its highest oxide Mn_2O_7,which corresponds to permanganic acid $HMnO_4$ the salts of which are isomorphous with the perchlorates.

In its general behavior manganese shows strong resemblances to chromium, iron, and other metals in the same horizontal series of the Periodic Table. "Manganese, iron, cobalt, nickel or their alloys have strong magnetic properties." All the elements in the above series, form double and complex salts. Isomorphism between the compounds of the metals is also common.

They all form oxides of the type RO in which the metal is divalent. With the exception of copper and zinc they also form the type oxide R_2O_3 and salts in which the metal is trivalent. Manganese forms mixed oxides with other elements of the type $RO.Mn_2O_3$; also the oxide MnO_2- isomorphous with TiO_2- acts as a weak acidic oxide forming manganites. It may also act as a basic oxide and form salts in which it is tetravalent. The trioxide MnO_3 is purely acidic and forms manganates.

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(1) Roscoe and Schorlemmer, Treatise on Chemistry, MacMillan, 1923.

Metallic manganese may be prepared by (a) heating any of its oxides with carbon at white heat; (b) reduction of the halogen salts of manganese by metallic sodium or magnesium; (c) electrolysis of a concentrated solution of the chloride or of ferro-manganese in a bath of molten sodium chloride; (d) Goldschmidt's process; (e) reduction of oxide by molten silicon.

Small amounts of impurities influence the properties of manganese considerably, and since none of the processes for preparing the metal give a pure product, its properties vary according to the method by which it is obtained. It is a grey, or reddish white metal, very hard, and brittle. Specific Gravity 8.3; atomic weight 54.93. Sp. Heat .122. Melts at 1260°C. and boils at 1800°C. under atmospheric pressure. There appears to be a varience of opinion as to its stability; some authorities claim it is stable in dry air, but readily oxidized superficially in moist air, while others claim it oxidizes so easily it must be kept in sealed vessels or under rock oil. Although it is claimed to decompose water, this property is doubted by some, who attribute such activity to impurities. It is readily dissolved in all dilute acids.

Manganese alloys with the base metals; the alloys with iron are of particular value. It imparts to its alloys varying degrees of toughness, hardness, malleability and magnetic properties, depending upon the manganese content.

For a detailed description of the chemical compounds of manganese the reader is referred to the Treatise on Chemistry by Roscoe and Schorlemmer, revised 1923, or to the U.S.Geol. Survey Bull. 427 by E. C. Harder.

VI USES

The principal use of manganese is as an alloying element and in this field it becomes of prime importance, especially in the manufacture of steel. The metallurgical industry consumes approximately 90 per cent of the manganese production, the remaining 10 per cent being distributed between chemical and other minor uses.

The principal alloys of manganese and their composition are given in the following tables:

Iron Alloys:

	Mn%	Fe%	Si%	C%	P%	S%
Ferro-manganese	78-82	8-15	0.5-1	5-7	0.1-0.3	<0.03
Spiegeleisen	18-22	70-80	1	5-6	0.15	<0.05
Silicon-manganese	55-70	20-5	<25	0.35		
Siliconspiegel	20-50	67-43	4-10	1.5-3.5		

Copper Alloys:

With the exception of the iron alloys cupromanganese with about 25 per cent Mn is the most important alloy and is used in the manufacture of manganese bronze, manganese brass, and manganese German silver.

Percentage Composition

	Cu	Mn	Zn	Sn	Fe	Al	Pb	Fe+Ni
Manganese bronze (specified)	75-76	16-17		5-6				
Manganese bronze (commercial)	57-60	Tr-1	38-41	0.25-1	0.25-1	0.25-1	0.1-05	
Manganin	82	15						3

Composition in Parts

	Cu	Mn	Zn
Manganese brass	10	30	20-30
Manganese German silver	60	40	15

Heusler alloys are mixtures of manganese, aluminum, and copper which possess magnetic properties. The maximum value is obtained (1/3 that of iron) when the ratio of manganese to aluminum is in proportion to their atomic weight (55 to 27.11). The copper functions only in making the alloy sufficiently soft to cast.

Iron Alloys

It is known that certain metals are solvents of their oxides, and in the case of iron the solubility of the oxide increases with the purity of the metal. All steels, Bessemer and Open Hearth, have more or less oxide dissolved in them at the end of the "blow" or "heat". Besides the oxides there are usually varying amounts of slag, sulphides and other impurities including gases which may be dissolved, occluded or mechanically held within the fluid. It is desirable to free the bath of as much gas and impurities as possible in order to obtain a product with the minimum amount of blow holes and brittleness. To obtain this end deoxidizers are used and of these manganese alloys of iron and carbon are the most extensively employed.

The iron alloys are prepared by smelting a mixture of carbon, iron, manganese ore, and any other required ingredient in a blast or electric furnace. The heat necessary for the reduction is high and increases with the percentage of manganese in the alloy. For this reason electric furnaces are popular in regions of cheap electric power.

The chief function of these iron alloys in steel making is the recarbonation and scavanging of the steel. In the latter rôle the manganese not only frees the bath of much of the iron oxide, by uniting with the oxygen forming MnO_2 (which goes to the slag) and returning the iron, but also offsets the injurious effects of sulphur, slag and to some extent phosphorous. Sulphur in steel exists as iron sulphide which **ordinarily** forms films between the grains causing"red shortness" but in the presence of manganese this is largely converted to manganese sulphide which may in part segregate to the slag and in part remain in the bath and on crystallization segregate to rounded or sharp inclusions. Manganese unites with any slag present, forming easily fusible silicates which wet one another with ease, thus facilitating coalescing and removal as slag.

The amount of ferro-manganese added depends upon the quality of steel desired. For ordinary steel about one per cent, of the bath, is needed, and in such instances the function of the manganese is only a deoxidizer and scavanger. Correspondingly greater amounts of the alloy are added according to the manganese content specified in the final product. Provided the carbon is fairly low steel may contain up to about 2 1/4 per cent Mn with advantage to many properties. With higher percentages there is a decrease in strength and ductility. Steel with 2 1/2 per cent to 6 per cent Mn is extremely brittle, but when hot is quite ductile and may be drawn to any size. With increase of manganese the steel loses its brittleness and becomes more tough and ductile and is non-magnetic; the maximum strength and hardness being reached at 14 per cent Mn. Such steel can not be machined and is cast as near as possible to its final shape. Its use is found in parts of machines where excessive wear occurs, such as crusher jaws, roll tires, bearings of heavy machines, car axles, railway switchs, etc. As the manganese-carbon ratio must be approximately 12-1 in manganese steel only ferro-manganese can be used as the alloy.

Recently the use of ferro-manganese has become more popular than spiegeleisen because of the small amount of the alloy needed to impart the desired qualities, its direct addition to the ladle without previous melting, and its small carbon content relative to manganese.

The reasons for adding the manganese to the steel bath may be summarized as:(1)

(a) Prevention of over-oxidation of the steel by reduction of small quantities of oxide in the bath.

(b) Addition of requisite amount of manganese necessary in the finished steel.

(c) Hindering of the formation of blow holes.

(d) Elimination of sulphur from the bath.

(e) Making of slag fluid and easy to run off.

(f) Addition of carbon to the bath, this, however, being incidental and not necessary.

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(1) A.H.Curtis, Manganese Ores, Imperial Institute, Min.Res., 1919.

Manganese also raises the critical temperature to which a steel may be raised without coarse recrystallization. When present up to 1.5 per cent the manganese increases the elastic ratio and ultimate strength without appreciably lowering the ductility and in this respect acts similar to nickel but a given amount of manganese will produce approximately the same result as twice the amount of nickel. The physical properties due to heat treatment are also increased.

Other metals or alloys which may be used in conjunction with the manganese compounds are aluminium, silicon, and titanium, or their alloys with one another or with calcium, iron and manganese. While such compounds may produce additional beneficial properties in the resultant steel and reduce the amount of manganese that otherwise might be required they can not supplant the use of the manganese alloys entirely. Perhaps one of the reasons why manganese can not be wholly replaced is that its oxides with silica form very fusible silicates which wet one another and thus allow of coalescing and floating to the slag; the other elements, aluminium, silicon, magnesium, etc. form insoluble and infusible oxides and their widespread diffusion in the crystallized steel causes "red shortness".

By using manganiferous pig irons or charging manganiferous ores to Open Hearth furnaces the presence of manganese in the bath is assured and its effect is primarily to produce a better steel. "It tends to eliminate sulphur as well as oxidation. Further it is now proved that there is enough residual manganese in the steel to effect a ferro-manganese saving of sizable proportions. Other benefits..... are a smaller requirement of lime and fluorspar and an increased output of steel".(1) Other favorable results obtained with manganiferous iron ores are the decrease action of the flush off slag on the furnace linings, the elimination of surface defects in the steel and thus a decrease in the rejects; also it is possible to charge a high percentage of hot metal without causing violent blow or boil.(2)

Copper Alloys

The specified composition of manganese bronze is given in the table, but the composition which gives rise to a high tensile strength is quite variable and consequently the commercial "manganese bronze" is not a uniform product. An analysis of the average is also given in the table. In some instances the bronze may contain only a trace or no manganese whatever, and in such cases the manganese has served its purpose as a deoxidizer. The tensile strength of good

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(1) Iron Age, Oct. 28, 1926. Editorial.

(2) Oglebay, Norton & Co., Cleveland, Ohio, Circular, Jan.1927.

manganese bronze varies around 40 tons per square inch with 20 to 25 per cent elongation. It is tough, malleable and ductile. When forged at a cherry red heat it becomes very strong and tough. Being non-corrosive it is used extensively in propellers, small propeller shafting, and other places where such a property is of value.

Manganese brass has a wide limit of composition depending upon the use to which it is to be put. It is used in bearings subject to high temperatures, as a solder and for coins.

The manganese German silver is a substitute for German silver, and is used for bearings, cocks and valves. Aluminium imparts good casting qualities and non-corrodibility.

Manganin has a low temperature coefficient of resistance and is extensively employed in electrical instruments.

Alloys of manganese with aluminium, antimony, tin, and bismuth, arsenic and boron are noteworthy owing to their peculiar magnetic properties.

Manganese oxides may be used as a flux for copper and silver ores and as such they act essentially as iron oxides. The manganese is lost in the slag and its presence in the fluxing ore is incidental; the total iron and manganese content being important. Silver and copper are paid for only in excess of a minimum value.

Chemical Uses

The above metallurgical uses consume about 90 per cent of the manganese production. The remaining 10 per cent is consumed in the chemical trade and in such the uses to which it is put are grouped under the following headings:

(a) Oxidizing Agent

1. Manufacture of chlorine and bromine
2. Manufacture of disinfectants
3. Decolorizer in glass
4. Leclanche cells and dry batteries
5. Drier in paints and varnishes
6. Manufacture of permanganates of sodium and potassium

(b) Coloring Material

1. Coloring glass, pottery, tiles and bricks
2. Calico printing and dying
3. Paints

(c) Gas purifier

(d) Fertilizer

Since the advent of popular radio, the larger part of chemical ore is used in the making of batteries.

VII MARKETING(1)

Of the manganese minerals only the oxides and carbonates have a commercial value, although some silicates may be used in the manufacture of silicon-manganese and silicon-spiegel. A classification of ores is given as:

45% Mn or over is manganese ore
35 to 45% Mn is ferruginous manganese ore
5 to 35% Mn is manganiferous iron ore
5% Mn not considered

The character of the ore determines the purpose for which it is used. Chemical ores should be high in oxygen but low in lime; metallurgical ores should be relatively high in lime and low in silica and phosphorus and if used for making ferro-manganese, (80% Mn), the iron should likewise be low. The physical properties are also important; fine soft ores are objectionable in blast furnace work as they impede the blast and cause considerable loss in flue dust. Hard, medium sized ore capable of supporting the weight of the charge is desired.

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(1) W.R.Crane, Marketing of Metals and Minerals, Spurr and Wormser, McGraw-Hill, 1925.

For chemical purposes the most important consideration is the amount of available oxygen contained in the ore mineral and the ease with which it may be liberated. For the common ore minerals the available oxygen is:

Mineral	MnO_2 content	Available O_2
Pyrolusite	100	18.39
Psilomelane	42.46 to 46.77	7.81 to 13.06
Manganite	49.44	9.09
Braunite	43.99	6.99

The ore should likewise be low in lime or other constituents which might cause excess use of acid. Experiments have shown that copper, nickel, and cobalt are very injurious to battery ores, while iron oxide may be present to 2 or 3 per cent without harmful effects. As used in batteries and glass manufacture the oxide is required in a finely divided state, so that, other things being equal, ores possessing such physical quality are favored.

There is no established schedule for chemical ores and most demands are supplied by brokers in lots of five to one hundred tons under guaranteed specifications. These were formerly 80 to 90 per cent MnO_2 but ore as low as 70 per cent to 75 per cent is at times used. Iron should be under 2 per cent, copper less than .02 per cent; cobalt, nickel and arsenic should not be present in any appreciable amount. The price is governed by the available oxygen content; the variation in price depending upon the ease with which the ore may be decomposed to obtain the oxygen. The physical properties and freedom from impurities such as iron, calcium etc. being of prime importance in the manufacture of glass batteries and chemicals.

Chemical or battery ore is sold by the gross ton; the granulated or powdered form is sold by the pound. Due to its softness it is necessary to pack the ore in containers and the price is correspondingly increased.

The following is a list of buyers of chemical manganese ore in the United States:(1)

Frank Samuel & Co., Philadelphia, Pa.
Mineral Products Sales Corp., 7 West 16th St., New York Ciy.
Kelley & Tennant, Inc., 91 Provost St., Brooklyn, N.Y.
Metal & Thermit Corp., 61 Broadway, New York City.
Import Chemical Co., 164 First St., Jersey City, N.J.
E. J. Lavino & Co., Bullitt Bldg., Philadelphia, Pa.
Pacific Coast Borax Co., 100 William St., New York City.

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(1) American Manganese Producers Association. Through courtesy of Engineering & Mining Journal.

Philip Brothers, Inc., 233 Broadway, New York City (Jobbers)
A. C. Daft, Oliver Bldg., Pittsburg, Pa. (Jobbers)
C. Tennant Sons & Co., 19 West 44th St., New York City(Agents)
C. W. Leavitt & Co., Inc., 91 Provost St., Brooklyn, N.Y. "
National Carbon Company, 30 East 42d St., New York City

"The following makers of dry batteries in Canada use manganese ore:(1)

Canadian National Carbon Company, 46 King St., W.Toronto.
Dominion Battery Company 20 Trinity St., "
Burgess Battery Company, Burgess Dry Cells — Niagara Falls, Ontario. Winnipeg, Manitoba.

"About 1,000 tons of manganese ore is used in Canada yearly for this purpose. The best ore for the purpose is pyrolusite. Usual ore requirements are 80 per cent MnO_2 less than 1 per cent iron, and less than 0.5 per cent of copper, nickel or cobalt, and 14 per cent or more available oxygen. If ore is porous less available oxygen types can be used.

"In glass industry, the Dominion Glass Co., 285 Beaver Hall Hill, Montreal, which has several plants in Canada use about 20 tons per year. For glass decolorizing the manganese ore should be free of iron.

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(1) Courtesy of George Hanson, Canada Geological Survey.

"The Paint and Varnish trades use manganese salts about 50,000 pounds per year.

"Chemical companies may use manganese ore but the Bureau of Statistics do not ask for manganese in their returns from the Chemical or Drug Companies."

Standard specifications for metallurgical purposes call for 40 to 50 per cent metallic manganese with a premium or penalty for every unit (1 per cent) above or below this limit, respectively. A maximum of 8 to 9 per cent silica; 0.15 to 2 per cent phosphorus and 0.5 per cent sulphur is allowed, any excess of such being penalized.

The following schedule of metallurgical ores is the most recent that could be obtained.(1)

"Manganese Ore Price Schedule"

"Schedule of prices at which purchases of domestic manganese ore will be considered: in carload lots.

"All prices are f.o.b. furnaces of the company at our option.

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(1) W.R.Crane, op. cit.

For Ores Analysing within the Following Limits when Dried at 212°F. Moisture to be deducted from the weight.

Metallic Manganese %	Iron maximum %	Silica maximum %	Phosphorus maximum %	Cents per unit pergross ton
50 and over	5	12	15	68
48 to 49.99	5	12	15	65
46 to 47.99	6	13	15	60
43 to 45.99	6	14	15	50
40 to 42.99	5	14	15	45

"For each 1 per cent of silica in excess of the maximum stipulated in the above spefification, there shall be a deduction of 25 cents per gross ton, fractions in proportion.

"For each 1 per cent or fraction thereof of iron in excess of the maximum stipulated in the above specification, there shall be a deduction of 25 cents per gross ton.

"Ores containing less than 40 per cent manganese, more than 15 per cent silica, more than 7 per cent iron, or more than 15 per cent phosphorus, are subject to acceptance or rejection at the option of the buyer.

"Each car to be sampled and analysed by buyer on arrival at destination, and result to be used as basis of settlement. In the event of a discrepancy between analysis of buyer and seller, a portion of sample taken by buyer is to be submitted to Andrew S. McCreath & Son, of Harrisburg, or Booth & Blair, of Philadelphia, whose analysis is to be final and binding to both parties. The cost of sampling by the independent chemist to be borne by the party shown to be farthest away from the result of the referee chemist.

"Railroad scale weight at point of shipment to govern as to quantity.

"Prices subject to change without notice unless specifically agreed to by the company."

With the exception of the oxides, rhodochrosite is the only other manganese mineral capable of meeting this demand for ferro-manganese. Marketable ores of this mineral contain 37 per cent Mn, and less than 1 per cent Fe and 10 per cent SiO_2.

The price is usually quoted as so much per unit (1 per cent) of metallic manganese for metallurgical ores and some chemical ones but in the latter case the price may also be stipulated in cents per pound.

The grade of the ore is determined by chemical analysis based on material dried at 212°F. The value having been calculated from the analysis, based on the contract schedule, penalties and premiums are adjusted and final settlement made.

The terms of payment vary but it is customary for the purchaser to advance 70 to 80 per cent of the estimated value of the shipment based on the shipping weights and a certified analysis of the ore attached to the bill-of-lading. The balance is paid for on receipt and after careful sampling and check analysis.

The market for and prices of manganese ores in the countries of large consumption - England, Germany, United States, Belgium, France and Japan - are governed by the steel output and thus vary accordingly. The world's supply is drawn from four main centers - Russia, India, South Africa and Brazil - each having large reserves of about equal grade and good facilities for delivery so that the price of manganese is rather closely governed and is approximately the same in each country. The volume of the shipment and the direction taken are the controlling factors in the final cost to the consumer.

Those countries having the largest reserves also have an abundance of cheap labor which coupled with ease of mining and cheap ocean freights put them in an enviable position. The domestic production of manganese ore by steel producing countries is at a severe handicap particularly so if their resources are of inferior grade, unfavorable physical properties and of small extent. These factors tend towards uncertainty of supply and irregularity in grade and thus preference for foreign supplies of uniform grade is emphasized.

In the United States domestic metallurgical ores are shipped by the carload lot of 30 tons minimum; foreign ores, except some Mexican, are contracted for by the cargo of 1,000 tons or more. Domestic ores are delivered f.o.b. furnace; foreign ores are sampled at the port of delivery, the payment being c.i.f. Atlantic or Pacific seaboard. The United States protective tariff imposes a duty of 1 cent per pound on the metallic manganese content of imported ores, concentrates and alloys containing in excess of 30 per cent Mn.

Manganese ore is shipped as ballast and occupies about 20 cubic feet per ton. The Russian ores are friable and produce an excess of fines during transport; the Indian and Brazilian products suffer but little.

Ports of entry into the United States are New York, Philadelphia, Baltimore, San Francisco, and Seattle. The inland points of consumption are Bessemer, Alabama; South Chicago, Illinois; Sparrow Point, Maryland; and Kettanning, Lebanon, Dunbar, Newport, Sheridan and Pittsburg, Pennsylvania.

The accompanying graph (Fig. 1) compiled from information obtained in the U.S.Mineral Resources and Engineering

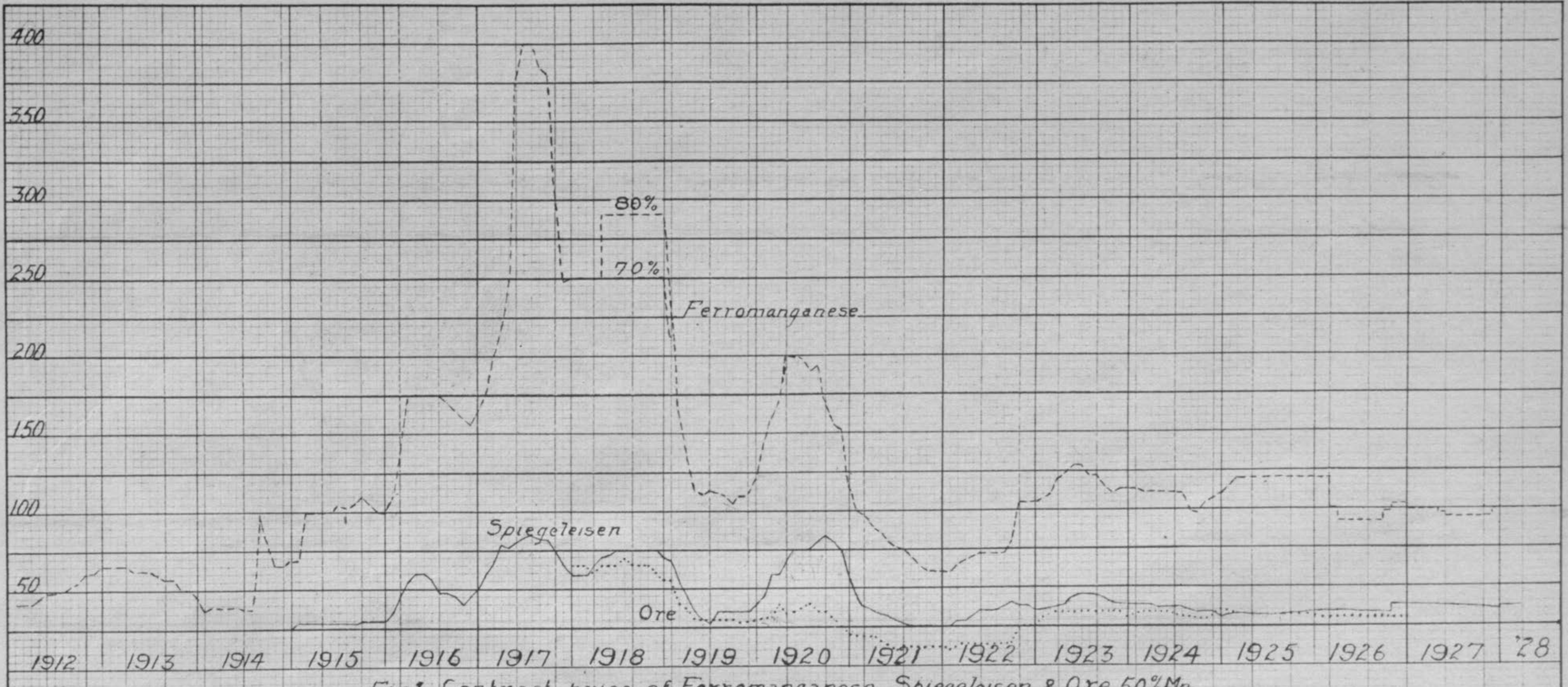

Fig1. Contract price of Ferromanganese, Spiegeleisen & Ore 50% Mn.

Mining Journal gives the price of ferro-manganese (1), spiegeleisen and 50 per cent manganese ore over a period of years. The variation in prices, due to abnormal war conditions, is clearly shown. The peak price of ferro-manganese was reached in 1917 following the declaration of unrestricted submarine warfare by Germany. The constant value in 1918 is a reflection of the United States Government action in co-operation with the steel producers, in drawing up a schedule of imports and prices in an attempt to stablize the industry and create a balance in the ratio of the price of the ferro alloys to that of ore. Such action was designed to encourage home production and give to the new operators, some degree of confidence as to the possible return on their investments.

Prior to the war the needs of the United States for the ferro alloys was met by imports of ore from Russia, India and Brazil; such ore being used by the United States Steel Corporation in making their own supply of ferro-manganese and spiegeleisen. These requirements were supplemented by importation of ferro-manganese from England, Germany and Canada. Small individual companies received their supply of ferro alloys entirely from imports. During the war crisis, there was a tendency in America on the part of large steel companies to produce more than their own needs of ferro-manganese

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(1) The duty on 80 per cent ferro-manganese is 1 7/8¢ per lb. on the content of metallic Mn, or $33.60 a ton (1926).

from imported ores plus home production with a corresponding curtailment of imports in the ferro alloys. The latest stage of war development showed the United States Steel Corporation supplying ferro-manganese for small domestic steel companies. This practice was continued and during 1926 the Bethlehem Steel Company became an active seller of ferro-manganese. This added competition caused a drop in the price of ferro-manganese from $115 to $80 per ton f.o.b. Atlantic ports. But during the latter part of the year the price went back to $100.

Firms in United States making, or shipping ferro-manganese or spiegeleisen in 1925. (f=ferro-manganese; s= spiegeleisen)(1).

(f) Anaconda Copper Mining Co., Great Falls, Mont.
(f) Bethlehem Steel Co., Sparrows Point, Md.
(fs) Bethlehem Steel Co., Johnstown, Pa.
(f) Electro Metallurgical Co., Niagara Falls, N.Y.
(s) Jackson Iron and Steel Co., Jackson, Ohio.
(f) Lavino Furnace Co., Lebanon and Marietta, Pa/. amd Reusens, Va.
(fs) Lavino Furnace Co., Sheridan, Pa.
(s) New Jersey Zinc Co., Palmerton, Pa.
(f) Tennessee Coal, Iron & Railroad Co., Bessemer,Ala.
(f) United States Steel Corp.,Etna, Neville Is., and Pittsburgh, Pa.
(s) United States Steel Corp., Etna and Pittsburgh,Pa.

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(1) U.S.Geol.Survey, Min.Res., 1926.

The following Steel & Metallurgical Companies in Canada use manganese ore:(1)

"Electro Metallurgical Company of Canada, Welland, Ont. The manganese ore comes from the United States to Canada and is returned as ferro-manganese.

"Manitoba Rolling Mills, Logan Ave., W.Winnipeg, Manitoba. Used 7 tons of manganese ore last year.

The following may use manganese ore:

"Algoma Steel Corporation

"The following probably use ferro-manganese instead of manganese ore:

"Steel Company of Canada, Hamilton, Ontario.

"British Empire Steel Corp., Nova Scotia."

"The world market of manganese is maintained by less than 50 buyers. The ore obtained from each of the main centers of production - Russia, India, Gold Coast and Brazil - has characteristics which satisfy certain consumers and not others. Coupled with this, the large consuming companies have taken interests in the producing concerns thus insuring themselves of a constant supply. These factors eliminate keen competition on the part of selling concerns, but the grade of ore from

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(1) George Hanson, Canada Geological Survey.

all the centers is so similar that prices remain nearly uniform. Moreover at present the major cost of the manganese ore is consumed in the transport and marketing of the product, so that any considerable reduction in the price of ore is hardly to be expected.

VIII PRODUCTION

Manganese is one of the most common minerals and although it forms many deposits throughout the world, comparatively few of these are sufficiently large and rich to meet the requirements of present day demands. Before the war Russia, India, and Brazil were the main producing centers, furnishing 95 per cent of the world's requirements. In 1914 the Geological Survey of the Gold Coast, Africa, discovered the Dagwin deposits and since 1922 the world's supply has been obtained from Russia, India, Gold Coast, and Brazil (in order of economic importance).

Underwar time stimulous many small and low grade deposits came into prominence and temporarily were extensively worked. China and Spain have maintained a small and varying production since the world war. The manganiferous iron ores and smaller manganese ore deposits of the Sinai Peninsula, Egypt, have become active producers since 1918, supplying ore averaging 32 per cent Mn and 25 per cent Fe. New discoveries in South Africa (Postmasburg) and Australia will soon (1927) be supplying considerable tonnage of excellent grade.

Of the large steel producing countries, Russia is the only one having reserves of manganese ore above her domestic requirements. England is entirely dependent upon importations chiefly from India, and the Gold Coast. Germany has considerable low grade ores but derives most of her manganese from the Nikopol region, Russia. The United States is likewise dependent upon foreign production. Prior to the war her demands were met by the Russian and Brazilian producers. During 1917 to 1918 home production amounted to 35 per cent of the total requirements but this was facilitated by marked changes in the processes of the steel companies and importation of high grade ore from Brazil and India, some of which was mixed with the domestic ores to bring them up to a necessary minimum of metallic manganese. At present the United States is again dependent upon foreign supplies, derived from the Tchiaturi region, Russia; and Brazil.

By financial negotiations the main sources of the world's supply of manganese ore have become divided between English, German and American interests. Germany controls the

Nikopol field, Russia. In 1925 the Harriman interests of the United States obtained a twenty year lease on the Tchiaturi deposits, Kutais Caucasus. The royalties and terms of the Soviet Socialistic Republic are somewhat exacting so that the price of these ores will temporarily be reduced in order to insure sufficient sales to meet the royalties demanded. American capital is also heavily interested in the Brazil deposits and recently came into the control of one of the deposits on the Gold Coast of Africa by means of option on the purchase of ore produced. English interests have control of the Indian, Gold Coast, Sinai Peninsula and Australian manganese resources.

The accompanying graphs, Figs. 2, 3, and 4, give the production of the main producing centers, over a period of years.

The foregoing statements have reference to metallurgical demand of manganese ore. The annual tonnage required in the chemical industries is very small in comparison. With the development of the motor car and high speed gasoline engines, the demand for battery ore steadily increased and the advent of popular radio caused an additional demand. During 1925 the consumption of the United States in chemical ores was estimated at 47,000 tons of which 40,000 tons were consumed in the battery industry.

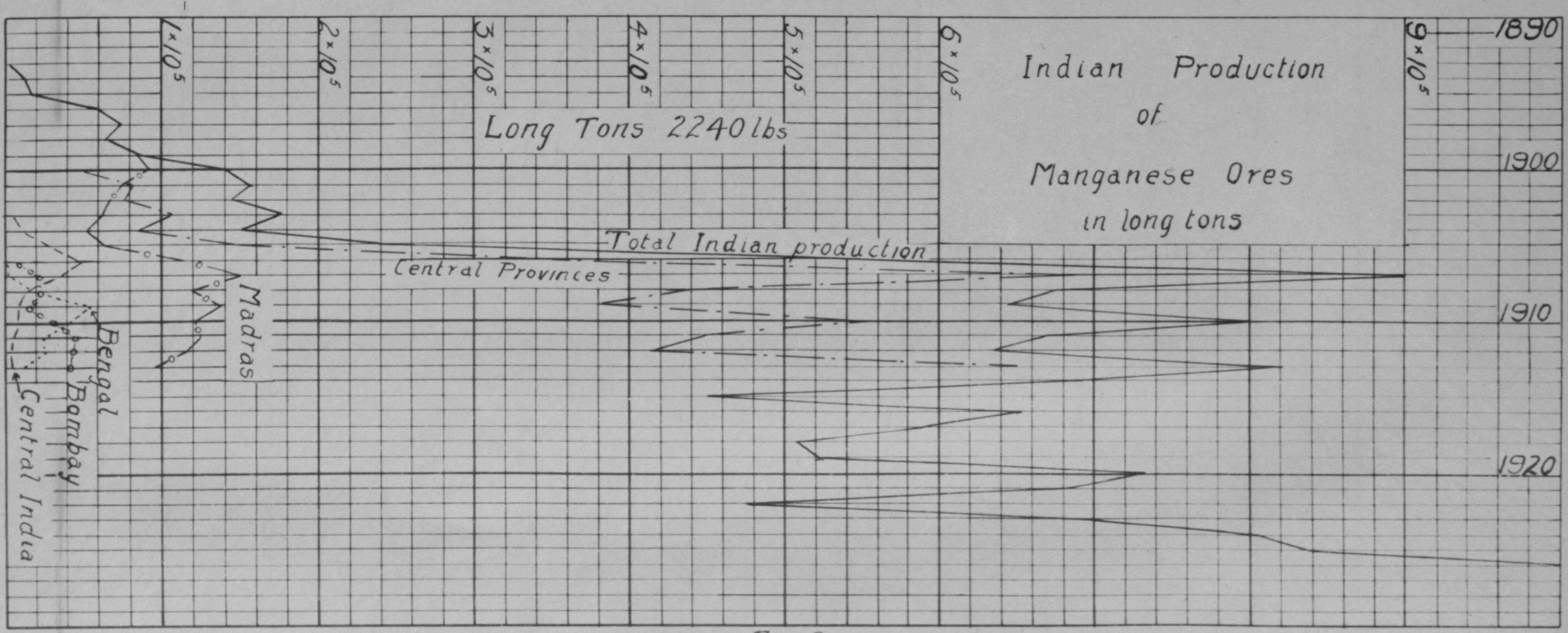

Indian Production
of
Manganese Ores
in long tons
Long Tons 2240 lbs
1×10⁵
2×10⁵
3×10⁵
4×10⁵
5×10⁵
6×10⁵
9×10⁵
1890
1900
1910
1920
Total Indian production
Central Provinces
Madras
Bengal
Bombay
Central India

Fig. 2

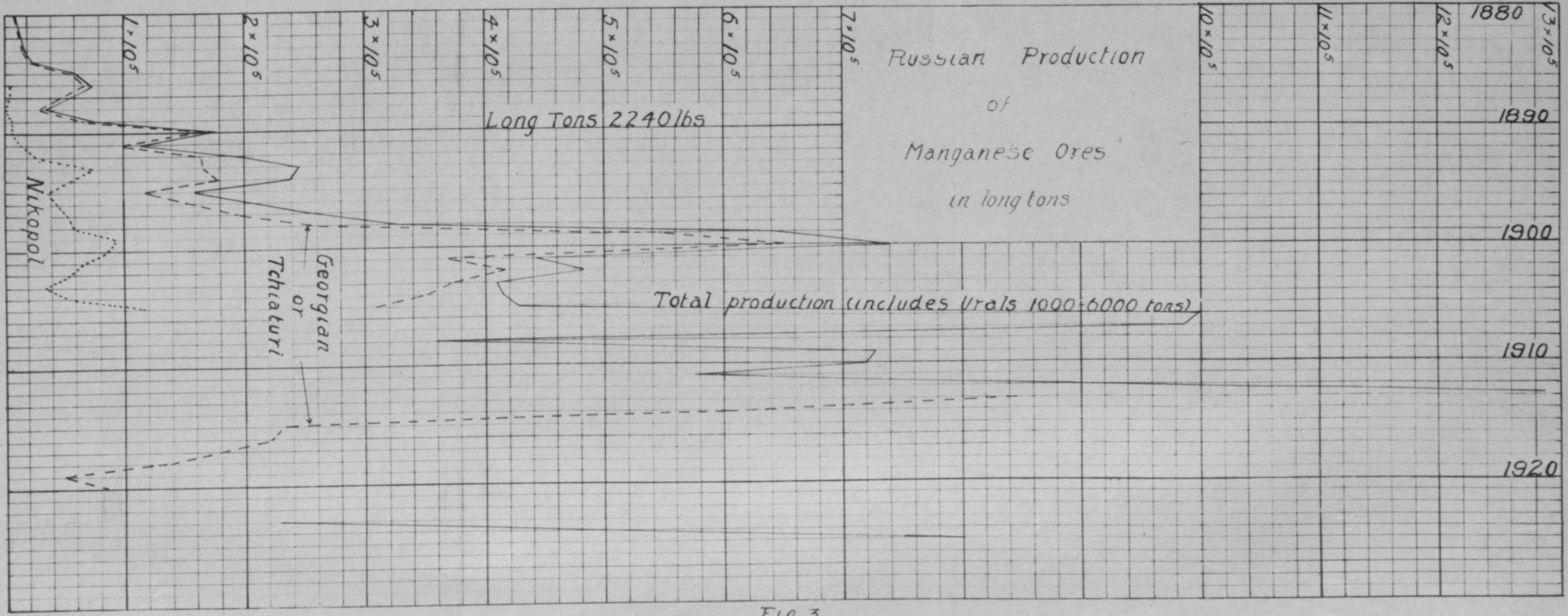
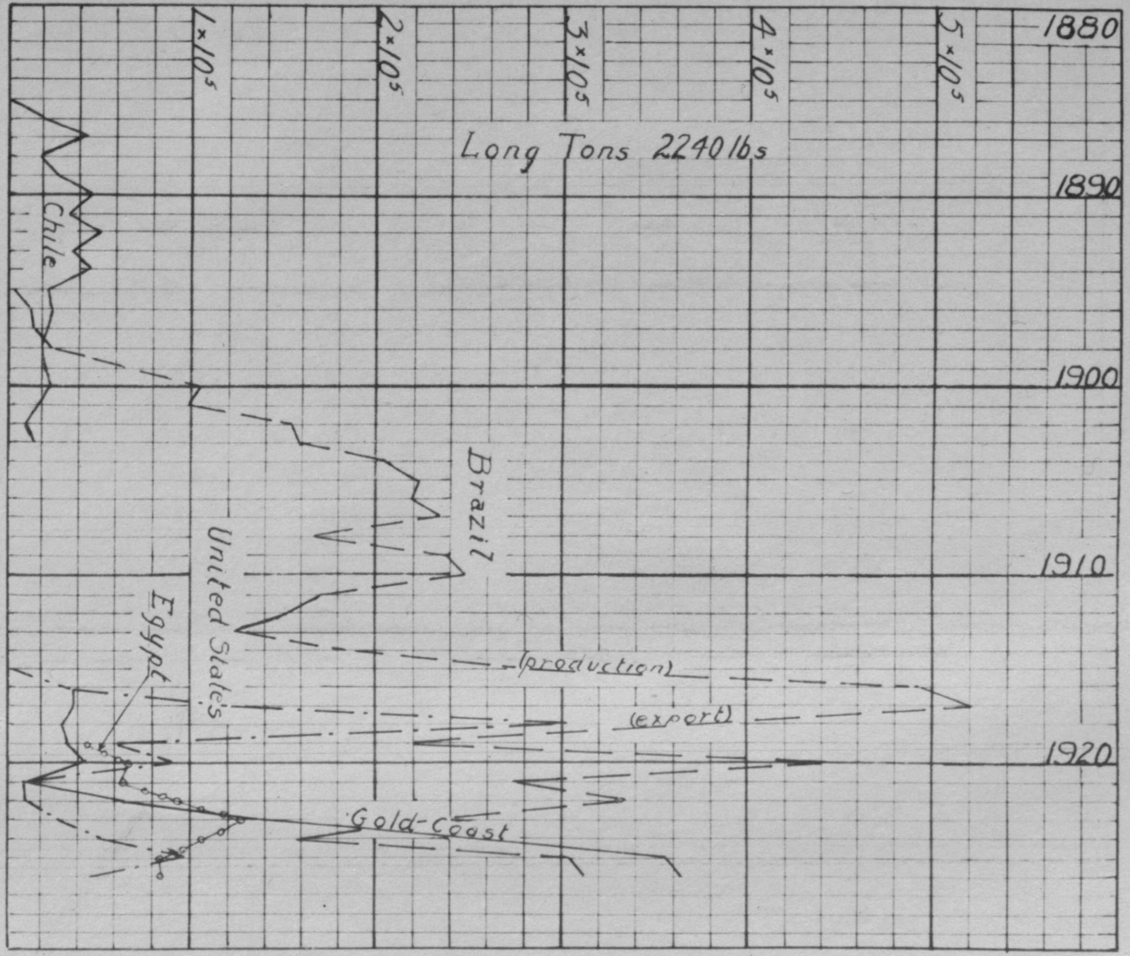

Russian Production
of
Manganese Ores
in long tons
Long Tons 2240 lbs
1×10⁵
2×10⁵
3×10⁵
4×10⁵
5×10⁵
6×10⁵
7×10⁵
10×10⁵
11×10⁵
12×10⁵
13×10⁵
1880
1890
1900
1910
1920
Nikopol
Georgian
or
Tchiaturi
Total production (includes Urals 1000-6000 tons)

Fig 3

Fig 4


1880
1890
1900
1910
1920
1×10⁵
2×10⁵
3×10⁵
4×10⁵
5×10⁵
Long Tons 2240 lbs
Chile
Brazil
United States
(production)
(export)
Egypt
Gold-Coast

The price of chemical ore in the United States, as quoted by the Foote Mineral Company, Philadelphia, has been since January 1, 1927 to date (March 10, 1928) $70 to $80 per ton in carload lots for powdered, coarse, or fine Brazilian or Cuban ores containing 82 to 87 per cent MnO_2. Quotations for domestic ores from October 8, 1927 to date (March 10, 1928) have been $40 to $50 per ton for ore containing 70 to 72 per cent MnO_2.

IX CANADIAN PRODUCTION

The Canadian annual production of manganese ore has always been small, never amounting to more than 2,179 tons according to official data. While some of the output was consumed in the metallurgical trade, and a small amount of wad used for paints and pigments, the larger portion was a very high grade product which found a ready market in the higher grades of chemical ore.

The main production in Canada has been from the Maritime Provinces and in these the chief centers of the industry were at Markhamville, N.B., and Tenny Cape, N.S. While many other localities contributed ore of equal quality the output from these was small in comparison and more sporadic.

In Nova Scotia, during the early stages of the industry, the Tenny Cape mine produced, perhaps, 90 per cent of the total output of the province; in later years, however, the discoveries at New Ross gave new life to the dwindling production. This renewed activity was short lived and not until 1915 was there any production comparable to the old days. The production during the war period and immediately following was derived almost entirely from the New Ross occurrences. In New Brunswick almost all of the production was from the Markhamville deposit.

Local reports, on good authority, claim that the Markhamville mine produced in the vicinity of 40,000 tons or more of ore. Addition of the total (exports) assigned to each province from 1873 to 1900 shows that there is a considerable discrepancy between the government records and local claims. Both the Markhamville and Tenny Cape mines were opened some years previous, the Markhamville in 1864, and Tenny Cape in 1862, and the unrecorded production in the interval may account for a large part of the discrepancy.

The following data relating to the Canadian production, imports and exports of manganese ores, were obtained from the Summary Reports of the Mines Branch, Ottawa.

Year	Production	Exports (tons)			Imports	
		N.B.		N.S.	lbs.	(2000 lbs/ton)
1873			1031			
1874		776		6		
1875		194		9		
1876		391		21		
1877		785		106		
1878		520		106		
1879		1732		154		
1880		2100		79		
1881		1504		200		
1882		771		123		
1883		1013		313		
					Fiscal Year	
1884		469		134	3989	1.59(approx)
1885		1607		77	36778	18.4
1886	1789	1377		441	44967	22.5
1887	1245	837		578	59655	29.8
1888	1801	1094		87	65014	32.5
1889	1455	1377		59	52241	26.1
1890	1328	1729		177	67452	33.7
1891	255	233		22	92087	46
1892	115	59		84	76097	38
1893	213	10		123	94116	47
1894	74	45		11	100863	50.9
1895	125			108	64151	32
1896				123	108590	54.3
1897				15	70663	35.3
1898	50			11	130456	65.2
1899	1581	3		67	141356	7 0.6
1900	30		34		126725	63.4
1901			440		272134	136
1902			172		476331	238
1903	91		135		279611	139.8
1904	66		123		275696	137.8
1905			22		235289	117.6
1906			93		244620	122.3
1907			1		386404	193.2 (9 mos.)
1908					732246	366.1
1909			3		382137	181

Year	Production	Exports (tons)		Imports	
		N.B.	N.S.	lbs.	(2000 lbs/ton)
				Calendar Year	
1910			4	1297020	648
1911	5		4	1924520	962.2
1912	75		10	2512610	1256.3
1913			8	5175195	2587.6
1914	28		30	3404863	1752.4
1915	201		255	2476328	1238.1
1916	957		957	2339809	1169.9
1917	158		185	3538623	1769.3
				Fiscal Year	
1918	440		640	3510018	1755
1919	(note stated)		784	3629307	1814.6
1920	649		606	2557280	1278.6
1921	68		637	2842778	1421.4
1922	73		81	609937	304.9
1923	200		138		
1924	584				

From a perusal of the U.S. Geological Survey Mineral Resource bulletins for a number of years past it would seem that Canada has been a small exporter of ferro-manganese to that country. In 1926 the amount exported to the United States was 18,792 tons of actual manganese content, or about 42 per cent of the total United States imports of ferro-manganese for that year.

The ore for the manufacture of the ferro-manganese has evidently been derived from the Indian and Gold Coast deposits. The process of manufacture is believed to be electrolytic.

The Canadian imports and exports of ferro-alloys for a number of years were:

Fiscal	Imports (cwt.) Ferro-manganese and Spiegeleisen more than 15% Mn	Imports (cwt.) Ferro-manganese and Spiegeleisen not more than 15% Mn	Exports (tons)
1917	224,140	10,866	
1918	256,980	15,965	
1919	665, 640	15,667	
1920	19,305	6,404	833
1921	138,022	8,639	925
1922	28,099	11,767	862
1923			1,236

Later figures than these were not available at the time of writing (March, 1928).

CHAPTER II

X WORLD OCCURRENCES OF MANGANESE

General Résumé

Prior to the war it was feared in some quarters that the available supply of high grade manganese ores in the world would be depleted in a relatively short time. The abnormal war conditions brought out how dependent the large steel producing countries were upon foreign supplies and the difficulties attendent on obtaining sufficient quantities from such restricted sources in the time of need. These conditions stimulated the search for new resources and also research in the beneficiation of low grade ores. The results have not only augmented the world's supply by new discoveries of ore as in the Gold Coast; Postmasburg, South Africa; Australia and elsewhere, but also the potential reserves of the older deposits have been increased by more intensive and detailed development and also by the more refined methods of beneficiation. From a commercial view at least the outlook on the manganese situation is more encouraging now than in pre-war days.

The manganese reserves of the world, graded according to their present economic resources and value, occur in

Russia, India, Gold Coast and Brazil. The combined reserves of these countries have been estimated at 200,000,000 tons or more.

The following table gives the world's annual production in a number of years and the percentage of the total supplied by the main sources:(1)

Year	Total Production metric tons	Russia	India	Gold Coast	Brazil
		(percentage supplied by)			
1909-1913 (incl)	1,910,000 (average per annum)	45	38		10
1918	2,103,000	20	25	1	19
1924	2,187,000	23	37	12	7
1925	2,570,000	32	24	13	12

Russia

There are three districts in Russia from which manganese has been produced, namely Tchiaturi, Nikopol and the central Urals. (See Fig. 5). Of these Tchiaturi deposits **are** the most important, having produced between 85 and 90 per cent of the total Russian production. The Nikopol ores are the next in importance while the Ural occurrences contribute only small amounts averaging between 1,000 and 6,000 tons annually.

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(1) U.S.Geol.Survey Mineral Resources, 1925, p.161.

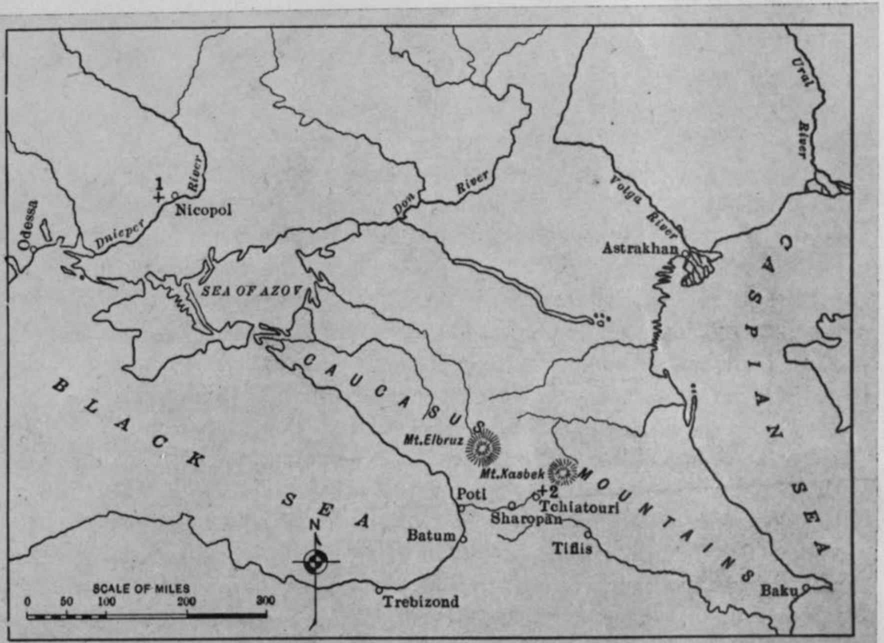

FIG. 5—MAP OF SOUTHEASTERN RUSSIA SHOWING THE LOCATION OF THE MANGANESE-ORE DISTRICTS. *After E.C. Harder*
1. Nikopol. 2. Tchiatouri.

The Tchiaturi deposits have been known since 1848 but were first worked in 1879. The Nikopol resources were first exploited about 1886 and have since maintained a steady production. Prior to the Russian Revolution the deposits were worked by concessions granted under the Imperial Government. These concessions were held by many nationals and in the Tchiaturi district at least the competition was keen and frequently led to wasteful methods of production.

From the literature examined it appeared that Germany had the main control through concessions granted to her nationals in the Tchiaturi region. This occurrence supplied a great deal of the ore required by foreign countries prior to the war, while the production from the Nikopol field was consumed by the Russian steel industry.

The Soviet regime nationalized all mines and all former concessions were repudiated resulting in a total loss to foreign holders. During the reconstruction period conditions became more stabilized and foreign capital once more became interested in the regions. Germany at first predominated the Tchiaturi district but in 1925 American interests secured the concession of sole operators in this area. Germany is said to have control of the Nikopol area and derives most of her needs from it.

<u>Tchiaturi District</u>.-(1) "The Tchiaturi deposits, in the province of Kutais on the southern slope of the Caucasus, are reached by a 21 mile spur line.....which leaves the Trans-Caucasian railway at the station of Kvrilli....and ascends the valley of the Kvrilli river to the town of Tchiaturi... The distance from the mines to Poti is about 90 miles and to Batum 126."

It is claimed that the ore horizon at one time extended over an area of some 55 square miles, but that erosion

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(1) E.C.Harder, Trans. Am.inst.Min.Engs., 1916, p.65.
U.S.Geol.Survey Bull.427, 1910, pp.208-210.

has removed the southwestern part of the original deposit and dissected the remaining portion so that now about 22 square miles are underlain by the ore stratum. The deposits are in a dissected plateau area in which the valleys are from 700 to 1,000 feet deep. The ore horizon outcrops some 400 to 800 feet below the hill tops. The reserves of this region are estimated to vary between 22, 125,000 tons of recoverable ore to 200,000,000 tons (metric).

The region is characterized by very gently dipping Cretaceous shales and limestones overlain by Eocene sandstone and associated sediments and these in turn by Oligocene and Miocene sandstones, shales, and limestones.

"The ore(1) occurs in a bed 6 to 7 feet thick.... at the contact of Eocene brown sandstone with the underlying Cretaceous limestone. The bed is without extreme or abrupt variations of thickness...and has a distinctly stratified structure and is composed largely of pyrolusite, though other oxides of manganese occur. The ore is concentric and oölitic and in many places shows botryoidal and concentric structure. In many places strata of sandstone or loose, friable arenaceous or calcareous material are intercalated with the manganese ore, and vary in thickness from a fraction of an inch to as much as 10 inches or a foot."

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(1) E.C.Harder, Trans. Am.Inst.Min.Eng., 56, 1916, p.65; also U.S.Geol.Survey Bull.427, 1910, pp.208-210.

The crude ore averages 40 to 45 per cent Mn and in places 50 per cent Mn. Although a product analyzing 61 per cent Mn may be obtained by beneficiation, the average of exported ore runs 48 to 50 per cent Mn; 6 to 8 per cent SiO_2; 1 per cent Fe; and 0.17 per cent P.

"The physical characteristics of the ore are unfavorable....as much of the ore is soft and grinds to a fine powder during the handling incidental to mining, cleaning and transportation. The loss of ore is therefore considerable, and much of the fine ore that is shipped is considered objectionable by the consumers." The ore, however, is well adapted to chemical uses and has supplied a large portion of the world's requirements of chemical ore.

Nikopol District.-(1) "The deposits....near Nikopol, on the Dnieper river, are 100 miles from its entrance into the Gulf of Odessa.....The ores are in beds about 3 1/2 feet thick and are in Oligocene strata. The ore-bearing layer consists of sandy clay much stained by manganese, which contains nodules of psilomelane and pyrolusite with concentric and cellular structure. The hanging and footwalls of the ore bed consist of glauconitic clays, which on the footwall are commonly sandy. The ores are but a short distance above crystalline bed rock and were probably derived from it through

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(1) E.C.Harder, U.S.Geol.Survey Bull.427, 1910, p.211.

weathering processes. The better class of ore contains 57 per cent Mn."

"Near Horodizce, 11 1/4 miles north of Nikopol, there is a bed of manganese ore 6 to 10 feet thick, overlain by Tertiary clays and underlain by granite but separated from it by a bed of kaolin and sand about a foot thick. The ore consists of a mixture of quartz grains and pyrolusite nodules."

The area underlain by manganese ore is said to be about 20 square kilometers and the total tonnage of ore available is estimated at 7,400,000 metric tons.

Ural Mountains District.- In the Ural mountains manganese deposits are found in the Governments of Perm and Orenburg. The ore is accompanied by brown iron ore and is found associated with Devonian limestones near their contact with igneous rocks and occur either in the limestone or in the igneous rock or at the contact of the two. While the limestones are considerably metamorphosed by the intrusions in places, the ores are found, in general, in the unmetamorphosed and fractured areas and are considered to have been connected in origin with the manganese-bearing hornblende of the igneous rocks.

Fifteen and a half miles southeast of Jekaterinburg, in the Urals, rhodonite mixed with quartz forms a bed 9 feet thick in argillaceous schists. Locally it is veined and stained with manganite.

India(1)

"From time immemorial manganese ores have been worked to a small extent by the natives of India, the uses to which they put the ores being in glass making, as "surma" for the eye-brows, and in the manufacture of special brands of iron....

"It was not until 1892, however, that any attempt was made to work the Indian deposits for export to the European and American markets. During the following years the manganese quarrying industry has spread to many parts of India....." and by 1906 attained the position as one of the leading producers of manganese ores, a position which she has maintained.

General Geology.- The Archean rocks of the Indian Peninsula are divided into:

(1) Oldest gneisses (Bengal gneiss)
(2) Schistose gneisses and the Dhárwárs
(3) Plutonic intrusives (Bundelkhand granite and charnockite series)

"The occurrences of manganese ores and minerals in India are classified according to the age of the rock with which they are associated, although they have in many cases

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(1) L.L.Fermor, Memoirs Geol.Survey India, vol.37,1909.

been formed by secondary processes subsequent to these associated rocks. All the ores at present being worked are associated with rocks of Archean age, with two exceptions. Those of Archean age are divided into three main groups:

(1) "Those associated with rocks of the Kodurite series of the Vizagapatam and Ganjám districts Madras.

(2) "Those associated with the gondite series of the Central Provinces, and Jhábua, Central India.

(3) "Those occurring as lateritoid on the outcrops of rocks of the Dhárwár age in Belgaum, Jabalpur, Mysore, Sandur, and Singhbhum.

"The two exceptions are those ores that can be regarded as.....true laterites....as in Goa, Belgaum and Jabalpur and possibly in Baluchistán."

The rocks of the Vizagapatam district are divided into:

(1) Kondurite series	Igneous
(2) Charnockite series	
(3) Gneissose granite	
(4) Calc-gneisses	Metamorphic
(5) Khondalite series	
(6) Contact products of 2 and 5	

The typical kodurite rock is composed of orthoclase, spandite (manganese garnet) and apatite in varying proportions. "Other members of the series receive their names in accordance with additional minerals present in the rock." Some are more acid and some more basic than the type rock. Magmatic differentiation is considered to be responsible for the various members found.

The manganese ores associated with this series were formed subsequent to the eruption of the rocks by the action of solutions containing dissolved CO_2 and alkaline carbonates percolating through the rock mass. The change is illustrated by $K_2O.Al_2O_3.6SiO_2 + CO_2 + 2H_2O = 2H_2O.Al_2O_3.2SiO_2 + K_2CO_3 + 4SiO_2$

The silica is carried as a colloid and in later deposition forms chert and opal by replacement.

It is advanced that the carbonated alkaline solutions took manganese into solution, probably as a bicarbonate, from garnets and pyroxenes and after migration, precipitation resulted due to saturation of the solutions with manganese bicarbonate and the manganese in depositing replaced all the minerals of the host rock except those containing manganese. This replacement of the kodurite resulted in a compact psilomelane studded with bright red or orange spandite garnets or else a compact ore free of gangue minerals. If the host mineral was feldspar the reaction is given as:

$$MnH_2(CO_3)_2 + 2(K_2O.Al_2O_3.6SiO_2) + O = 2K_2CO_3 + 2Al_2O_3 + 12SiO_2 + H_2MnO_3$$

If the replaced rock was spandite, then

$$2[3(CaMn)O(Fe,Al)_2O_3.3SiO_2] + 3MnH_2(CO_3)_2 + 3O_2 + 6H_2O = 6(MnO_2.H_2O) + 2(Fe,Al)_2O_3 + 3CaH_2(CO_3)_2 + 6SiO_2$$

The ores formed by such secondary processes are classed as:

(1) Those formed by the replacement of rocks not originally containing manganese. Manganese entirely of external origin.

(2) Those formed by replacement of rocks, such as kodurite that contain a fair amount of manganese silicate, the manganese of the latter being added to that of the attacking solutions, the larger portion of the manganese being of external origin.

(3) Those formed by decomposition in situ of rocks composed almost entirely of manganese silicate. In this case about half the manganese is of external origin.

The ores formed according to these three methods are:

(1) Pyrolusite and psilomelane.
(2) Psilomelane with some braunite.
(3) Psilomelane with braunite as specks and patches.

The Dhárwár series are considered to be of late Archean and to have been originally clays, sandstones, limestones, and contemporaneous basic lavas. Metamorphism has resulted in the formation of slates, phyllites, mica schists, quartzites, crystalline limestones, complex gneisses, and hornblende schists. They are correlated with the Huronian of North America.

During the deposition of the Dhárwár sediments, it is assumed that manganese oxides were sometimes deposited chemically from solutions, thus forming a manganiferous sediment. If the later metamorphism, to which the series was subjected, was not too great then such sediments were consolidated to form manganese ores of varying purity. If, however, the metamorphism was intense then a recrystallization took place resulting in the formation of spessartite, rhodonite, manganiferous pyroxenes and other manganese bearing minerals. Such a rock is termed a "gondite". Thus the gondite series is a particular phase of the Dhárwár series. The typical gondite rock is a fine-grained mixture of quartz and spessartite in varying proportions. These rocks are found principally in Central India, the Central Provinces and Bombay. The "oxy-alteration" of the gondites, forming manganese ores, is considered to have taken place in depth and the ore is termed "deep secondary ore" to distinguish it from the "outcrop secondary ore" formed by surface replacement.

The ores associated with piedmontite in marble are considered to have been originally impure manganiferous limestones. Intense metamorphism converted these to quartz-pyroxene-gneisses which later became altered to the present crystalline limestones due to alteration by carbonated waters. During the various stages the manganese is considered to have remained as the oxide, if the original sediment was pure, or if impure to have suffered various metamorphic changes along with the other minerals.

From the general discussion given it would seem that each lateritic deposit in India presents different and varying aspects so that their origin must be approached as individual problems. It is noted that in some of the laterites all traces of any original manganese are entirely removed. If manganese is associated in a laterite deposit then the various manganese oxides are in general segregated to themselves in contrast to the intimate mixture of the oxides of iron and alumina. Of the many manganiferous lateritic deposits only three are considered as true laterites. These are at Goa and Talevádi, in Belgaum and Gosalpur in Jabalpur.

The remaining occurrences are termed "lateritoid". They show a "downward passage from lateritic masses of iron and manganese ore at the surface, through rock containing more and more quartzite, slate, and other rock, and less and less

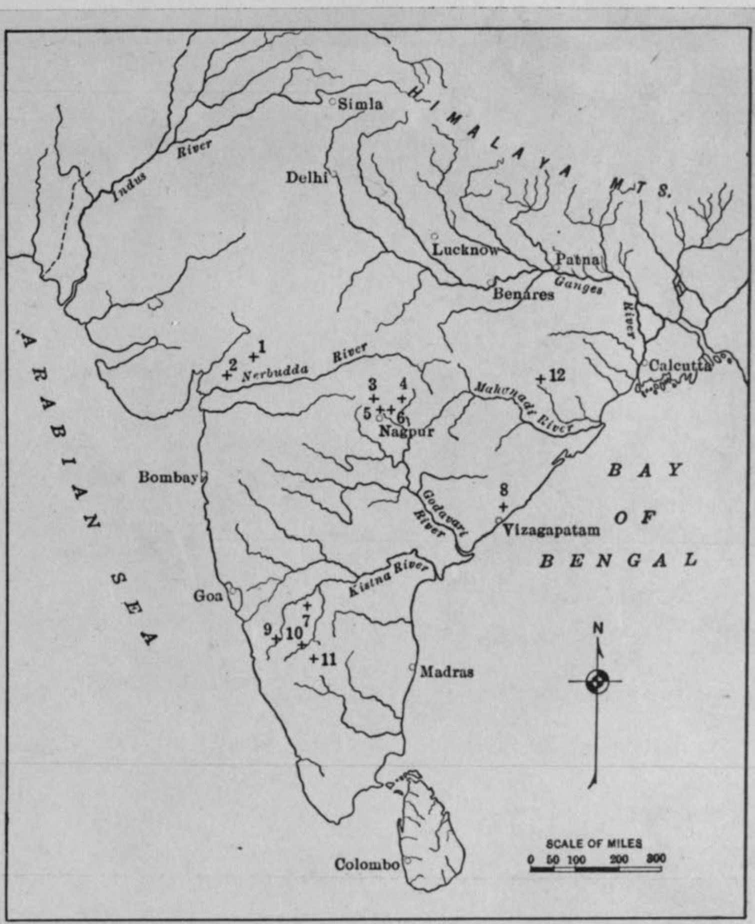

FIG. 6—MAP OF THE PENINSULA OF INDIA SHOWING THE LOCATION OF THE PRINCIPAL MANGANESE-ORE DEPOSITS. (Adapted from a map by Fermor.)

1. Jhabua.
2. Panch Maháls.
3. Chhindwára.
4. Bhandára.
5. Nágpur.
6. Bálághát.
7. Sandur.
8. Vizagapatam.
9. Shimoga.
10. Chitaldrug.
11. Tumkur.
12. Gangpur.

After E.C. Harder

ore, to a rock free from all signs of ore." As the host rocks contain little or no manganese most of it must have been brought in from the outside by percolating waters.

The following is a brief synopsis of the main Indian occurrences (1). There are in all twelve principal manganese districts and these are shown on the accompanying map (Fig. 6).

Individual Districts.- JHÁBUA DISTRICT. The ore occurs in the less metamorphosed phase of the Dhárwár series and is intercalated with black and red quartzite. The horizon is between beds of sericite and talc schists but is usually separated from them by a sandy layer. The ore differs at the two ends of the deposit. The northern part consists of psilomelane, with abundant braunite, in association with spessartite and rhodonite. The southern end has only psilomelane and braunite with no evidence of the other two minerals.

The larger part of the deposit is supposed to be an alteration product of an original manganese silicate rock interlayered with the sediments, while the southern part is considered to have been laid down as original manganese oxide interlayered with quartzite.

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(1) E.C.Harder, Trans., Am.Inst.Min.Met.Eng., 56, 1916.

PANCH MAHÁLS DISTRICT. The deposits occur in siliceous slates, often sericitic and calcareous, and fine-grained quartzites of the less metamorphosed phase of the Dhárwár series. The ores are very irregularly distributed and appear to be replacements of the quartzites and locally of the slates, but in places they appear to be interbedded with the quartzites. The ore is a mixture of psilomelane and braunite associated in places with pyrolusite.

CHHINDWÁRA, BÁLÁGHÁT, BHANDÁRA AND NÁGPUR. The ores of these districts occur chiefly in the recrystallized phase of the Dhárwár series, although those of the Bálághát region are in the less metamorphosed phase.

The ores at Bálághát are composed of interlaminated manganese oxides and colored quartzite, in a series of phyllites, schistose grits and quartzite. The principal mineral is psilomelane with some braunite and hollandite and occasionally pyrolusite. Where the ore is more metamorphosed, spessartite and rhodonite are found along the contact of the ore bed and the enclosing rock, and braunite is usually more plentiful.

The other three occurrences are in the gondite series and occur as beds and lenses conforming with the country rock. They consist mainly of spessartite, rhodonite and braunite with minor amounts of psilomelane. Quartz is generally plentiful.

Another type of deposit consists of bands of nodules in crystalline limestone in association with piedmontite or with spessartite and rhodonite. The ore is mainly hollandite with some psilomelane.

These three types are considered as metamorphosed phases of original sedimentary beds of manganese oxides. Besides these there are two other types resulting from surface weathering. The weathering of the Dhárwár series, where these are manganiferous produce deposits of psilomelane, pyrolusite and wad, but these are unimportant. Where, however, the original rock is gondite then the surface weathering may result in important deposits of pyrolusite, psilomelane and wad.

SANDUR DISTRICT. There are four occurrences within this district, the most important of which are the Rámandrug deposits. Here the rocks are chloritic, sericitic, and biotitic phyllites with interbedded ferruginous quartzites, and basic lava flows of Dhárwár age. The manganese and iron ores usually outcrop along the top of ridges, and the ore outcrop frequently shows tracing of bedding conformable with the enclosing sediments. Although this surface bedding suggests that the ores are interlayered with the phyllites, it is found in depth (50 to 100 feet) that the deposits give way to variagated and banded lithomarge (kaolin) which Femor considers to be the residual weathering product of the phyllite. Thus it is supposed that these deposits represent local replacements of the phyllites. The ore minerals are psilomelane and wad and in vugs in these manganite and pyrolusite are found.

VIZAGAPATAM DISTRICT. Geologically the region consists of alternating bands of gneissoid, garnetiferous granite and the Khondalite series (garnite, sillimanite, quartz and graphite). At the contact of these rocks and associated with the khondalite series, is a calcareous gneiss containing pyroxene, wollastonite scapolite, garnet, calcite, and sphene. Associated with these rocks is the kodurite series of intrusive origin.

The most important mine is at Kodur where the manganiferous belt is three miles long and one-quarter miles wide and is bordered by wollastonite-scapolite-diopside gneiss, the whole being enclosed in khondalite. The manganiferous band is kodurite altering to manganese ore, kaolin, wad, ochre, and quartz and other products of weathering. The orebodies are irregular in size and distribution and appear to have been formed where the original kodurite was rich in spandite. The principal ore mineral is psilomelane associated with braunite, which in places may predominate. Pyrolusite is plentiful.

SHIMOGA, TUNKUR AND CHITALDRUG DISTRICTS. The deposits occur in the less altered Dharwar series and are similar to the Sandur occurrences. Those of Shimoga are the most important. They represent superficial replacements of decomposed phyllites and quartzites and in depth pass from mixed manganese and iron ore into decomposed wad, kaolin and friable quartzite. The ore is psilomelane, wad, and pyrolusite. The other two occurrences are similar to Shimoga.

GANGPUR DISTRICT. The ores occur in the Dharwar series and are interbedded with quartzite and schist and are associated in many places with gondite, spessartite or spessartite-rhodonite rocks. The ore is principally psilomelane and braunite.

Gold Coast Africa(1)

General Geology.- The manganese deposits of the Gold Coast, British West Africa, occur in the Birrim series of pre-Cambrian rocks. This series is made up of mudstones, sandstones, grits, conglomerate and subordinate limestone, with tuffs and lavas of basic type. These rocks strike generally NE and show varying degrees of metamorphism, both dynamic and pyrometasomatic.

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(1) Kitson, Am.Inst.Min.Eng., Cleveland meeting, Apr.1927.

Intrusive into the **Birrim** series are granodiorites and porphyries over a large part of the area. Two granitic intrusions also occur, the older a biotite granite and the younger a muscovite granite or muscovite-biotite-granite. These granites appear to be concordant intrusions and have caused severe metamorphism resultant in crystalline schists and paragneisses.

Later dynamic forces produced para- and ortho-gneisses and schists of various kinds in certain regions. Thus the series presents extremes of character and appearance in different areas of the territory.

The original sediments had a group of beds in them which contained varying proportions of manganese dioxide. These strata were both argillaceous and arenaceous and were apparently deposited on a fairly deep sea bottom, the manganese being deposited either through chemical action, bacterial action, or both.

Due to metamorphic processes the manganese content became recrystallized to spessartite, which in the fine schists and hornfels, is of microscopic size but in the paragneisses the grains are as large as peas. The least altered rocks are now slates, phyllites, and indurated sandstones, with which the manganese oxides are intimately associated; the argillaceous beds are the richer in manganese. Later processes of weathering and oxidation concentrated the manganese into commercial deposits. In certain respects they resemble the deposits of India and Brazil as contrasted to the Russian deposits of Tertiary age.

In neither slightly altered nor highly recrystallized rocks is the MnO_2 of sufficient quantity to be of commercial value. Only where weathering has occurred, under tropical conditions, are deposits of economic importance found. There are two types of concentration:

(a) Massive

In the massive type the manganese has been leached from the surface rocks and deposited lower down, wherever the character of the containing rocks allowed for solution, percolation of solution and redeposition. This action is still in progress as shown by the rapid deposition of manganese on rocks over which the local surface waters flow.

(b) Concretionary

In this type the secondary deposition has occurred in the disintegrated argillaceous rocks. Under suitable climatic conditions, with a good cover of soil allowing slow percolation of surface waters through it, these concretionary deposits are formed.

Kitson says: "Manganese ores of massive type are formed principally in rocks of argillaceous kinds, and similarly, though to a less degree, the formation of economic deposits of concretionary ore, for a sandy soil would be less likely to admit of deposition of the oxide and the quality of the deposit would be more siliceous by reason of the highly siliceous and larger nuclei forming the cores of the granular ore."

Individual Districts.- The known deposits occur in five sections of the territory. (Fig. 7).

DAGWIN-INSUTA-SEKONDI

All within 35 miles of the sea port Sekondi.

ASHANTI DISTRICT SE of Kumasi (middle).

SIRIPE DISTRICT)
SIRO-WA) Northwestern section
HAPA)

DAGWIN-INSUTA. Of these deposits, the Dagwin-Insuta ores appear to be the only ones of economic importance. They are 34 miles by railway from Sekondi and occur on a ridge for a continuous length of 2 1/2 miles. The ridge stands about 400 feet above the valley in the NE and gradually pitching SW it disappears abruptly into a swamp near the railway.

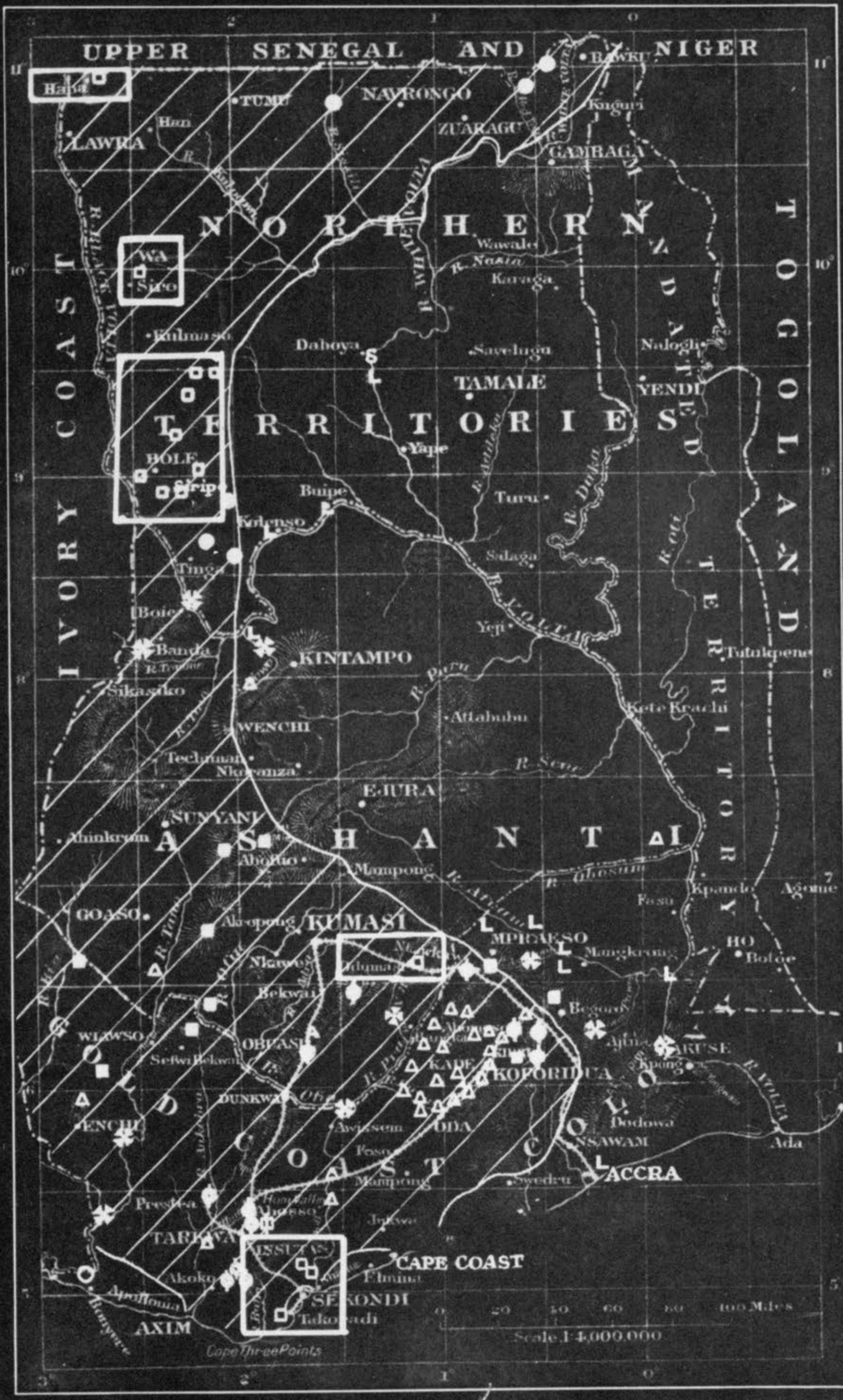

FIG. 1.—MAP OF THE GOLD COAST, SHOWING MANGANESE DEPOSITS, ☐; MANGANESE MINES IN OPERATION, ⌀, AND SUITABLE SITES FOR DAMS FOR WATER POWER, ✠. CROSS-HATCHING DENOTES MAIN AURIFEROUS AREA.

Fig. 7

The country rock appears to be a series of manganese-bearing phyllites, dipping steeply NW. They belong to the B~~e~~irrim series and are succeeded by tuffs and lavas. To the NW they are overlain unconformably by the auriferous conglomerate of the Tarkwa series. The metamorphism was caused by a nearby mass of granodiorite.

The rocks are deeply weathered and correspondingly enriched. At various places the replacing manganese oxide has retained completely the original stratification of the sediments. Overlying the weathered rock is a thick (100 feet) covering of red soil, containing sufficient manganese nodules to be used as an ore. It is mined by steam shovels, and washed (soil contains about 60 per cent manganese ore 40 per cent rock). The estimated detrital ore amounts to 3,000,000 tons and very likely is of much greater extent. In addition, underground work has proved a number of bodies of massive ore.

The other deposits about the Sekondi region are in highly metamorphosed sedimentary rocks, but as little secondary enrichment has occurred there are no deposits of commercial interest.

ASHANTI DISTRICT. The deposits in Ashanti are at Odumase. The rocks in this region are siliceous slates and flagstones, well-weathered and covered with thick soil. The manganese-bearing strata are approximately 25 to 35 feet wide, strike N. 60° E. and dip 45° to 60° NW. An average of 7 samples across these beds gave Mn, 22.2%; Fe, 4.37%; the P_2O_5 is low varying from .05 to .1 per cent.

About 7 miles to the NE are beds of sericite-chlorite and quartz schists striking N. 10° W., dip 45° to 75° E. They show a little secondary pyrolusite and psilomelane and at the base of the hill on which they occur is a small amount of granular and nodular ore is found.

These deposits are not considered of commercial value.

SIRIPE DISTRICT. The deposits about Siripe are contained in metamorphosed siliceous sediments. There has been little secondary enrichment and thus they are not of economic importance.

SIRO-WA. The deposits of **Siro-Wa** are on a low V-shaped ridge composed of fine mica schists striking N. 10° W., dip 50° to 65° SW. In places there appears to have been considerable secondary enrichment but little work has been done on the deposits.

HAPA. The ores of the Hapa district in the extreme northern portion of the district are in phyllites and slates. There has been little or no enrichment.

Value of Deposits.- The Dagwan-Insuta deposits are the only ones of economic importance. They are in a district of one of the highest rainfalls of the country and in a thick forest region. Excessive humidity and protection of rocks by soil appear to be two essentials in the secondary concentration.

Analysis of Ores.-

	Mn%	Iron	P_2O_5
Dagwin-Insuta	50-53	2-4	.1- .12
Odumase	22.22	4.37	trace
Siripe (Kalimbi Hill)	15-22	5-10	"
Siro-Wa	30.1	7.7	
Zuraga	9-12	2-4	trace

Brazil (1)

In Brazil manganese ore occurs in the states of Bahia, Minas Geraes and Matto Grosso. The deposits in Minas Geraes are the most important, having produced more than 95 per cent of the total Brazilian output. Within this state there are two districts, (a) Miguel-Burnier; (b) Lafayette or Queluz and these represent two different types of formation. (Fig. 8).

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(1) E.C.Harder, Trans. Am.Inst.Min.Met.Eng. 56, 1916.
J.T.Singewald, Jr. and B.L.Miller, idem.

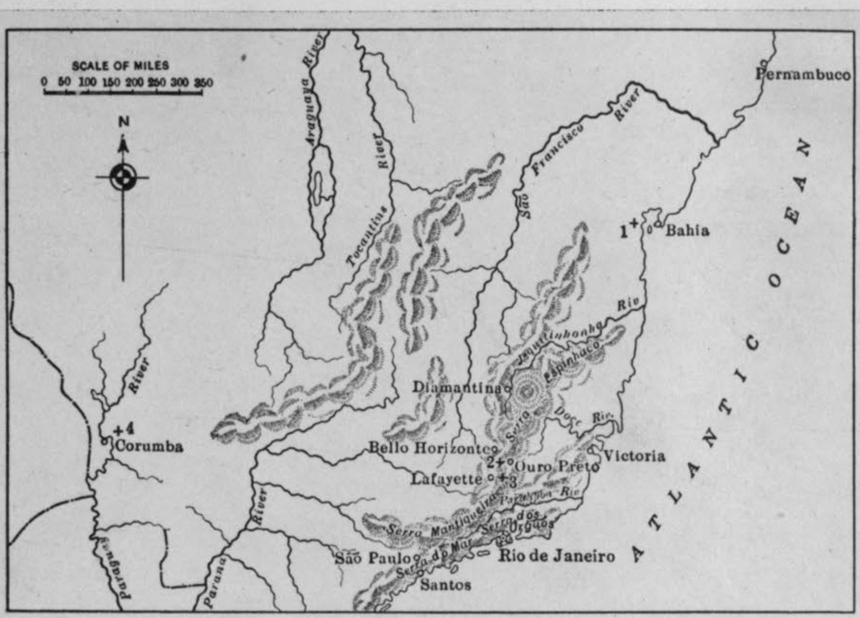

FIG. 8 —MAP OF PART OF BRAZIL SHOWING THE LOCATION OF THE PRINCIPAL MANGANESE-ORE DISTRICTS. *After E.C. Harder.*

1. Nazareth.
2. Miguel Burnier-Ouro Preto.
3. Lafayette.
4. Corumbá.

Miguel-Burnier District.- The Miguel-Burnier district is 310 miles north of Rio de Janeiro and lies to the south of the iron ore region of central Minas Geraes. "The orebodies occur as lenses or beds intercalated in a series of sedimentary strata showing a rapid succession of itabirite, schist, calcareous schist and limestone. Stratigraphically they are found in the upper part of the Itabira iron formation and in the lower part of the overlying Peracicaba schist, formations of probable Algonkian age. The ores are very high grade manganese oxides, chiefly a mixture of psilomelane and pyrolusite, averaging 50 per cent Mn; 1 per cent SiO_2; 0.03 to 0.05 per cent P. The beds are steeply dipping and narrow, rarely over 6 feet in width....and the individual deposits are relatively small."(1)

There have been two theories advanced to explain the origin of these ores. H.K.Scott(2) claims that the present orebodies represent "a residual deposit from which the other elements have been leached out." O.A.Derby(3)

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(1) Singewald and Miller, Op. cit.

(2) H.K.Scott, Manganese ores in Brazil. Jour.Iron and Steel Inst., 57, 1900.

(3) O.A.Derby, Discussion to Scott's paper "Manganese ores in Brazil", Op. cit.

adopts this view and suggests that the original rock was an impure limestone with admixed "metallic carbonates and siliceous impurities." Harder and Chamberland (1) on the other hand consider that these deposits represent "original sedimentary deposits of manganese oxide." Singewald and Miller favor the residual deposit hypothesis.

Lafayette District.- (2) The Lafayette district is some 283 miles north of Rio de Janeiro, and about 20 miles south of the Miguel-Burnier area. The ores are found in the basement complex of Archean rocks which are here represented by gneisses and amphibolite and micaceous schists into which there has been intruded a granite; smaller intrusions of diorite and gabbro are also found in the region.

The manganese deposits occur as elongated masses, of more or less lenticular shape, within the rocks of the basement complex. The ore consists of psilomelane, pyrolusite and manganite. Analyses quoted by Harder give the composition of the ore as 49 to 52 per cent Mn; 1 to 7 per cent SiO_2; 0.08 to 0.15 per cent P. The ores represent the residual products of weathering of original manganiferous rocks.

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(1) E.C.Harder and R.T.Chamberlin Geology of Central Minas Geraes, Brazil. Jour.Geology, 23, 1915, pp.358-363.

(2) Harder, Singewald and Miller, Op. cit.

The origin of the manganese rock is believed to be a "product of dynamo-metamorphism of manganese sediments deposited in the form of manganese carbonate with varying but considerable quantities of silica and varying but smaller quantities of alumina." The metamorphism resulted in a rock containing rhodochrosite, spessartite, rhodonite and tephroite. Graphite is found in places.

The orebodies are considered to have been formed from these metamorphic rocks under conditions of weathering and oxidation. Meteoric waters are assumed to have taken the manganese into solution as the bicarbonate and deposited it elsewhere as the oxide. The process of concentration is believed to have been one of simultaneous leaching of SiO_2 and CO_2 and the addition of manganese oxide, volume for volume, resulting in a compact mass of oxide. The drusy character of the ore as now found is thought to be due to subsequent solution and redeposition by meteoric waters working through the oxides.

Sinai Peninsula(1)

The Sinai deposits are in west central Sinai, about 13 miles southeast of Abu Zenima, a port on the northeast side of the Gulf of Suez about 80 miles southeast of Suez. The deposits are on a plateau, some 2,000 feet above sea level,

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(1) A.H.Curtiss, Manganese ores, Imperial Inst., 1919.

which is dissected by deep ravines. These deposits were discovered by T. Barron of the Geological Survey of Egypt, in 1898, and have been described in detail in the various publications of the Survey Department of Egypt. The occurrences of manganese are numerous but those in the Um Bogma Hills are the most important. The ores are associated with flat lying Paleozoic marls, dolomites and sandstones, and appear to be locallized in the vicinity of faults. Their average thickness is between 2 and 3 meters. Although the orebodies are found at the base of the Carboniferous limestone, they are believed to have been formed in late Tertiary times and owe their origin to solution of the dolomitic limestones, by waters travelling along faults, with a concentration and oxidation of the iron and manganese carbonates near the faults. The dolomites contain on an average 0.30 per cent MnO_2 and are considered as the possible source of the manganese.

The ore is mostly soft, and varies from almost pure pyrolusite to an ochreous hematite. Psilomelane is also present. Highly ferruginous beds with patches of hard and soft manganese ores are likewise present. The average analysis of the ore is given as: Mn, 32.30 per cent; Fe, 25.08 per cent; SiO_2, 2.79 per cent; $BaSO_4$, 3.29 per cent; P, 0.12 per cent. The estimated resources (1919) of manganese ore amounted to more than 12,000,000 tons of which nearly half was wholly or partially developed.

Australia

At the time of writing (March, 1928) no recent data concerning the recent development of manganese ores in Australia could be obtained. The following information is contained in "Manganese Ores" (1).

In 1919 the Gladstone district, Queensland, was considered one of the more important parts of Australia as regards the production of manganese ores. The output has varied from 4,600 tons in 1902 to 21 tons in 1917, between 1903-1911, the average production was a little over 1,000 tons and in 1916, 643 tons. The production was consumed by the Mount Morgan gold mine in the chlorination process.

The Gladstone district is a low area, most of it less than 100 feet above sea level, and is some 15 miles long and 12 miles wide at its greatest width. The rocks are ferruginous slates, schists, quartzites and other sedimentary rocks, of supposedly Permo-carboniferous age. These are intersected by igneous dikes. The orebodies are sometime lenticular, with their long axis parallel to the cleavage of the rocks but in general are quite irregular.

The most important mine is the Mount Miller, where the orebodies are very irregular and vary in width from 3 to 21 feet. The ore is massive psilomelane with some pyrolusite and

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(1) A.H.Curtiss, op. cit.

may be braunite. The ore contains 18 to 51 per cent Mn and averages 20 per cent SiO_2. In 1903, 1350 tons were mined averaging 74.1 per cent MnO_2.

Other deposits are known in Queensland. At Aukland Hill, Gladstone district, and at Cooroomare, Rockhampton district, restricted production has yielded ore averaging 65 per cent MnO_2 and 60 to 70 per cent MnO_2, respectively. Other places that may be mentioned are the Maryborough, Ipswich and Darling Downs districts, and Pie and Eel creeks near Gimpie.

South Australia has also produced ore since 1882. The Pernatty Lagoon occurrences, 4 miles east of Woocalla on the Port Augusta to Kalgoorlie railroad came into prominence in 1916. The ore occurs in pockets in dolomitic limestone and the overlying soil, and is in part associated with manganiferous iron ore which contains 27.67 per cent Mn; 34.04 per cent Fe; 0.1 per cent P, and 0.13 per cent S. The manganese ore contains from 45 to 56 per cent Mn; 65 to 89 per cent MnO_2; 0.01 to 0.09 per cent P; and 0.09 to 0.38 per cent S.

Chile(1)

General Review.- "Manganese ores were extensively mined in Chile for about 15 years before the close of the last century, during which period, perhaps, somewhat more than half a million tons were exported, most of it going to the United States.....Since 1905 practically no manganese ore has been mined in Chile. The mines have been abandoned... yet the deposits are by no means exhausted."

"Manganese ores occur in Chile in the Huasco and Carryal districts of Atacama, the Los Chorros, Las Canas, La Liga, Arrayan and Corral Quemada districts of Coquimbo and the Aculeo district of Santiago.....Most of the ore reported from Chile has come from the Carryal and Corral Quemada districts, but considerable ore has been shipped from Las Canas and La Liga also." (Fig. 9).

"Chilean manganese ores, according to their geologic occurrence, may be classed under three heads:

(1) Ores occurring interbedded with jasper and chert in a limestone chert formation.

(2) Ores occurring interbedded with red sandstone, shale and limestone which in turn are interlayered with massive volcanic flows.

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(1) E.C.Harder, Trans. Am.Inst.Min.Met.Eng., 56, 1916.

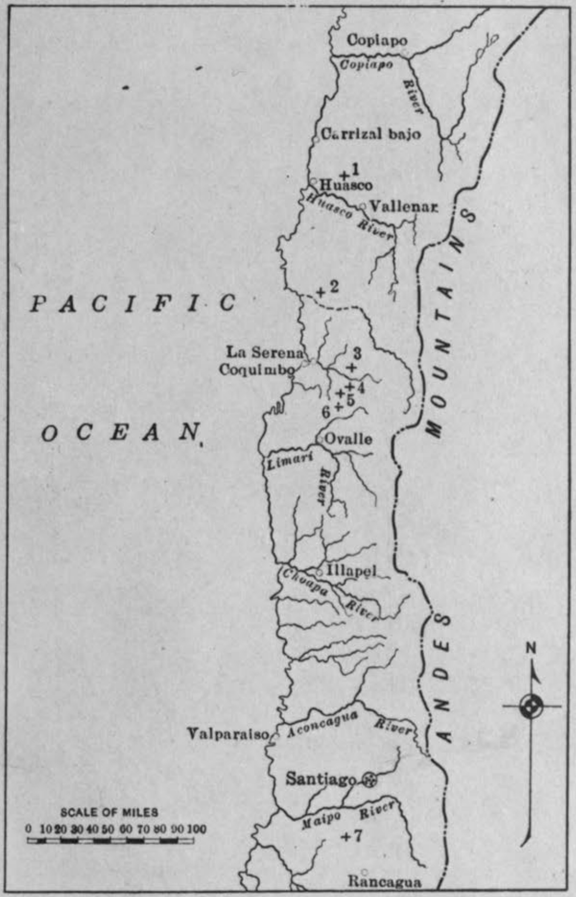

FIG. 9—MAP OF PART OF CENTRAL CHILE SHOWING THE OCCURRENCES OF MANGANESE ORE. After E.C. Harder.

1. Carrizal.
2. Los Chorros.
3. Las Cañas.
4. La Liga.
5. Arrayan,
6. Corral Quemada.
7. Aculeo.

(3) "Ores occurring as veins in volcanic flows."

"To the first type belong the ores of Huasco and Carryal; to the second type, those of Las Canas, La Liga, Arrayan and Corral Quemada; and to the third type those of Aculeo and Los Chorros. The sediments and volcanic rocks with which the ores are associated are of Mesozoic age."

Individual Districts.- CARRIZAL DISTRICT. This district is about 350 miles north of Valparaiso in a rugged barren part of the Coast mountains. The ore occurs in a north-south belt. "In the northern part, which is several miles in extent, there are from one to three beds of manganese ore, generally separated by a few feet only of chert or jasper. They are quite continuous.....but locally beds pinch out and new ones come in." The dip varies from 60° to 70°E to vertical and the ore beds are conformable with the sediments which are mainly grey chert and limestone with local beds of shale. Occasionally sills of dark green basic igneous rocks occur.

"The manganese beds vary in thickness from less than a foot to 4 or 5 feet. They are enclosed by pink or dark red jasper which usually extends several yards from the ore contact and then gives place to grey chert." The jasper owes its color to hematite impregnations. The ore is dense, hard, black psilomelane.

"The southern portion of the ore belt is comparatively short and shows several breaks of continuity. The principal part of it consists of four parallel ore beds striking approximately NE-SW and dipping 45° NW....The ore beds are enclosed in beautifully banded red jasper, which, however, does not extend far from the contact. In general the country rock is interbedded grey or white chert and grey limestone, locally crystalline. Some distance below the ore horizon is a thick sill of green basic rock."

"The ore is hard bluish-black braunite with some psilomelane and an admixture of soft black oxides."

LAS CANAS, LA LIGA, ARRAGON AND CORRAL QUEMADA DISTRICTS. These districts lie about 230 miles north of Valparaiso. and are in a region of volcanic effusives, which show all the variations in color and composition characteristic of them but are chiefly trachytic and of prevailing dark red and purple hues. Locally beds of manganiferous sediments are found, within the volcanics and these range in thickness from a few feet to 50 feet or more and consist of red and pink sandstone, shale, and limestone, and locally jasper.

The ores are interbedded with the sediments and consist in most places of fine granular to finely crystalline pyrolusite which is generally compact but soft. The ores may be enclosed between beds of sediments - usually limestone -

or between sediments and lavas; the contacts of the ore may be sharp or it may show gradational characteristics for several feet.

Cuba (1)

Distribution.- Ore is found in Oriente; Santa Clara and Pinar del Rio provinces, but only in the Oriente is it of commercial value. There the ore occurs in three districts; one north of Santiago de Cuba; one south of Bayamo and Baire; and one on the Carribbean coast between Torquino Bay and Nortillo. In Santa Clara province a little ore is found west of Trinidad. In Pinar del Rio, north of Pinar del Rio and farther west near Mendoza.

General Geology and Topographic Features.- The manganese ores of Cuba occur in the oxidized zone mainly near the surface but in places extending to at least 100 feet, and considerably below groundwater. The deposits are found principally in sedimentary rocks, such as limestone, sandstone and shale, that are in places metamorphosed, and in beds that originally may have been water laid tuffs but are now partially replaced by manganese oxides, zeolites, calcite and other minerals. In the most heavily mineralized localities the deposits are in and about masses of siliceous rock, locally termed jasper and bayate that are associated with country rock. At one locality south of Nayamo, the manganese

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(1) E.F.Burchard, Trans.Am.Inst.Min.Eng.63,1920, pp.51-104.

and its siliceous associates are in igneous rocks, such as latite porphyry and latite.

The sedimentaries dip from 0° to 45° and are locally faulted and thus may have influenced localization of the orebodies to some extent.

The deposits about Santiago and Bayamo are north of the Sierra Maestra and are in a basin drained mainly by the Rie Cauto and its tributaries. The deposits are on both sides of the basin and show an interesting concordance of elevation suggesting a formation at a particular stage in the physiographic development of the region. The deposits of Portillo are at the base of the south slope of the Sierra Maestra.

Types of Deposits.- The minerals are a mixture of pyrolusite, psilomelane, manganite and wad; braunite was noted in one place in the Oriente ores but there are no carbonates. In the Trinidad deposits ankerite and rhodonite are present in the metamorphosed limestones and calcareous schists. Analyses of the ore from the various mines show the composition to vary from 44.63 to 51.91 per cent Mn; 0.033 to 0.07 per cent P; 0.52 to 4.39 per cent Fe; 1.09 to 6.11 per cent SiO_2.

In Oriente there are three general types (a) deposits in bedded rocks; (b) deposits in irregular masses of siliceous rock; and (c) nodules and fragments in clay.

The extent and quality varies considerably. Most of the largest and richest orebodies are associated with jasper;

those that have replaced limestone are rich but small. Tuffaceous ore interbedded with limestone is mostly in thin beds; where detrital deposits of workable size occur they are low grade and thus require washing. Residual clay types yield good ore after picking, screening and washing, but are not extensive or numerous.

Deposition.- The jasper type is regarded as one of the earliest formed; the jasper being deposited in limestone and glauconite beds by solutions enlarging joints and crevices and locally replacing the enclosing rocks by silica and manganese minerals. Jasper and manganese were deposited contemporaneously, or nearly so, with manganese slightly later accompanying secondary silicification.

The regularly bedded deposits in volcanic tuff are between foraminiferal limestone of Eocene age. After the deposition of these beds later solutions moved through porous beds, partly replacing original material. Some irregular masses appear to have been formed by transported material of easily disintegrated tuffs and beds; the detrital material having been cemented by MnO_2.

It is possible that the manganese was derived from the volcanic rocks of the Sierra Maestra, transported by artesian water and deposited, with silica, as masses of manganiferous jasper in joint fissures and cavities in limestone and other rocks in the local anticlines of the basin as well as along beds of more porous tuffs. The jasper and bedded tuffs in weathering may have contributed the manganese that is now found in the adjacent rocks and in detrital deposits.

The manganese of Trinidad is from volcanic or igneous rock with structure favoring a flow of underground water to the surface.

United States

General Résumé.- The reserves of manganese ores of the United States are classified by the U. S. Geological Survey, Mineral Resources (1) into (1) high grade chemical ores; (2) high grade ore and ore capable of benificiation; and (3) low grade ferruginous or manganiferous ores.

Prior to the war, the main production of the first class of ore was obtained from Virginia, Georgia and Arkansas, but due to abnormal war stimulus Colorado, Arizona, Nevada, Montana and California took the lead in the production of this type of ore. Montana developed large resources of high grade oxide ore and likewise became an important producer of rhodochrosite.

The second type of ore is unimportant in the United States under normal conditions of production.

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(1) U.S.Geological Survey, Mineral Resources, 1921.

The third type may be subdivided into the manganiferous ores of the west that are used as a flux in copper, silver and lead smelters, and the manganiferous iron ores. Of the latter type the Lake Superior region is the most important producer, such ores being obtained from the Cuyuna, Mesabi, Menominee and Gogebic fields. Of these the Mesabi district has been the most irregular reaching a maximum of 800,000 tons in 1919 and is now producing under 100,000 tons annually. The average for the last five years being 72,587 (1).

The Menominee and Gogebic districts have been important contributors and for the last five years have furnished on an average of 326,078 and 731,010 tons, respectively. The Cuyuna range started its shipments of manganiferous ore in 1913 and has since showed a steadily increasing tendency of production, reaching an output of some 1,123,909 tons in 1927. Its average production over the last five years being 883,938 tons.

Mr. Zapffe calls attention to the fact that the manganiferous iron ore used in the Lake Superior region varies from a minimum of 2 per cent Mn to a little over 10 per cent Mn. Ores of 35 per cent Mn do not exist in any quantity.

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(1) C.Zapffe, Am.Inst.Min.Eng., Cleveland meeting, April, 1927. Reserves of Lake Superior Manganiferous Iron Ores.

The following is a brief summary of the manganese districts in the United States. The information has been obtained principally from the following articles:

(1) Manganese - R.A.F.Penrose, Ann.Rept.Arkansas Geol.Survey,1893.

(2) E.C.Harder, U.S.Geol.Survey Bull.425,1910.

(3) J.F.Pardee, " " " " " 725,1921.

An additional source of manganese is that obtained from the roasting of the manganiferous zinc ores of Franklin Furnace, N.J.

Ninety-two per cent of the manganese used in the United States is consumed in the steel trade. The remaining 8 per cent is classed as chemical ore and of this 40,000 to 50,000 tons is used in the manufacture of dry cell batteries. Only a small amount is consumed in the manufacture of glass, bricks, pottery, etc.

New England Region.- Manganese deposits are found in both the crystalline and sedimentary areas. In the former the mineral is usually **rhodonite**, which may have associated with it localized deposits of wad which are the result of superficial weathering of the silicate mass. Such deposits are found at Blue Hill, Maine, and Cummington, Massachusetts, and have been mined to a limited extent for ornamental purposes, jewellery and also as a flux. Other occurrences of rhodonite are found at Winchester, and Hinsdale, New Hampshire, Plainfield, Conway, Chesterfield, Sheffield, Massachusetts, Sneech Pond and Pawtucket, Rhode Island.

In the sedimentary rocks of western New England manganese is found associated with brown iron ores and is sometimes of sufficient quantity to form a manganiferous iron ore. The manganese ore, mostly a mixture of psilomelane and pyrolusite, occurs in irregular kidneys and pockets in clay, along with associated fragments of brown iron ore. Deposits of this type occur at Redding, Salisbury, Connecticut, Berkshire Hills and western Massachusetts, Brandon, South Wallingford, Chittenden, Vermont. Wad and bog ore are found in various parts of New York State. These ores have been used in a small way for their iron or manganese content.

Piedmont and Coastal Plains Region.- The Piedmont area is considered as that strip of country underlain by crystalline rocks which extend from New Jersey to Alabama and lies between the Appalachians on the west and the "fall line" on the east. The Coast Plain is between the "fall line" and the Atlantic and is underlain by Mesozoic and Cenozoic sediments.

The deposit near City Point, Prince George County, Virginia, is the only manganese occurrence reported in the Coastal Plain region. Here the manganese is in association with iron ores in Tertiary rocks.

The rocks of the Piedmont area are ancient crystallines and metamorphics with younger intrusions of diabase, gabbro, and diorites. All these rocks have suffered considerable weathering, the oxidized zone sometimes extending to a depth of 150 feet or more, and it is in this zone that the manganese deposits are found. The source of the manganese is considered to be the manganese-bearing amphiboles, pyroxenes, garnets, micas, etc. originally present in the unweathered rock mass. Where the manganese has remained as a residuum of the original mineral it is found as grains of one of its oxides scattered through the sand and clay; the nodules, kidneys, and pockets of ore found in the clay and mud are considered to be the manganese that was dissolved, transported and redeposited in favorable places during the process of weathering.

The principal deposits are those in the James River and Stanton River valleys in Virginia where the ore, composed mostly of psilomelane and pyrolusite, occurs along and near the contact of granite and mica schists. The ore is found in both the granite and schist, and decreases in amount away from the contact. In South Carolina the occurrences near McCormick and Kings mountain are all irregular veins and replacements, few of which are sufficiently large to work.

In contrast to these deposits are the manganiferous zinc ores of Franklin Furnace, New Jersey. These deposits are found in crystalline limestones associated with igneous gneisses of pre-Cambrian age, and are considered to represent original contact deposits of franklinite, willemite, zincite and calcite. Later metamorphism caused by the injection of pegmatite dikes resulted in the formation of tephroite, schefferite, gahnite, polyadelphite (manganese garnet), axinite, apatite, rhodochrosite, fluorite, sphalerite, galena, arsenopyrite, chalcopyrite and löllingite.

The manganiferous residue derived from the roasting of the franklinite is used in the manufacture of spiegeliessen.

Appalachian Region.- (1) The Appalachian region is the southern continuation of the western New England sedimentary area and extends from Pennsylvania through Virginia and Tennessee into Georgia and Alabama including a small part of western North Carolina. This belt is bounded on the east and southeast by the Piedmont region on the west by the Cumberland and Alleghany Plateaus.

Manganese ores occur at intervals throughout the Paleozoic rocks from Pennsylvania to Alabama. The principal deposits (Blue Ridge, Virginia, Cartersville, Georgia) lie in a narrow belt along the extreme eastern edge of the Appalachian Valley. Besides these two there are also many other less important deposits in Virginia, Tennessee, Georgia

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(1) E.C.Harder, U.S.Geol.Survey Bull.425, 1910.

and Alabama. "Other deposits occur inside the Appalachian Valley, in a second belt a little west of and parallel to the main belt."

"The manganese deposits of the Appalachian region occur in residual clay and sand derived from the Cambrian, Ordovician, and to a slight extent from Silurian sediments" and have associated with them, in many places, deposits of limonite. In travelling from the Piedmont area, westward, successively higher geologic horizons are encountered. Thus the deposits in the eastern belt are associated with Cambrian quartzites, shale, and limestone, those in Tennessee and Georgia with the Knox dolomite, and in Virginia with Silurian rocks. Besides the manganese ores there are many manganiferous iron ores.

BLUE RIDGE AREA. The Blue Ridge area is on the contact between the metamorphics of the Piedmont area, and the Paleozoic sediments of the Appalachians. The sedimentary rocks range from the Cambrian to the Devonian. The Cambrian is composed in its lower members of quartzites and shales, and these are succeeded by a heavy quartzite which is in turn overlain by the Sherwood limestone and the Buena Vesta shale. The latter two have been removed from the top of the ridge and are now found along the western flanks of the Blue Ridge. It is in the clay derived from the decomposition of the

Sherwood limestone and lower quartzite that the deposits are found. The deposits consist of local concentration of manganese fragments into irregular pockets several hundred yards in area and up to 100 feet deep, except at the Crimora mine where conditions have favored the collection of the ores in basins of clay in the underlying bed rock. The ore is associated with clay of varying color and ranging in consistancy from a stiff to a sandy clay; fragments of unaltered rock, mostly sandstone and chert, are common.

The ore is psilomelane and pyrolusite and is found as kidneyed-shaped masses, and irregular bodies in the clay or forming the matrix of a breccia composed of sandstone or chert fragments. Alternating concentric layers of psilomelane and pyrolusite are found within some of the nodular ore.

NEW RIVER AREA. The New River area in northwest Virginia is best known for its limonite deposits with which there is a small amount of manganese; this in places is sufficiently abundant to form a ferruginous manganese ore. These occurrences are in Cambrian and Ordovician rocks, principally in the clays derived from the Erwin quartzite and to a lesser extent from the Shady limestone (Cambrian).

Manganese and manganiferous iron ores occur in eastern Tennessee and western North Carolina associated principally with the Shady limestone and to some extent in the residual clays derived from the lower formations.

CARTERSVILLE AREA. The Cartersville area is some 15 miles long and 6 miles wide extending in a north-south direction in Bartow County of northwestern Georgia. The rocks of the district are Cambrian and Ordovician, but the ores are associated with the Weisner quartzite and the overlying Beaver limestone. The former contains layers of siliceous shale and fine conglomerate and weathers to a sandy variagated brown and yellow clay, while the limestone is dolomitic with local developments of shale and chert, and yields a dark residual clay with chert fragments.

The ores are found scattered through the residual clays of both these formations and locally the fragments are concentrated into economical deposits. The ore is psilomelane and pyrolusite which occurs in kidney-shaped and irregular masses, as a cement to a breccia of chert and sandstone fragments and as seams and irregular pockets. These different types may occur separately or together within a single deposit.

ORIGIN OF APPALACHIAN ORES. "Penrose held that they were laid down in local basins during the deposition of the rocks in whose residual clays they are now found. It is now believed that the metal was in the first place obtained from the crystalline rocks of the Piedmont region and first concentrated in certain Paleozoic beds. The final concentration occurred in the Cretaceous and Tertiary during the several epochs of peneplanation."(1)

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(1) W.Lindgren, Mineral Deposits, 3d Ed., 1928, pp.385-387.

Lower Mississippi Valley and Gulf Region.- Within this region deposits are found in the crystalline areas of central Texas, and Pilot Knob, Missouri, and in the Silurian and Devonian rocks of west and north central Arkansas.

BATESVILLE DISTRICT. The Batesville district in north central Arkansas is underlain by rocks varying in age between Ordovician and Pennsylvanian. Of these the Ordovician and Mississippian are the best represented whereas the St. Clair limestone of Silurian age is developed only locally, and the Devonian, Chattanooga shale is of doubtful occurrence. The Cason shale of Ordovician age is the important horizon in connection with the manganese deposits. It shows marked variations in character from place to place, and where present rests on either the Polk Bayou or the Izard limestone and is overlain by the St. Clair limestone, if present, or by the Boone chert. "The entire formation is heavily impregnated with manganese and iron oxides and the shaly layers contain an abundance of small flattened button-like pebbles, of manganiferous iron ore."(1) The phosphate deposits of the Batesville region are intimately associated with the manganese ores.

The ore has three different types of occurrence; the most important are the occurrences in the Cason shale,

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(1) E.C.Harder, U.S.Geol.Survey, Bull.427, 1910.

which where extensively developed consists of a mass of "manganiferous and ferruginous clays with scattered bunches of ore, or if still consolidated consists of layers of shale, sandstone, and sandy ferruginous manganese ore."(1) A second type of occurrence is where the ore is found in clay below the ore horizon or where it has been eroded away. The third type is found in the southern part of the district where there is a bed of low grade manganiferous iron ore, beneath the St. Clair limestone, made up of flattened, button-like pebbles of ore arranged along the bedding planes of the shale.

The ore is principally psilomelane, but braunite is also present along with soft friable oxides. Amorphous soft oxides, in places form the matrix to a chert breccia. The Cason shale is believed to be the source of the manganese, the final concentration occurring during the Cretaceous and Tertiary peneplanation. "The Batesville ores contain much hausmannite and braunite. It is possible that some manganese deposits in Arkansas and Oklahoma are derived from later veins of rhodochrosite, which break through the sediments."(2)

In west central Arkansas manganese and iron ores are found in early Paleozoic rocks. The ore horizon is a novaculite (almost pure silica, varying from a hard translucent

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(1) Op. cit.

(2) W.Lindgren, Mineral Deposits, ed Ed.,1928, p.385.

white, grey or buff rock with conchoidal fraction to a soft porous or granular rock with irregular fracture), of late Silurian and Devonian age. The ore, principally botryoidal psilomelane and some pyrolusite, is found at the top of this rock as stains or in a network of thin pockets and seams.

CENTRAL TEXAS. The manganese ores of central Texas are found in association with the quartzites, gneisses and micaceous and garnetiferous schists of probable pre-Cambrian age. The ores are a mixture of oxides and silicates such as spessartite, andradite, piedmontite, and tephroite. The ore minerals, mainly psilomelane and pyrolusite, have been derived through oxidation of these silicates and are now found as layers and lenses conformable with the enclosing rocks.

Lake Superior Region.-(1) One of the most important sources of manganese in the United States is the Lake Superior manganiferous iron ores. Of these the Cuyuna Range is most prominent. Here the iron ores are found associated with pre-Cambrian ferruginous cherts, calcareous slates, amphibolites, quartzites, micaceous and chloritic schists and other metamorphic rocks. In general the ore beds are

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(1) E.C.Harder, U.S.Geol.Survey Bull. 427, 1910, pp.127-131.
W.Lindgren, Mineral Deposits, 3d Ed., 1928, pp.388,407,410.
G.A.Thiel, Economic Geology, 19, 1924, pp.107-145.

steeply dipping between a hanging wall of green slate and a footwall of amphibole-magnetite rock. The iron ores are replacements of the ferruginous cherts and the calcareous slates, and grade into these both laterally and in depth. The limonitic ores are considered by Thiel to be a replacement of the gray green calcareous slates whereas the hematite magnetite ores are regarded as being derived from the ferruginous cherts. Stratigraphically he places the cherts higher than the calcareous slates.

All the rocks contain a varying but persistent amount of manganese, the carbonate rocks containing around 6 per cent of Mn. The iron ores resulting from the weathering of these rocks all contain some manganese. Those ores that are sufficiently high in manganese (10 to 25 per cent Mn, or over) to be considered manganiferous iron ores, are thought to be derived from original carbonate rocks, or rocks with intercalated carbonate members, whereas the ores with low manganese content have been derived from the ferruginous cherts.

The following is a summary of Thiel's conclusions:

"1. The development of intimate mixtures of iron and manganese oxides is shown to occur on the Cuyuna Range in the simultaneous replacement of chert by manganite and hematite; in the replacement of concretionary limonite by manganite; in the contemporaneous deposition of hematite and psilomelane, in nodular concretionary ore, and in the intimate intergrowth of manganite and pyrolusite with hematite in martite crystals.

"2. The high grade Cuyuna manganese ores are mostly composed of manganite and are confined to carbonate horizons. In the unaltered state the rocks are gray green carbonate slates, containing a higher percentage of manganese than the pink or dark, massive, ferruginous cherty horizons.

"3. The soft thin-bedded limonite with concretionary manganese ore is derived from a slate rock, whereas, hematite ore is more commonly found as a replacement of ferruginous cherts. Some of the limonite and hematite is later replaced by manganese minerals.

"4. In the process of alteration of slates or ferruginous cherts into manganiferous iron ores, limonite and hematite replace the primary sedimentary minerals, and they in turn are replaced by manganese minerals. However, some evidence was observed of direct replacements of gangue mineral by manganite and psilomelane.

"5. In the limonitic high phosphorous ores pyrolusite and psilomelane are most abundant and in the hematite, high silica, low phosphorus ores, manganite, and psilomelane predominate.

"6. The presence of manganite as the predominant manganese mineral indicates that the present orebodies were formed by solutions from overlying portions of the iron formation that have been removed by erosion. This conclusion is supported by the fact that a résumé of the literature shows that manganite is not as abundant as pyrolusite and psilomelane in the zone of leaching, but is more abundant at greater depth."

In a later paper Thiel (1) draws attention to the quartz veins that cut the Cuyuna iron formation, and points out the presence of primary manganese carbonate in these veins as "that at least a part of the manganese of the manganiferous ores of the Cuyuna Range was introduced into the sediments after the major deformation and metamorphism had been completed." This conclusion does not modify his earlier views that much of the ores were derived from an earlier bedded carbonate precipitate.

Rocky Mountain Region.- (2) Prior to the war many localities through New Mexico, Colorado, Utah, Arizona, and Montana produced manganiferous silver ores, the manganese of which was used as a flux in smelting. In 1916 the Philipsburg

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(1) G.A.Thiel, Economic Geology, 19, 1924, p.377.

(2) E.C.Harder, Op. cit.

J.J.Pardee, U.S.Geol.Survey, Bull.725-C,1922.

district, Montana, shipped large quantities of high grade manganese oxides and in subsequent years became the most important producer of high grade manganese ore in the country. In 1917 moderate shipments were made from the Butte district and attempts were made to concentrate the highly siliceous and manganiferous materials in some of the veins. The year 1918 marked the mining of large quantities of rhodochrosite in both districts.

MONTANA. Philipsburg. The rocks of the district are Paleozoic quartzites, shales, and limestones intruded by a granodiorite batholith of Tertiary age. The mineralizing solutions derived from the batholith produced the lead-silver-zinc ores of the district which have as a gangue quartz and rhodochrosite. Besides occurring in the quartzose veins the rhodochrosite likewise forms replacements in the limestone. Subsequent weathering and oxidation resulted in the replacement of the rhodochrosite by the manganese oxides, principally pyrolusite and psilomelane with some braunite, without marked migration of the manganese. The resultant oxide ore is a cellular mass.

Butte(1). The Manganese of the Butte district is associated with the silver-lead-zinc veins of the

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(1) Harder and Pardee, op. cit.

district and occurs as the carbonate and silicate along with the quartz gangue. Considerable bodies of rhodochrosite also exist and these form the main reserve of the district. The oxidation of the manganiferous lodes has produced high grade oxide ore in places but mostly it has resulted in a highly siliceous material difficult to concentrate.

Other Localities. Besides the Philipsburg and Butte occurrences manganese is known in several districts where it is in association with lead, silver, and zinc ores, and as such is generally classed as manganiferous silver ore. A very small amount has been mined as manganese oxide but the vast majority of it has been used in the smelting of the ore. In such occurrences the manganese is found either as rhodochrosite or as a mixed carbonate of iron, calcium and magnesium. Occurrences such as these are known in the Butte district, at Neihart, Wickes and other places.

UTAH.(1) The manganese deposits in Utah are mostly in the eastern part of the state just south of Green River, Little Grande district. Others are found in the western part about Tintic and Erickson.

The rocks of the district are the La Platte sandstone, McElmo, Dakota sandstone and the Mancos shale. The area is in

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(1) Harder and Pardee, op. cit.

an arid climate and the topography is characterized by deep, precipituous valleys and wide flat topped uplands. Wind erosion is paramount.

Pardee classifies the deposits into three types:

Deposits interbedded with the Sediments.- These are mostly in the Little Grande district and are associated with limestone and gypsum of the McElmo formation. The ores are pyrolusite and manganite principally and have been derived from the oxidation of a manganese carbonate originally deposited along with the limestone. They form "blanket veins" at or near the surface.

Residual deposits.- These consist of fragments of pyrolusite and manganite scattered over the surface of the ground and have been derived from the preceding type through the disintegration of the rock and the removal of the rock minerals by wind erosion.

Replacement deposits.- These deposits are found chiefly in the western part of the state and are the result of surface weathering of original masses of rhodochrosite and rhodonite formed by the replacement of the country rock by magmatic waters. The oxide ore is mainly psilomelane and pyrolusite with wad and more or less vein quartz and country rock. The unaltered primary material is rhodonite, rhodochrosite, and quartz associated with pyrite, sphalerite, and galena.

COLORADO(1). Leadville. The rocks about Leadville range in age from Archean to Quarternary. Upon a basement of Archean granite are found Cambrian quartzite, Silurian dolomitic limestone, Devonian quartzite, Carboniferous (Leadville dolomite) limestone and shale. These are intruded by Mesozoic diorite and porphyry and overlain by Tertiary rhyolites and andesites.

The ores are found in the Leadville limestone beneath masses of porphyry and in the Silurian limestone under the Parting quartzite (Devonian). The orebodies are irregular in shape and grade into the enclosing limestone, the contacts with the porphyry and quartzite being sharp.

The unoxidized ores contain pyrite, galena, sphalerite, and argentite in a gangue of quartz, with some calcite and barite. Manganese is said to be present in amount up to 1 per cent. Through processes of oxidation the manganese content has been increased to 15 to 25 per cent and is in the form of wad scattered through limonite. According to their content the ores have been used for their lead and silver content, for the manufacture of spiegeleisen and ferromanganese, and as a flux in smelters.(2)

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(1) E. C. Harder, op. cit.

(2) idem.

Besides the Leadville occurrences manganiferous silver ores occur in Eagle County and in the San Juan district. Manganese and manganiferous iron ores are found in limited amount at Taylor's Peak and Ceholla Valley, Gunnison Co.

NEW MEXICO (1). Manganiferous and ferruginous silver ores occur at Silver City, Kingston and Lake Valley, New Mexico. They are said to average 12 per cent Mn and to have been used as a flux in smelters.

Great Basin Region.- (2) The manganese ores of the Great Basin have no great importance. They are mostly manganiferous silver ores. Such deposits are found at Pioche and Eureka, Nevada, and in the Tintic district, Utah. The small bedded deposit at Golconda, Humbolt Co., Nevada, is believed to be related to hot spring waters, charged with manganese, collecting an isolated basin and depositing their manganese content.

Pacific Region.- CALIFORNIA (3). The California oxide ore is found in association with the Franciscan formation of the Coast Ranges and the Calaveras formation of the Sierra Nevadas. The deposits in the latter are not considered of

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(1) Op. cit.

(2) Op. cit.

(3) Op. cit.

commercial value. Those in the Franciscan formation are found associated with the jasper lenses contained in it, and are believed to be derived through the weathering of these jasper lenses which contain a small amount of manganese in them. Such deposits vary in size up to 10,000 to 15,000 tons.

OREGON. In Oregon (1) manganese deposits are known in Jackson and Josephine counties in the southwestern part of the state, and in Baker County in the northeastern portion. Those deposits in the Lake Creek district, Jackson County, consist of manganite, psilomelane and wad filling cracks, pores and other cavities in the Tertiary volcanic tuff. The deposits are of considerable surface area but do not extend more than a few feet below the surface. The ore is segregated in streaks, nodules and grains and may be easily separated from the containing rock.

In the Pleasant Valley and Durkee districts of Baker County the deposits occur as oxidized portions of original carbonate and silicate minerals that replaced the siliceous argillites and limestones of Paleozoic age. The oxides are pyrolusite, psilomelane, and manganite and have associated with them quartz, kaolin, and locally a little iron. Traces of gold, silver, and tungsten are said to be present in some.

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(1) J.T.Pardee, op. cit.

WASHINGTON.[1] The manganiferous deposits in Washington consist of superficially oxidized carbonate and silicate minerals that have formed replacements in the country rock as at Three Buttes mines, near Omak, and a deposit near Ential in the Okonogan and Columbia valley, a second type is characterized by bementite and these are located in the Olympic Mountains.

"The Crescent mine, situated a short distance west of Lake Crescent, in the Olypmic Mountains of Washington, yields an unusually high grade of manganese ore, which is suitable for making steel. Several manganiferous lodes of promising appearance have been found in the same area, and some mear Humptulips, on the south side of the mountains. These and deposits on Skokomish River and at other places in the Olympic region are distributed around three sides of the mountains through a distance of 110 miles.

"The characteristic and generally the most abundant manganese mineral in this belt is bementite. Hausmannite occurs in several of the deposits and is locally abundant in the Crescent mine, where it forms the most valuable constituent of the ore. In addition more or less of a manganiferous carbonate is present, and bodies composed of fine-grained quartz and iron oxides form a large but separate part of the lodes.

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(1) J.T.Pardee, U.S.Geol.Survey Bull.725-C,1921, and Bull. 795-A, 1927.

"The deposits are associated with an impure red limestone of marine origin, which is probably to be correlated with the Franciscan formation of California. The limestone is overlain by a thick series of basaltic flows and tuff of Tertiary age that are partly altered to greenstone. The manganese is thought to have been deposited originally with the limestone as a carbonate. The concentration and change of much of it from the carbonate into bementite and hausmannite are believed to have been caused by warm solutions charged with silica that were expressed from the lavas or their magma. Afterward mountain-building movements and erosion elevated and exposed the manganiferous beds.

"The beds at the horizon of the manganiferous deposits are very incompletely explored and are to be regarded as the possible source of large quantities of ore."

CHAPTER III

XI OCCURRENCES IN NOVA SCOTIA.

In the following description the deposits are mentioned in the order of their geographical distribution from east to west. All of the properties, with few exceptions, have remained idle for many years and are in very poor condition for examination. Accordingly, much of the data referring to the various properties were obtained from local residents who had worked in the mines, or from previous reports, written while the properties were working. These were supplemented as far as possible by a careful examination of the dumps, and surrounding geology.

The principal references consulted in the preparation of this report included:

Reports by H. Fletcher, Ingall and others, found in the Canada Geolgical Survey Reports of Progress from 1879 onward.

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Other references are found as footnotes.

Cape Breton Island

Occurrences of manganese, principally as wad, are rather common about the Bras d'Or Lakes. The following localities were visited by the author: Lock Lomond, Terra Nova, Tom's Brook, Beaver Cove, and Boularderie Island, and a description of each is given. The ones worthy of note are those about Lock Lomond, Terra Nova, and Boularderie Island, the others are occurrences only.

LOCK LOMOND.- Location.- Occurrences of manganese in the Lock Lomond district are on the adjoining farms of N. Morrison and McCuish, 2 1/2 to 3 miles east, on the Enon-Big Glen Road, from Enon Postoffice, Cape Breton County, C.B. The workings on Morrison's place are about 1/4 mile south of the road and just west of a small creek flowing north. W.Long. 60° 29' 45"; N.Lat. 45° 49' 15". On McCuish's property the ore was found along the eastern bank of a brook near the western end of the property. An old road, 1/4 to 1/2 mile long leads from the main road to the showings. W.Long. 60° 30' 10"; N.Lat. 45°49'.

History. The discovery of manganese in this vicinity was first made by Hugh Fletcher about 1879. Shortly afterwards the Hon. E.J.Moseley of Sydney, C.B., obtained the mining rights and produced about 129 tons during 1881-1882; up to 1890 some 300 tons are said to have been shipped from the locality. The mines laid idle from 1890 to 1915, when the Dominion Steel Corporation sunk a shaft on the Morrison occurrence. In 1920, Mr. C.B.Wetmore, of Sydney, C.B., obtained the right of search in the locality and removed some 12 tons or more of ore from the McCuish mine. Since then no work has been done.

Geology on Morrison Property. The rocks in which the manganese is found are limestones, shales and grits of lower Carboniferous age. At Morrison's mine, there is a light brown to grey fossiliferous limestone underlain in order by fine conglomerate, reddish sandstone, reddish and greenish grit, and red arenaceous shale. This series overlies unconformably a reddish granite which outcrops a short distance away.

Occurrence on Morrison Property. The ore occurs in bunches in red shale and as veinlets, nodular masses and replacements in the underlying limestone, the latter having a tendency to follow the bedding planes and retaining in varying degree the original structure of the limestone. The main concentration appears to be at or near the base of the limestone and following approximately parallel to the conglomerate-limestone contact. Some manganese is found as a cement to the conglomerate and also in narrow veinlets in the underlying reddish sandstone. The old reports claim that the main production came from pockets in the shale.

Mineralogy on Morrison Property. The manganese is present as pyrolusite, which is both dense and columnar in habit. Within the main mass of ore, radiating groups of acicular crystals are common. Analyses of the ore gave MnO_2, 91.84 per cent; Fe_3O_4, 0.12 per cent; insol., 2.91 per cent(1). Associated minerals are calcite, barite, and selenite.

Workings on Morrison Property. The development on Morrison's farm consists of a number of shallow trenches, a shaft 20 feet deep and a tunnel. Good ore, of limited quantity, is said to occur in the bottom of the shaft. The tunnel is now entirely caved, but according to H.Fletcher it followed a 7-inch seam of ore in reddish sandstone.

Geology on McCuish Property. On McCuish's farm, the westerly of the two occurrences, there is a grey to buff lime-

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(1) F.D.McAdams, Canada Geological Survey, Annual Report, 1881-1882, p.12-H.

stone overlying a red argillaceous shale which in turn overlies a hard conglomerate consisting mostly of porphyritic pebbles. These beds have a very low dip NW in places approaching 10°.

Occurrence on McCuish Property. The ore is found as lenses along the bottom of the limestone and between the bedding planes of the shale. Local reports said that the ore was found in long chimney-like masses varying in width and thickness up to 18 inches, or more. The location and attitude of the workings add weight to this description.

Mineralogy on McCuish Property. The minerals present are pyrolusite, manganite and hausmannite forming massive, or finely porous ore made up of interlocking acioular crystals. The porous ore is mostly pyrolusite with the other minerals scattered here and there as unaltered residual remnants. In the massive ore manganite and hausmannite are more plentiful but the alteration to pyrolusite is conspicuous.

As represented by the specimens collected, the massive ore developed through a replacement of the limestone. In thin section it is seen to start with a slight yellowish smudge on the calcite, and this gradually increases until minute rounded amorphous blebs of manganese oxide (manganite?) are seen within the calcite. Further addition of oxide results in the massive ore. Along with the amorphous development there is a small amount of crystal development of manganite. Subsequent changes (closely associated with the final replacement of the $CaCO_3$) resulted in crystalline manganite and hausmannite. Further alteration produced the porous ore composed mostly of pyrolusite. Within the vugs delicate incrustations of barite may be seen.

Workings on McCuish Property.- The largest and most recent work consists of a trench some 300 feet long, 15 to 20 feet wide, and varying in depth up to 20 feet; the bottom of this following closely parallel to the limestone, shale, and conglomerate contact. This is about 1/4 mile in from the main road and C.B.Wetmore, of Sydney, is said to have obtained most of his ore from it. In a small, badly broken shed at the foot of this trench there are some 5 tons of well-picked ore. About 1/4 mile farther up the brook are the old workings consisting of a number of pits, and a small, narrow tunnel following down the dip of the beds.

TERRA NOVA. Location.- This deposit is between the headwaters of the Gaspereaux and Salmon rivers, 3 1/2 miles south of Big Pond, Cape Breton County, C.B. It is about 1/3 mile NE from the house of F.D.Campbell. W.Long. 60° 32'. N.Lat. 45° 51' 45". Access from Big Pond is obtained over the Big Pond-Enon road for 3 1/2 miles, and thence by a secondary side road to Campbell's place.

History.- The first work was done in 1893 under the supervision of A.Morrison. Little was accomplished by this effort and the property laid idle until 1919, when another effort was made. In 1927, the right of search was obtained by Mr. Ed. Stapleton of Sydney.

Geology.- The district is underlain by porphyries and granites and Carboniferous conglomerate, limestone, and the Millstone grit. The deposit is in low, swampy ground, and the exposures are conspicuous by their absence.

Occurrence and Mineralogy.- From field observations and a study of specimens sent to the Survey by Mr. Stapleton, and those collected during the field examination, it is seen that the ore is replacing a dark buff, limy clay, and also veining granite. The minerals present are braunite and pyrolusite. Braunite is mostly associated with the clay, and forms a dense, hard ore, through which fragments of clay may be seen here and there. The braunite-pyrolusite ore is found as veinlets in the granite. Polished sections showed the braunite to be the earlier mineral and this was replaced by the pyrolusite, perhaps through the intermediate stage of manganite, but not definite evidence of this could be found. Thin section showed braunite developing along cracks in the granite minerals.

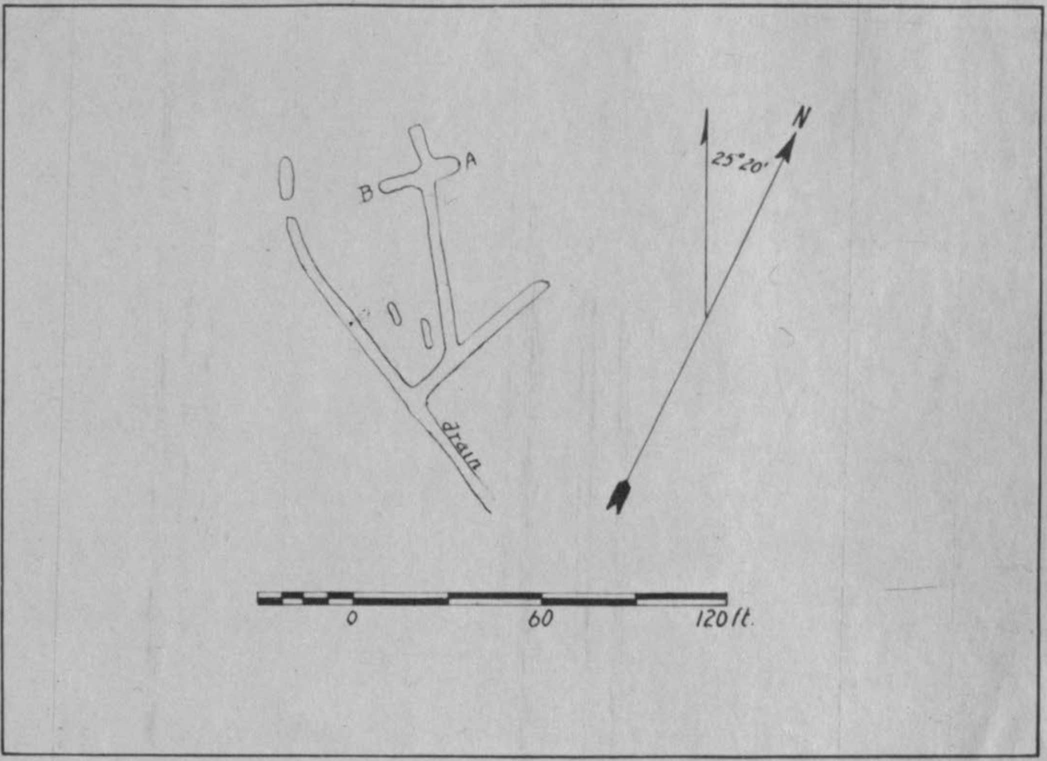

Fig 10. Terra Nova

Workings.- Development on the property consists of a number of connected trenches (Fig. 10). According to Mr. Morrison, Big Pond, who worked here in 1919, the ore was found in the trench A.B. extending from A to B in a wedged-shaped mass some 3 feet wide and of varying thickness. At B it was 2 feet thick and appeared to be "dipping NW into the rock". The last three feet of the trench was in ore over its entire width.

MCVICARS. On the farm of John McVicar, Lock Lomond, there is an occurrence of hematite. A shaft about 25 feet deep was sunk through Carboniferous limestone to the ore strata which is reported to be parallel to the bedding and of variable thickness up to 8 feet. On the dump of this old shaft, considerable manganese ore is present. The specimen collected from here is well-crystallized hausmannite in association with calcite, rhodochrosite, manganite, pyrolusite, and limonite and hematite. The hausmannite is replacing the original limestone but the rhodochrosite appears to be later because it forms veinlets in the hausmannite, and incrustations upon it in cavities. The manganite and pyrolusite are forming as alteration products of the hausmannite. The relation to the reported hematite ore is not known; coatings of limonite occur on the hausmannite, being derived from the leaching of the rhodochrosite present.

As far as the writer can ascertain this occurrence has been advertised as an iron ore and no mention made of the manganese content.

TOM'S BROOK. The location of this deposit is approximately W.Long. 60° 41' N.Lat.45°46', or about two miles east of Hay Cove and on the old Lock Lomond-Red Island road. There are two places where work has been done, the first is in from the main road about 1/2 mile and occurs on the west bank of a creek. This is a large oxidized cropping consisting of limonite, magnetite, and some small grains of pyrite. Local reports claim manganese was shipped from here in small lots, but no evidence of manganese minerals was seen. Some 250 yards east of the creek, there are some old pits about which were small dumps consisting mostly of clay, some limestone and a little manganese. The ore here was evidently very erratic, of small quantity and confined principally to the clay as nodular masses, such being derived by weathering of the underlying limestone.

BEAVER COVE. On the farm of James McMullen there is a small isolated pocket of wad.

BOULARDERIE ISLAND. Location.- On the southeast shore of Boularderie Island, in the vicinity of Island Point, there are two occurrences of wad or bog manganese. The more northerly (W.Long. 60° 30'. N.Lat. 46° 10') is on the property of J.McNeil, Big Bank, P.O., Victoria County, C.B. It is on the lake shore; a secondary motor road connects it with North Sydney. The second deposit is two miles farther south (W.Long. 60° 31' 45". N.Lat. 45° 9') on the same road, and is on the farm of J.O'Handly, Island Point P.O., Victoria County, C.B. This bog is on the gently sloping eastern bank of a small stream about 1/2 mile west of the lake shore.

Geology.- The area is underlain by Carboniferous limestones, shales, sandstones, and conglomerates with intercalated iron formations and thick beds of gypsum. The strata at these localities are dipping gently westward, or to the centre of the island.

Occurrence on McNeil's Property.- Along the beach of J. McNeil's the wad is on top of and replacing a sandstone along the joints. Limonite is common throughout the wad, and in places alternates with layers of bog manganese. The ore is in a semi-consolidated state; it is said to be high in iron and silica, and runs about 30 per cent Mn (G.S.Ross, Syndey, C.B.). The deposits extend up the steep slope of the shore and trend a little south of west. A number of trenches here and there on the deposit show it to vary in thickness up to 5 feet, and to cover an area of 5 to 10 acres.

In 1912, J.A.Gillis did some prospecting on it, and again in 1917. The "Besco" investigated this occurrence in 1915 and were apparently satisfied with the grade of ore but did not take it up. During 1917 it passed into the hands of Mr. D.A.Cameron, Syndey, and has remained idle since.

Occurrence on O'Handly's Property.-The occurrence on O'Handly's farm is of similar type and origin. It is found between the grass roots and a fine white sand, ranging in thickness from 1 to 7 feet and extending over about 27 acres, with an estimated tonnage of 200,000 tons (G.S.Ross, Sydney). Mr. Ross claims the average of 110 samples gave 40 per cent Mn and 7 to 17 per cent Fe.

Analyses of Bog Ore on Boularderie Island.- The following are some analyses of the ores mentioned above:

	I	II	III
Manganese peroxide	25.42	11.04	44.33
Iron sesquioxide	---	12.49	35.50
Insoluble	---	57.76	10.00
Water	35.52	---	---

I and II Analysed by Mr. Hoffman, Canada Geological Survey, 1879. II carried traces of Cu, Co and Ni = .2 to 3%.

III E.Gilpin. Trans. Royal Society Canada, 1884.

Although these deposits were known from 1880 onward the first intensive work on the O'Handly deposit was not done until 1915, when a series of long trenches were dug up the sloping hill for the purpose of draining the bog and obtaining an estimate of its tonnage. Apparently no work has been done since.

The accessibility, grade and quantity of these bogs make them of value. The wad, however, is friable and fine-grained and for this reason would need briquetting before use in the manufacture of ferro-alloys.

Origin.- The presence in the Carboniferous strata of spathic iron (siderite) near Island Point, and the occurrence of iron formation about the bog manganese deposits here strongly suggests that the source of the manganese for these deposits is in such formations. The meteoric waters working through the Carboniferous rocks cause a solution of iron and manganese which are later deposited at the surface in the form of wad. The restriction of the O'Handly occurrence to the eastern slope of the valley may be due in large part to the westerly dipping strata.

The manganiferous strata are generally intercalated with gypsum beds. A chemical change within the gypsum results in the production of sulphur and hydrogen sulphide (H_2S); the presence of these in spring water issuing from the gypsum-bearing strata is quite evident. There is probably, also, an addition of sulphuric acid to the groundwaters. It is possible that these waters circulating through the iron manganese-bearing strata might take the iron and manganese into solution as the ferrous and manganous sulphates; but it is perhaps more probable that if any sulphuric acid were present in the waters, that it would react with the lime carbonate of the strata, resulting in a solution rich in carbon dioxide, and this solution, if in contact with the iron and manganese minerals would dissolve them as the bicarbonates.

Antigonish County

In Antigonish County occurrences of wad have been noted near Tracadis, Upton, Pomequet, Ohio, and Lochaber. These are all of small extent and have been formed in recent times from the surrounding rocks.

Pictou County

OCCURRENCES OF WAD. Deposits of wad are known to occur near Afton, Sutherland, Meadowville, and Glengary. These are small local occurrences in which the manganese minerals are found for a short distance under the grass roots or as a coating and cement in recent gravels. Near Glengary nodules of fibrous pyrolusite are reported as occurring in the marine limestone close to its junction with the pre-Carboniferous rocks. This occurrence could not be found by the writer.

BRIDGEVILLE. Location.- Of more importance is the occurrence of manganese as an accessory constituent in the limonite ore of Bridgeville. W.Long. 62° 35' 20". N.Lat. 45° 24'. This occurrence is on the property of the Nova Scotia Steel Company just across the brook from the farm of Mr. Albert Grant.

History, Workings, and Development.-[(1)] The property was first owned by the Glascow Iron Company, which later changed to the Nova Scotia Steel and Coal Company, in whose name the property is now held. In working the limonite a zone relatively high in manganese was discovered, and in this a tunnel some 100 feet in length was driven which showed the ore to be about 4 feet wide, striking NW and dipping to the SW parallel to the strata. The floor of the tunnel is in good ore, but no sinking was done.

The bulk of the manganese ore was consumed by the local blast furnace in producing a pig relatively high in manganese. A small quantity of the exceptionally pure ore was shipped to chemical works in Illinois.

Geology and Occurrence.- No reference of the structure of this locality could be found in any of the references to which the writer had access. Mr. R.E.Chambers, New Glascow, worked these limonite deposits in the 90's and he described the geology as Silurian rocks overlain by Carboniferous strata in a series of steeply pitching troughs (anticlines and synclines). Wherever the rock in the bottom of a trough is limestone overlying or near the Silurian the best and thickest ore is found, and this thins laterally on both sides, away

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(1) Information on this occurrence furnished through the courtesy of R.E.Chambers, New Glascow.

from the axis of the trough (syncline). The ore in general is a limonite carrying 52 per cent Fe; 12 to 18 per cent SiO_2; and 1 to 2 per cent, or more of manganese. In places, however, there has been a relative concentration of manganese until the ratio of iron: manganese = 1:1. In rare cases large masses of exceptionally high grade manganese ores were found.

Two analyses by E.Gilpin, Jr.(1) of the manganiferous iron ore and the pure manganese ore are given as:

Manganese peroxide	14.41	---
Manganese sesquioxide	---	62.95
Ferric oxide	48.22	10.85
Alumina	trace	2.88
Lime	0.015	7.28
Baryte	---	0.67
Magnesia	---	1.63
Carbonic Acid	---	---
Sulphur	0.48	---
Phosphorus	0.02	---
Insol.	25.13	2.73
Water, comp.m	12.53	
moisture		1.45

Botryoidal and stalactitic forms of limonite are common and caverns and vugs are of frequent occurrence.

<u>Mineralogy</u>.- The main mineral at Bridgeville is limonite, which contains varying amounts of manganese. In places the manganese has been concentrated by natural processes

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(1) E.Gilpin, Jr., Trans. Royal Society Canada, Sect.IV, Vol. II, 1884, pp.7-13.

and exists as irregular bodies and veinlets in the limonite. The manganese minerals determined from specimens were chiefly pyrolusite, with a very small amount of manganite. Associated gangue minerals are calcite and barite, the latter being of local occurrence and is not common.

Hand specimens and polished sections show the limonite to be delicately and beautifully banded, such colloform structure suggesting a colloidal precipitation. The pyrolusite is well-crystallized in small plate-like forms and is distinctly later than the limonite. In places the pyrolusite exhibited a colloform structure but close examination proved this to be an inherited character, derived from the limonite which it had replaced.

The original deposition of the manganese was probably contemporaneous with the limonite and may very well have been colloidal; the secondary concentration of the manganese, however, affords no evidence of such a mode of precipitation.

The barite, so far as could be ascertained, was deposited after the limonite but prior to the concentration of the manganese, or else, the barite crystallizing in cracks within the limonite had broken it up and formed the loose breccia as seen in the specimen. On the surfaces of some of the barite plates, minute acicular crystals of manganese minerals were observed.

Origin.- The description of the occurrence of the limonite ores, by Mr. Chambers, suggests that at some time after the deposition of the lower Carboniferous strata, an underground drainage became established with the main flow concentrated along or near the axis of the synclinal troughs. Later solutions carrying iron, either as the soluble ferrous bicarbonate or ferric hydroxide in colloidal suspension, perhaps both, deposited their lode along these water channels and in the caverns. The original deposition as a colloid contained various impurities as silica, phosphorus, manganese, etc. Subsequent reworking of the limonite deposit by meteoric waters resulted in a solution and reconcentration of the manganese forming the deposits as described above.

Colchester County

In Colchester County manganese oxide is found in deposits of considerable purity in the vicinity of East Mountain; as an accessory constituent in limonite ores around Londonderry and Clifton, and as **numerable** small bog deposits here and there over the country. The majority of occurrences appear to be associated with Carboniferous strata, but in the region about Five Islands and Economy manganese minerals are to be found as veinlets in Triassic sediments and likewise associated with the zeolites of the Trassic trap rocks.

BORDEN PROPERTY. Location.- This occurrence is a little more than seven miles east of Truro, and about one and one-third miles south of the main Truro and New Glascow highway. W.Long. 63° 06' 30". N.Lat. 45° 25' 15". It is about one-half miles NE of the old manganese mines.

Ownership and History.- Until 1926 the property was owned by Philip Archibald at which time it passed into the hands of Mr. Borden, who is now farming the site. The occurrence on this property is said to have been the original discovery of manganese in the district, and after some work here the company moved south to the manganese mines.

Topography.- The property is on the west side of a brook, the topography is irregular in detail but is generally of moderate slope eastward.

Geology, Mineralogy, and Occurrence.- On the Earltown sheet #58, Canada Geological Survey, 1902, the rocks of this locality are mapped as the Mispec or Union series of Devonian age. The rocks in the dumps showed a much altered greenish shale cut by an aplite dike which has associated with it magnetite, hematite, and some pyrite. No manganese minerals could be detected in any of the rock lying about the dumps.

Workings.- The workings consist of a number of trenches here and there on the hillside and steep banks of small tributary gullies. All the trenches are badly caved and no bedrock is showing.

MANGANESE MINES. Location.- The Manganese mines W.Long. 63° 08' 45". N.Lat. 45° 25" are on the farm of Stanley Coulter about 6 1/2 miles east of Truro; the Canadian National Railroad is 3/4 miles south of this location and the Truro New Glascow highway is 1 3/4 miles north of it. A secondary dirt road is within two hundred yards of the workings.

Ownership and History.- The property was worked from 1880 to 1895 and during this period about 2,000 tons of ore were mined and shipped. Further work was carried on at irregular intervals, but no work has been done for twenty years or so. The right of search in this district is held by W.S.Carlisle and J.B.Thompson of Truro (1927), who believe that their license will include the property on which the Manganese Mines are situated.

Geology.- The rocks at this mine are red micaceous sandstones underlain by a hard red shale. The old residents of the locality who worked in the mines, claim that these rocks were dipping about 45°. They likewise report the presence of a thin veneer of limestone which overlaid the sandstone and was removed in mining operations.

Occurrence and Mineralogy.- The principal ore mineral is pyrolusite which occurs either as compact masses of small interlocking prismatic grains or as fine acicular crystals which extend perpendicular to the walls of the veinlet and in places attain a length of one inch. Manganite is likewise present as small residual grains here and there. Calcite is associated with the manganese minerals and commonly occurs along the walls of the veins with the manganese minerals in the centre. It is likewise found within the ore minerals and may form a thin parting along the centre line of the vein.

The ore is found in veinlets up to 1 1/2" to 2" wide, within the sandstone; these are most common along joints, but are also to be seen extending along the bedding planes. In places an ore breccia may be observed which consists of fragments of sandstone cemented by pyrolusite. The character of this breccia suggests that during or immediately subsequent to the deposition of the sandstone the stratum became partially consolidated and was then broken, the fragments rolled about until they became subangular and were cemented again by finer material of the same nature as the original sediment. It appears that the ore-bearing solutions worked through the finer matrix depositing most of their mineral content here, but also permeated the coarser material of the fragments where manganese oxides were likewise formed.

Some ore occurred as nodules and boulders in the soil overlying the deposit, but most of it was derived from the underlying sandstone. In this the heaviest concentration was found along or near the sandstone shale contact.

Origin.- There is no direct evidence regarding the source of the manganese. The character of the deposit indicates the ore was deposited from migrating meteoric waters.

Development.- The workings consist of a number of scattered pits, large and small, that are now badly caved or filled with water. The main pit is approximately 100 feet by 70 feet, at the bottom of which there is a shaft which extends to about 100 feet below the surface of the ground. The size of the dump about the pit is large, and the amount of ore obtained must have been small in comparison to the rock handled.

EAST MOUNTAIN. Location.- The East Mountain occurrence, locally known as the Fraser property, is approximately 6 miles east of Truro and one-half mile NW from the Manganese Mines just described. Access to the property may be had over the Truro, New Glascow highway for 4 1/2 miles, and thence by a secondary dirt road for 1 1/2 miles. It is found along side this road, where it passes along the NW bank of a small gully eroded out by a little tributary of Clifford Brook. The workings are on the farm of A.R.Fraser. W.Long. 65° 09' 30". N.Lat. 45° 25' 15".

Ownership and History.- The presence of manganese was first discovered about 1897 when a water hole for cattle was dug in the bottom of the small creek. The ore was then followed up-stream some 200 feet by trenching (Fig. 11), where a large mass of ore was found. At this place a shaft was sunk, vertical for the first 4 or 5 feet and then on an incline of 55°NW for 20 feet.

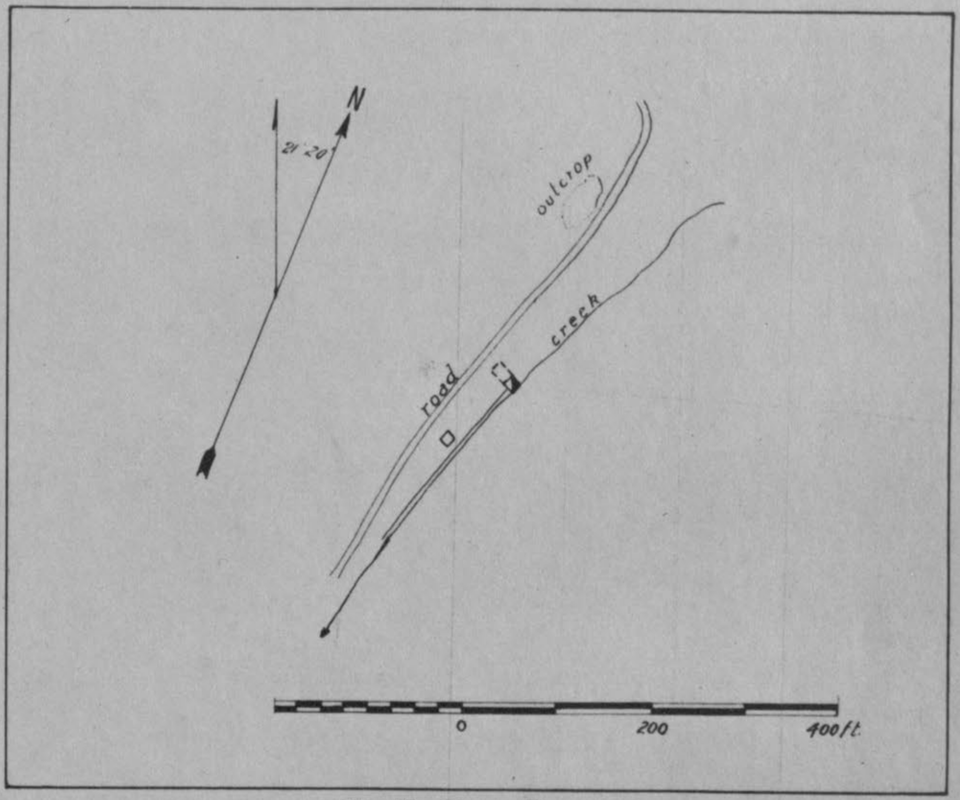

Fig 11 East Mountain

From these early workings some 100 tons of ore were shipped. The property then lay idle until 1918 when Mr. W.S. Carlisle of Truro, who holds the right of search in this district, pumped out the old shaft, cleaned down the sides and sunk another 4 or 5 feet. As a result of this work some 10 tons of ore were obtained and is now stored in barrels in a small shed adjoining the shaft.

Topography.- The country about is rolling agricultural land, formerly wooded, with small evergreens and deciduous trees but now largely cleared and under cultivation.

Geology.- On the Earltown sheet #58, Colchester Co., the rocks are mapped as the Mispec, or Union (Devonian) but the workings show the containing rock to be a buff colored limestone which grades upwards into a red calcareous shale, and is underlain by a thinly laminated, reddish to grey sandstone. The limestone and shale may possibly be a small outlier of Lower Carboniferous rocks, similar to several others which occur in the vicinity. 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 N. 60° E. (mag) dip 60°NW.

Occurrence.- The occurrence of the ore as described by one who worked on the property in 1918 is that it is found in three layers, each about one foot in thickness, separated by 3 to 4 feet of marine limestone containing nodular ore; the nodules varied from pea size up to 3 or 4 inches in diameter.

A study of the rock about the dump shows a buff colored limestone replaced by light brownish to red varieties. Chemical tests showed that these latter contained manganese and iron, the red variety having the greater content of these minerals.

Mineralogy.- The ore is pyrolusite, with minor amounts of manganite. In the main it is massive consisting of a compact mass of fibrous, interlocking crystals, but small vugs and pores are common, into which the pyrolusite projects as minute acicular crystals. Here and there in these vugs tiny plates of barite may be seen. Within the ore calcite is rare but adjoining it and in stringers veining the country rock veinlets of well crystalline calcite are common. Such veinlets may or may not contain small amounts of manganese; if manganese is present it usually occurs as a veneer over crystal faces or along joints.

Origin.- This deposit is a replacement in limestone resulting from a progressive concentration of manganese by meteoric waters. The source of the manganese is not known, but may have been an original constituent of the limestone or may have been derived from the weathering of a nearby syenite mass,- chemical tests made on a sample of this syenite showed manganese to be present. The initial stages of this concentration were marked by a gradual increasing content of manganese and iron, probably as carbonates, to the limestone. Later, solution and oxidation became more pronounced resulting in the formation of vugs, pores, and a precipitation of the manganese oxides in these. The transportation of manganese was limited; a considerable portion forming in place as a direct oxidation product of the manganiferous carbonate.

Development.- The main work on the property is the shaft which is vertical for the first 4 or 5 feet and then descends on an incline of 55° to the NW for 25 feet. This is now filled with water. The long trench previously mentioned is filled and a small flow of water is following its course.

Analyses.- An average of two samples of ore collected by Dr. W.L.Uglow (1918) gave:

Moisture	5.81
Manganese	47.94
Iron	0.90
Silica	15.77
Phosphorus	0.027
Sulphur	0.017

A sample collected by the present writer from the barrels of ore in the shed yielded:(1)

Manganese	57.89
Insol. & Silica	0.64
Iron	0.31
Sulphur	--
Copper	--
Phosphorus	0.017
Available Oxygen	16.48

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(1) Analyst, A.Sadler, Dept.Mines, Ottawa.

These samples were made by the Department of Mines, Ottawa.

OTHER OCCURRENCES. Other occurrences have been noted in this locality but so far as could be ascertained they are hardly worth noting. By the schoolhouse on Mr. Hoar's farm, pits have been dug in a hard sandstone, showing manganese minerals to occur as thin seams and veneers along the joints of the rock. The occurrences are marked on the Earltown sheet #58, Colchester Co., W.Long. 63° 11' and 63° 12' and approximately N.Lat. 45° 25'. These are only small pits and no shipments were ever made.

Old reports describe a property near East Onslaw, but two days search about the settlement failed to reveal any indications of any old manganese workings, nor did any of the old inhabitants have knowledge of such.

The farmers about the Manganese Mines, and the vicinity claim that boulders of manganese ore are frequently turned up while ploughing the fields.

CLIFTON. About one-half mile south of Clifton Station on the old Midland Railway there is an occurrence of limonite belonging to Mr. Amos Yuill. Iron ore was shipped from here to Londonderry in 1890. This limonite is manganiferous but there is no record of any manganese ore or minerals having been found.

BLACK ROCK. Location.- Ten miles west of Truro at Lockherd Point W.Long. 63° 29'. N.Lat. 45° 19' an occurrence of manganese is found about 100 yards west of the ferry wharf and between high and low tide level.

History.- Early reports claim some work to have been done in this locality. At present the only evidence for such is a small pile of boulders containing manganese which have been placed just above high water mark.

Geology.- In this vicinity the stratigraphic sequence is a thinly laminated, dark grey, fine-grained manganiferous limestone, succeeded by a limestone conglomerate, both of Lower Carboniferous age, and this in turn by Triassic sandstones and grits. The lowest member is made up of several divisions, more clayey in parts than in others; the laminations are in places emphasized by thin partings of clay. The whole is locally warped into many small folds and rolls, with a general strike of 100° (Mag) and dipping 15°SW.

Joints and zones of minor movements are common and these are frequently healed by calcite. Detailed study of the rock shows it to contain many specks, and irregular veinlets of a pink carbonate. The irregularity of the veinlets has been caused by the tendency of the solutions forming them to work along each of the closely spaced bedding planes before breaking through to the next.

The limestone conglomerate is made up mostly of fragments very similar in character to the underlying laminated member. There is very poor assortment in the size of the fragments and many of these show marked angular outlines. Small local lenses of variegated sandstone and shale are found in the conglomerate.

Occurrence and Mineralogy.- The minerals noted were calcite, limonite, manganite, pyrolusite and hausmannite. There is a dark brown carbonate containing considerable manganese and some iron but the indices of this are very close to those of normal calcite. The limonite is botryoidal and shows marked recrystallization into radiating groups of crystals which extend across the original formational banding of the limonite.

Polished sections show the manganese to be present mostly as manganite which now exists in crystalline form, but a rough colloform banding may be made out on close examination. This suggests that the manganese oxides may have been originally deposited in a colloidal mass, and later crystallized to manganite. Pyrolusite is sparingly present and forms an exceedingly fine replacement of the manganite. The hausmannite is found as minute grains and clusters through the specimen.

These minerals occur in veinlets two inches to one foot in thickness, which cut sharply across the bedding planes of the thinly laminated lowest limestone member, and in general following the jointing; irregular replacement has taken place along these.

Origin.- There is no direct evidence relating to the origin of this occurrence, but it is suggested that meteoric waters percolating through the limestone dissolved the manganese and iron contained in it as carbonates, and later deposited their lode along the joints, and bedding planes, forming the veinlets now found. This action occurred during intervals of uplift, subsequent to the deposition of the limestone.

Evidence that may be used to support this view is found some distance away where a small trickle of water is emerging from a point at the contact between the limestone beds and limestone conglomerate previously mentioned. This seepage has enlarged the joint and is depositing limonite along the walls and on the rock over which it runs.

LONDONDERRY. The limonite ores of Londonderry, Colchester County, contain manganese as a favorable accessory mineral to the iron, but never in sufficient quantity to form a manganese ore. Through the courtesy of Mr. R.E.Chambers of New Glascow, analyses of these ores, taken while the mines were in operation, were examined and these showed that the manganese content varied from .5 to 3.0 per cent averaging between 1.5 and 2 per cent Mn.

LOWER FIVE ISLANDS. On the farm of Mr. Webb, Lower Five Islands, there are thin seams and small pockets of psilomelane, exposed along the sea cliffs, which are here formed of Triassic volcanics, red sandstones, and shales.

In the early days several barrels of manganese ore are said to have been obtained from these cliffs and from a narrow seam which crosses the old road, farther back from the beach.

LOWER ECONOMY. The low sea cliffs which occur near the Baptist Church W.Long. 63° 58'. N.Lat. 45° 23' 30" just east of Lower Economy are composed of Devonian sandstone and shale unconformably overlain by Triassic sandstone and conglomerate. Towards the western exposure of the Devonian rocks a few thin seams of exceedingly fine manganite may be seen in the Paleozoic strata. The inhabitants claim that many years ago several barrels of ore were obtained from a two-inch veinlet of ore and shipped to Windsor.

Cumberland County

The manganese deposits of Cumberland County are of no importance economically. Pyrolusite has been reported in the vicinity of Amherst and Minudee but no information concerning these occurrences could be obtained from the inhabitants of the localities. The occurrences near Parrsboro, Rose, and Jersey may be of scientific interest.

PARRSBORO. About four miles east of Parrsboro the north shore of the Minas Basin is bordered by Triassic volcanics, including breccias and viscicular flows. The amygdules of the later are filled with quartz, calcite, and various zeolites. Native copper may be seen in some of the quartz fillings. Occasionally narrow veinlets of pyrolusite, psilomelane and other manganese oxides may be found cutting through these rocks. The source of the manganese is undoubtedly in the igneous material.

ROSE. Location.- At Rose W.Long. 63° 47'. N.Lat. 45° 36', there is an occurrence of bog manganese on the farm of S.Halliday. This locality may be reached from either Westchester Station, or Oxford Junction on the Intercolonial Railroad. From the former one takes the main motor road west for about 8 miles; if leaving from Oxford Junction one proceeds about 6 miles south to Collingwood Corner, and then east on the Collingwood Westchester road.There is little to choose between the two routes.

Topography.-The surrounding country is rolling agricultural land much of which was at one time cleared but has of recent years grown over again. Sugar Loaf Mountain (El.1020 feet), the highest prominence in Nova Scotia, lies to the immediate south and presents a rolling, well-timbered summit slightly higher than the surrounding country.

Ownership and History.- The bog ore is on the farm of S.Halliday, whose family has held the land for the last thirty years or more. The material was long considered as a small showing of coal and after its identity became known it remained untouched.

Geology.- The geologic sequence of the district as determined by H.Fletcher and illustrated on the Wentworth sheet #62 is a Carboniferous limestone overlain successively by the Millstone grit conglomerate; the Millstone grit; the New Glascow conglomerate and the upper and middle Permian. This series is flexed into a shallow syncline, the axis of which strikes slightly north of east; the south limb has very shallow dips north while the north limb shows relatively steep dips to the south.

Occurrence.- The bog ore is found as small nodular masses about the grass roots; these nodules range in size from sand grains to irregular masses about one inch in diameter. The nodules are found in irregular pockets varying in width up to 3 feet and in depth from 4 inches to one foot; these are found intermittently along the water courses, being most frequent in the swampy areas along the main water channel.

Workings and Analysis.- There has been no development or shipment. Analysis (1) of a sample collected from a large pocket gave:

Mn	21.21
Insol. and silica	24.64
Iron	6.50

Origin.- The occurrence is of interest in showing the formation of manganese after the glacial period and extending into the present. The manganese content is probably derived from the underlying Carboniferous limestone, which forms the bed rock at this locality, and is deposited about the grass roots and sand grains by bacterial action.

JERSEY. *Location*.- The deposit of bog ore examined at Jersey is on the farm of Charles Weatherby, approximately 2 1/2 miles north of Atkinson Siding, on the Intercolonial Railroad W.Long. 63 44'. N.Lat. 45° 40', and from this place it is reached by a good dirt road running through a rolling country drained by small brooks and marshy seepages.

Ownership and History.- The property is owned by Mr. Charles Weatherby and the presence of the manganese, at first thought to be coal has been known to him for thirty years or more.

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(1) Analyst, A.Sadler, Dept. Mines, Mines Branch, Ottawa.

Geology and Occurrence.- The occurrence is found within the area of New Glascow conglomerate and Permian rocks previously described. The ore is found as a soft, semi-sectile cement in the lower soil and as incrustations on stones along the main channel of swamy areas; small rounded concretions about the roots of the vegetation are also quite common. Porous sandstone boulders may be soaked through with manganese oxides. The pockets vary greatly in size, the majority ranging in width up to 6 feet, and in thickness from 6 inches to 1 1/2 feet.

Development, Analysis, and Origin.- A few trenches have been dug in various places in the swamp areas which show some ore; masses are frequently turned up when ploughing the low ground.

Analysis (1) of the bog ore gave:

Mn	24.81
Insol. and silica	13.71
Iron	8.72

The origin is similar to occurrence on the farm of Mr. S.Halliday.

SUGAR LOAF MOUNTAIN. Some years ago Mr. W.I.Stonehouse of Millesville, claims to have found a vein of manganese

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(1) Analyst, A.Sadler, Op. cit.

ore on the northern slope of Sugar Loaf Mountain, but after several hours search in the vicinity, he was unable to locate it.

Hants County

EAST NOEL. Near Dinsmore Mills (Noel sheet #64) there is an occurrence marked at W.Long. 63° 41' 30". N.Lat. 45° 18'. It consists of small stringers of needle ore cutting sandstone. It was first worked in 1880 by "Miner" Brown, who is said to have obtained about one ton of ore from a 25-foot shaft, which is now filled with water.

WRIGHT PROPERTY. Manganese is said to occur on the property of Mr. John Wright W.Long. 63° 48'. N.Lat. 45° 17', of Minasville. About 1887 Mr. McFee did some work here and later between 1900 and 1902 Mr. J.Wright, the owner, sunk two more small shafts. It is claimed that a small amount of good "hard" ore was taken from the workings.

The rock is a hard sandstone and shale, probably of Devonian age, in which the ore is found along cracks and joints.

MCDONALD PROPERTY. Location.- The occurrence is on ground owned by Joe and Amos McDonald and is about one-half mile south of Minasville along the western slope of Moose Brook W.Long. 63° 48' 30". N.Lat. 45° 16' 30", the two shafts and beginnings of a tunnel are in the field, just south of the house.

History and Ownership.- The workings on the property were made by Mr. John Mosher about 1891, who owned the farm at that time. He later (1916?) sold the place to Joe and Amos McDonald. A small amount of "hard" ore was obtained by Mr. Mosher.

Geology, Mineralogy and Occurrence.- The rocks are alternating reddish to brown thin sandstones and shales; the shales are badly crushed and broken. This series, striking E-W (Mag) dipping 55°S. is mapped by Fletcher (Five Island and Tennycape sheet #75) as "non subdivided" Devonian. The ore, what there is of it, occurs as thin films and seams of manganite (?) along the cracks in the shale and sandstone.

CAPT. SCOTT'S MINE. Location.- The Scott mine is approximately one and one-quarter miles SW from Minasville. W.Long. 63° 50'. N.Lat. 45° 16'. It is in a well woody, swampy country. The old road leading to it is well grown over.

History, Ownership, and Workings.- About 1887 Capt. Scott obtained permission from the owner of the land, Mr. Reed, and dug several pits and a large open cut which are now well caved and grown up with brush. In 1900 Capt.Scott is said to have bought the property and held it until 1924 when he sold to Mr. William Hughes.

Geology, Occurrence, and Mineralogy.- The occurrence is just within the Lower Carboniferous limestone as mapped by Fletcher (1905). The cut shows a buff to brown bedded limestone in which manganese minerals, probably pyrolusite and manganite occur along the joints.

MORTON REYNOLDS. This "mine" is a little more than one and one-quarter miles west of Minasville and approximately one-half mile north of Scott's mine. W.Long. 63° 50'. N.Lat. 45° 16 ' 20". It was first worked in 1891 by Mr. McVicars who sank a shaft about 30 feet deep along the steeply dipping sandstones and shales. The ore occurred in small stringers up to 3 inches in width, and he is said to have obtained about three tons from this work. In 1921, Fredrich Hoit pumped out the shaft but did not do any other work. The shaft is now full of water.

FAULKNER MINE. Location.- The Faulkner mine is one mile east of Tennycape and a little to the south of it. W.Long. 63° 51' 30". N.Lat. 45° 15 ' 45". Access to it may be had by a secondary dirt road from Tennycape.

History, Ownership, and Production.- This property was formerly owned by Joseph Faulkner who leased it to William Stephens of Tennycape about 1887. During a period of one and a half months of this year Mr. Stephens removed some 1,200 pounds from surface workings. In 1907, Mr. Lenard Reymolds of Moose Brook bought the property and in subsequent years sunk a shaft for 35 feet (vertical) and from this obtained one ton or more of good ore.

Geology, Mineralogy, and Occurrence.- The rocks are a series of red shales and brown limestones, with some lime breccia, and in these, mainly the lime members, the ore is found in vugs and small stringers associated with calcite which in places is manganiferous. The ore occurs as well crystallized manganite, and pyrolusite, the crystals of which attain a length of one-half inch to one inch. Fine crystalline aggregates of interlocking grains of these minerals are likewise present.

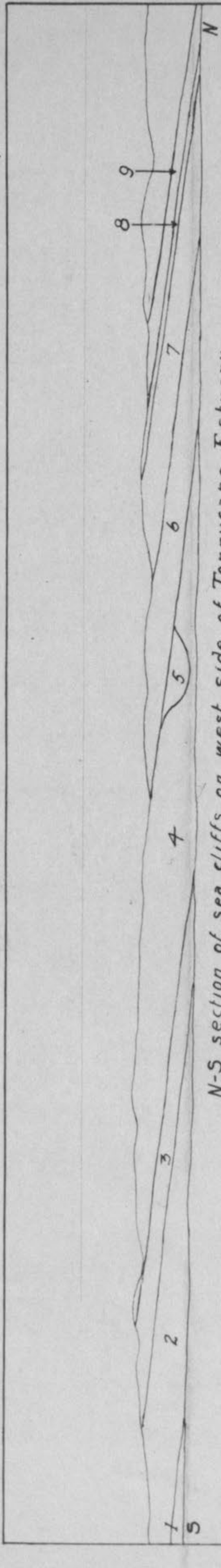
The occurrence marked by H.Fletcher on the Five Islands and Tennycape sheet #75, 1905 at W.Long. 63° 52'. N. Lat. 45° 15' 20" could not be located, nor did any of those who have been connected with the manganese mining in the district know of any workings in that vicinity. They thought that either float or bog ore had been observed here.

FLOAT MANGANITE. Mr. L.Reynolds found a large piece of float manganese, weighing 150 to 200 pounds, about five miles south of the Faulkner mine. This mass consists entirely of manganite and exhibits a marked columnar structure developed perpendicular to concentric colloform banding.

TENNYCAPE ESTUARY. Along the western shore of the Tennycape estuary, recent erosion has produced a cliff one-half mile or more in length, and of varying height up to 40 feet, in general decreasing in altitude as the shore of Cobequid Bay is approached. This cliff affords a natural section which is of considerable interest.

Geology.- From the post road bridge north along the cliff, the first one-third mile or so of the rocks are Paleozoic sandstones and shales, probably of Upper Devonian or lowest Mississippian age. In the shales may be found fossilized plants, in places parallel to the bedding and in others exhibiting the roots and trunks of tree ferns in the same relative altitude as they grew. This series is now striking N. 270° E. (Mag) and dipping 50°S. The diastrophic movements subsequent to their deposition but pre-Triassic, were quite severe and found relief chiefly along the shale members, many of these being reduced to a crumbling mass of intensely sheared rock; in one instance a portion of a tightly folded syncline of sandstone strata was included within a badly sheared shale member.

Progressing north along the shore, one comes to the Triassic sediments which overlie the Paleozoics with a marked unconformity. These rocks, striking ± N. 270° E. (Mag) and dipping 10° to 15° N., are composed of sands, grits, fine and very coarse conglomerates which vary in color from red to yellow and gray. In general it may be said that in the lower



N-S section of sea cliffs on west side of Tennycape Estuary

1. very coarse poorly sorted lime cement some Mn.
2. mostly well sorted beds of sand + gravel not much Mn
3. coarse poorly sorted some boulders 2 ft thru' not much Mn
4. cross-bedded grits + sands with pockets of congl.
5. pocket of congl with considerable Mn replacing lime cement
6. fairly well sorted boulders average 3 in. to 4 in some larger lime cement best Mn
7. fine + coarse material cross-bedded. lime cement. Mn. in coarse beds
8. sand
9. gravel bed some pebbles 2 in.

Fig 12

portion, at this locality, the finer and better sorted material tends towards the yellow and grey hues, whereas the coarse and poorly sorted layers are of the brownish to red color.

At this locality the basal member of the Triassic is a fairly well sorted gravel, but immediately overlying it there is a conglomerate bed that is very poorly sorted, containing material that ranges in size from fine sand to boulders three and four feet in diameter. The general section (Fig. 12) consists of alternating bands of poorly and well sorted material, with occasional pockets of coarse material in fine and vice versa. This lower portion of the Triassic suggests that it was formed as an alluvial fan, to torrential rivers under semi-arid to arid conditions.

The pebbles and boulders are mostly sedimentary rocks such as sandstone, grits, arkose, and slates but igneous representatives are also present as boulders of granite and porphyry. The cement, in the main, is calcite with some iron oxides and minerals of the kaolinite group and is most plentiful and noticeable in the coarse material but is not so conspicuous in the finer well sorted sands.

<u>Mineralogy and Occurrence</u>.- Manganese minerals are found in the lower part of this Triassic section, principally in the strata that contain pebbles and small boulders up to 4

and 5 inches in diamter, but also in both the better and more poorly sorted material. The minerals are manganite and pyrolusite which are both finely acicular and pulverant. Psilomelane is also present. These minerals occur in places as masses resembling small pebbles, or as fine crystalline aggregates, or as films about boulders and pebbles; the films may in places extend within cracks in the boulders. The main occurrence of these minerals, however, is a replacement of the carbonate cement. Vugs, lined with calcite crystals, are found here and there and about the periphery of these manganese oxides are found as a soft pulverant coating, or they may occur within the vug as aborescent masses on the calcite. Close examination reveal these masses to consist of innumerable interlocking small hairlike crystals of manganite forming a porous aggregate. The faces of the calcite crystals show a decided etching in the immediate vicinity of the manganese and etching is common within the vug as a whole.

A similar occurrence may be found on the eastern shores of this estuary.

Origin.- The Triassic of Nova Scotia (1) is considered to be made up of a lower sedimentary series, overlain by effusive basalts, amygdaloidal flows and tuffs. The earlier

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(1) Sir William Dawson, Acadian Geology, 1868.

part of the volcanic activity is thought to have been contemporaneous with the deposition of the upper part of the sedimentary rocks; apparently it was ushered in by tuffs and amygdaloid flows. Then followed the outwellings of basaltic rocks.

The manganiferous sediments at the Tennycape estuary as well as at the "Wheadon" occurrence (see page 145) are believed to represent the earliest of the Triassic sediments as at the latter place the sands and grits may be seen to be resting directly on a water worn surface of Paleozoic rocks, and in the former locality the beds are only a few feet stratigraphically above the Paleozoics.

As the manganese oxides are replacing the cement in these rocks it appears that they were deposited later than the formation of the sediments and thus the date of concentration is post Lower Triassic. The writer does not feel justified in stating the age in any more definite terms.

The source of the manganese is a different question and is less easily answered. One may look to the erosion of the older terrains as a source, but the later Triassic effusives are a possible and important source that can not be overlooked. Mention is made elsewhere of the widespread manganese content of these rocks. The question may well be asked whether the manganese oxides were deposited by solutions arising in the effusives contemporaneous with their extrusion, or closely subsequent to it, or whether the manganese has been derived from the general rock mass by later processes of weathering. As far as could be ascertained there are no accompanying minerals that would add weight to the hypothesis that the oxides were derived from solutions arising in the volcanic rocks, nor is there much evidence to conform the view that subsequent processes of weathering and leaching of the overlying rocks was the important factor in the concentration of the oxides in these deposits. Indirect evidence that might be taken as favoring the latter view is found at Five Island and elsewhere.

The manganese oxides which occur in the Triassic sediments near Five Islands, Colchester County, are found as narrow ramifying veinlets and nodular masses in the red arenaceous shales and sands, and suggest a concentration by meteoric waters. Again the veinlets of pyrolusite that are found in the trap rocks about Two Islands, Cumberland County, are believed to have been formed by surface waters leaching the manganese from the trap rock and depositing it in cracks and fissures.

TENNYCAPE MINE. Location.- The Tennycape mines are situated one and one-half miles southwest of the town of Tennycape, at W.Long. 63° 53' 45". N.Lat. 45° 15' 10". They are reached by means of a secondary dirt road 1 1/2 miles long, which leaves the main post road one-half mile west of Tennycape. The workings are on the north side of Rennie Brook, near its source, and the ground slopes to the creek bottom with a medium gradient.

History, Ownership, and Production.- The information regarding the history and ownership of the Tennycape mines was furnished by Mr. W.F.Stephens, of Tennycape, whose family has been intimately associated with the manganese mining in this district, Information on the occurrence and mining of the ore was furnished by Mr. Stephens, and also by Mr.David Brown.

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 derived from working the soil overlying the occurrence and obtaining the manganese which remained in it as boulders; open cut methods were also used in the underlying limestone and considerable ore was derived from this work. As a result of open cut work a large lense of ore was encountered within a short distance of the surface and from 1870 to 1875, 1,000 tons of good ore are claimed to have been removed from this.

Mr. Nash owned the ground immediately adjoining the Tennycape mine to the west (Fig. 13) and during the above activities produced a small quantity of ore from his workings.

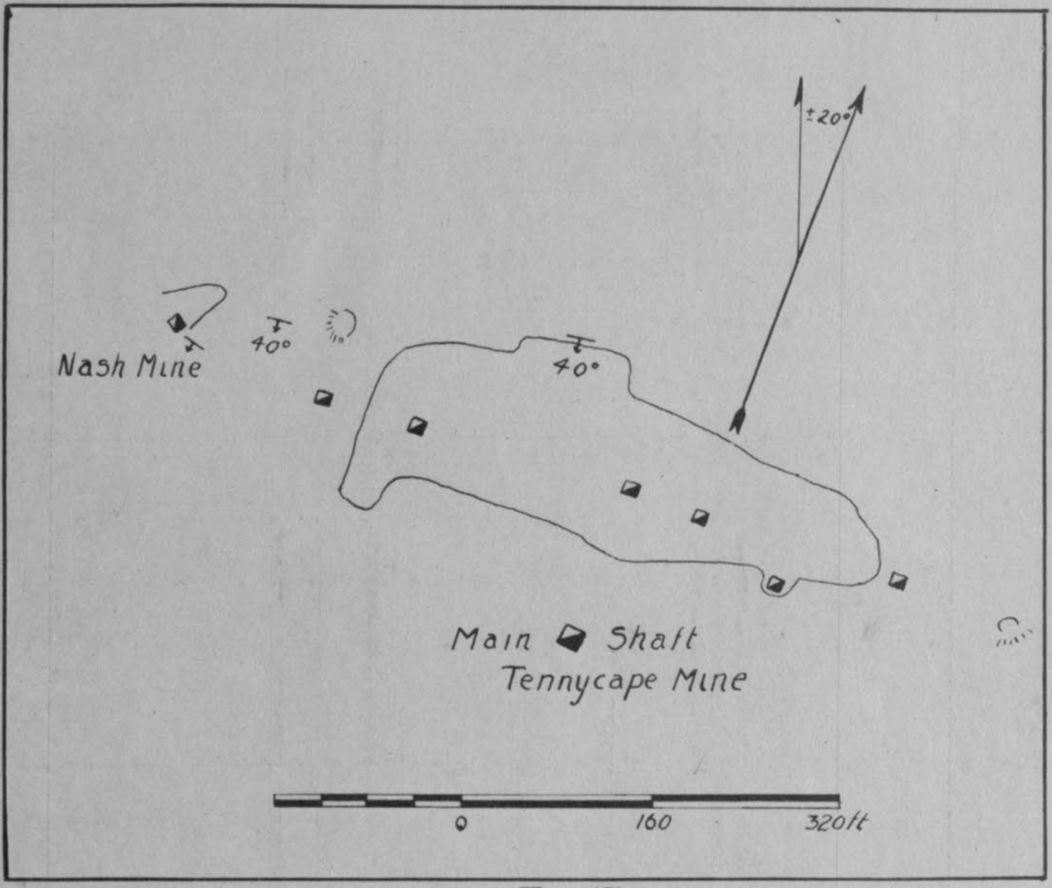

Fig. 13

In 1877 J.W.Stephens, of Tennycape, bought the property and during the following fifteen years is said to have carried on active mining operations resulting in a yearly production of about 200 tons.

In 1895, Mr. McVicar and Mr. Shaw bonded the property and did a little work, but later sold to a company, the chief members of which were Messrs. Bock, Halifax; Barnes, Boston, Mass.; French from Maine; and W.F.Jennison, Truro, N.S. Very little work was done by this company.

During the winter of 1917 to 1918 Mr. Hassan pumped out the mine, and sampled the workings and the dumps for an American company, but nothing further developed. Since then the property has remained idle.

Geology.- The rocks consist of a basal sandstone, overlain by an 8-foot bed of limy shale - the "hard rock" of the local miners and the footwall ore zone - and this in turn by a brown to grey dolomitic limestone, the lower part of which is brecciated and recemented with lime - the "soft rock" which carried the best ore. Old reports (1) claim that the limestone is overlain by gypsum, the outcrop of which is near the creek bottom and is now covered with debris. Gypsum has been mined within one-half mile of the mine, and the horizon is only a short distance above the manganese-bearing limestone. This series is striking N. 280° E. (Mag) and dipping 40°S. The strike and dip are those of the sandstone; local warpings and flextures in the shale and limestone makes it difficult to obtain their true attitude, but they appeared to be conformable with the underlying sandstone. If an unconformity exists it is a very slight one.

Occurrence.- The best ore was found in the soft rock as stringers, nests and pockets. The stringers varied in size

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(1) R.A.F.Penrose, Geol.Survey Arkansas, 1896.

up to 6 to 10 inches and in the main were nearly perpendicular to the bedding and trended westward down the dip. Near the "hard rock" they frequently widened out to form more or less of a blanket parallel to the bedding, and which at times was of considerable lateral extent. The nest and pockets varied in size from an inch or two in diameter to those containing several hundred tons of ore and in one instance 1,000 tons. These pockets in places were isolated and in others connected by thin seams of ore.

In the "hard rock" the ore occurs as veinlets ramifying through the rock in all directions. In places these stringers are small and widely spaced and in others, while narrow, are so plentiful that they form a good milling grade of ore.

Besides being found in situ a considerable amount of ore was obtained from the soil immediately north of the outcrops of the limestone, and this represented the residual product resulting from the weathering of the ore outcrop since glacial time. This ore occurred in pieces from nut sizes to those weighing 100 pounds or more, and formed a valuable source of ore easy to recover.

The thickness of the rock containing pay ore was about 30 to 40 feet; laterally the ore extended from 400 or 500 feet east of the main shaft (Fig. 13) to 200 or 300 feet west of it; the best pay zone outcropped about 100 feet east of the main shaft and raked west so that at the bottom of the main shaft its eastern limit was a short distance west of the shaft. The ore east of this zone was good quality, but it was in small stringers and nests here and there which made mining costs high.

Mineralogy.- The ore was mostly soft needle ore (Pyrolusite) and was exceptionally pure. Psilomelane and manganite were also present in varying amount. The minerals associated with the ore were botryoidal masses of limonite, calcite, selenite and barite, one or more of these being present in considerable amount in some sections and absent in others.

Development.- A compass and pace survey of the workings was made and this is given in Fig. 13. The initial work was confined to the large open cut and then shafts were sunk in the bottom of this and at either end as shown. From these, tunnels were driven following along the stringers of ore, and where the quantity of ore permitted, it was stoped out. Later the main shaft was sunk vertically for 160 feet and then a short tunnel driven north to the footwall and thence connections made with the previous workings. The underground workings extended eastward from the main shaft for about 400 feet and westward for a shorter distance. Mr. Brown said that there was little evidence of systematic mining and no advance development probably due to the pockety character of the ore.

At the present time the pit and shafts are filled with water.

Production.- This mine was the most important occurrence of manganese in Nova Scotia and has contributed from 85 to 90 per cent of her total manganese production. During its life, it was the main center of production. Hand cobbing and sorting into first and second grades was carried on at the mine.

Economic Possibilities.- The mine has not been worked below the 160 foot level and there is a possibility that more ore might be found in the deeper levels. The dumps are large and contain a lot of first class ore mixed in with the rock. There is likewise a considerable quantity of similar waste material in the underground workings as only sufficient was removed to allow for further workings. Besides these two sources there is also considerable ore in fine interlocking stringers in the footwall shale of the open cut. Under favorable market conditions it might pay to mill the footwall shale and the dumps and obtain the manganese content, but the quantity will be limited.

Origin.- The origin of this deposit is similar to other manganese ore deposits in the Lower Carboniferous limestone of Nova Scotia and a general discussion of this subject is given later.

PARKER MINE. Location.- The Parker mine is one-half mile to the northwest of the Tennycape mine, at W.Long. 63° 54'. N.Lat. 45° 15' 40". Access to it from the Tennycape mine may be had over a poor dirt road in places quite wet and swampy.

History, Ownership, and Production.-The mine was worked by Mr. William Stephens, of Tennycape, about 1882, who removed some 50 tons of very good ore and shipped it to the United States, receiving $140 per ton for it. The ore was on the property of Mr. Parker, who received a royalty on all ore removed from his ground.

Geology, Occurrence, and Mineralogy.- The mine consisted of a large pocket of very pure pyrolusite, occurring in a small outlier of Lower Carboniferous limestone. It is claimed that all the ore was removed by William Stephens. At present the mine is marked by a large irregular pit, some 100 feet long and 50 feet wide, filled with water.

WHEADON OCCURRENCE. Location and General Information.- This occurrence is just south of the post road, about half way between Rennie Brook and Wilcox Brook. W.Long. 63° 56' 10". N.Lat. 45° 15' 30". The ground is sloping northward to Cobequid Bay. The old workings are about 75 yards back and a little to the east of the barn on Mr. Wheadon's farm. The ground was formerly owned by Mr. McMillan, who, in 1900, sold to Mr. Beckman, and he in turn sold the ground in 1924 to Mr. Wheadon. About two ton of pyrolusite is said to have been obtained from here.

Geology and Occurrence.- The cut shows a Triassic alluvial deposit of fairly well sorted pebbles of heterogenous character, resting on a water worn surface of slate. The older rocks are classified by Fletcher as Devonian. The Triassic gravels are cemented with calcite and the pyrolusite has replaced this cement. This occurrence is correlated to that in the Tennycape Estuary and was formed at the same time and under the same conditions.

HIBERNIA. Location.- The Hibernia mine is located approximately two miles southwest of the Tennycape mine, at W.Long. 63° 55' 30". N.Lat. 45° 14'. It is most accessible over the road that passes just east of the Tennycape workings, but past this latter place the road is in very bad condition and in places is difficult to follow.

History and Ownership.- The ground, on which the occurrence is found, is claimed to belong to the Churchill estate of Cheverie, Hants County. About 1885, Mr. J.Stephens put two or three cuts into the bedrock and from these is said to have taken out about two tons of ore.

Geology, Occurrence, and Mineralogy.- The occurrence is found at the contact of the Carboniferous limestone, and what Fletcher has mapped as "not subdivided Devonian". The cuts that were seen showed a reddish shale and sandstone overlain by a limestone conglomerate and this in turn by gypsum. The conglomerate contains rounded water worn pebbles of quartz, sandstone, and shale varying in size from one-fourth inch to 3 or 4 inches in diameter. These are cemented by lime which forms by far the largest percentage of the rock. This series appeared to be striking N. 270° E. (Mag) and dipping 50°S.

The manganese minerals, consisting of (psilomelane?) and a little pyrolusite, occurred in the cracks and seams of the arenaceous shale and about the fragments and lining joints in the limestone conglomerate.

OTHER OCCURRENCES NEAR TENNYCAPE. Other occurrences of manganese are marked in this locality at W.Long. 63° 45' 40". N.Lat. 45° 14' 20", and another in McLennon Meadow at W.Long. 63° 52' 30". N.Lat. 45° 14'. At the former location manganese was found in small quantity but was never worked. At McLennon Meadow the occurrence is in a swamp, and contains hard bog ore but is of no value.

JENNISON PIT. The Jennison pit occurs about one-half mile west of the plaster quarries at Walton, W.Long. 63° 58' 45". N.Lat. 45° 13' 45", and on Fletcher's map, Walton sheet #74, it is at the contact between Carboniferous limestone and undivided Devonian. All that could be seen here was a hole in the ground now caved and grown over with grass and small shrubs. There was no evidence of manganese on the dump but rumor has it that a small amount was removed.

WHALE CREEK. One mile north and east of Walton at Whale Creek W.Long. 64°. N.Lat. 45° 14' 20", there is an occurrence of manganese marked on Fletcher's map (Walton sheet #74). On the south bank of Whale Creek, just back of the house owned by Mr. C.M.Parker,- formerly belonging to Mr. Wire - there is an old cut in limestone which shows manganese stains along the joints. There is no record of any manganese being removed from here.

Across the creek on the property of Monson Parker there is a tunnel 70 to 80 feet long penetrating a knob of thinly laminated limestone which strikes N. 35° E. (Mag) dip 30°NW. In this limestone small veinlets of pyrolusite occur; two or three tons of ore are said to have been derived from this work.

Mr. Parker claims that a small quantity of ore was removed from the sea cliff adjoining his property on the north. Here the rocks are badly deformed shales of Paleozoic age, overlain unconformably by the Triassic sands and gravels. The ore occurred in the shales as narrow veinlets.

SHAW AND CHURCHILL MINE. Location.- The Chruchill mine is on the west side of the Walton River, directly opposite Walton, and within 75 yards (south) of the main road. W.Long. 64° 00' 30". N.Lat. 45° 13' 30".

History, Ownership, and Production.- Work on this property was started about 1885 and continued in a small way for the following ten years. During this time about 200 tons of good chemical ore were removed from the open pit work, and shipped to American markets. The property was always held by the Churchill estate.

Geology, Occurrence, and Mineralogy.- The manganese occurred in a small outlier of Carboniferous limestone lying in a depression in the older steeply dipping Devonian sandstone and shales. Pyrolusite with a small amount of manganite formed the ore in this occurrence; calcite and barite were likewise found in association with them.

Workings.- The workings consisted of a large open pit, the bottom of which is below high tide level. This pit is now filled with water.

STEPHENS MINE. Location.- The Stephens mine is within 3/4 mile of Walton. W.Long. 64° 01'. N.Lat. 45° 13' 15", and is reached by means of a good dirt road that leaves the main post road about one-half mile west of the bridge over the Walton river.

History.- This mine was first owned by Mr. Wm. Stephens and worked by J.Brown, from 1870 to 1875, who is said to have obtained a few tons of very good ore. About 1885, R.J.Stephens worked on the property and removed some 10 to 20 tons of ore. In 1899 the property passed into the hands of W.F.Stephens and from 1902 to 1907 Wm. Stephens did some work and recovered about 20 tons of ore. There are at present about 3 1/2 barrels of ore in a shed on the property, and this is claimed to have been removed from the Stephens property. Mr. A.Parsons, M.P.P., of Walton, owns the timber limit over the area on which the prospect is located.

The above information was furnished by Mr. W.F. Stephens of Tennycape.

Geology, Mineralogy, and Occurrence.- The rocks on this property are a lower thinly laminated limestone, overlain by a brownish to grey apparently massive limestone about 10 feet thick, and this in turn by a pebble conglomerate which contains small rounded grains of quartz, some chert and small limestone fragments; the main mass of this latter bed is limestone. This series exhibits many local crinkles and warpings, particularly in the laminated member, but in general strikes N. 265° E. and dips 40° to 50° S.

The ore was found in the pebble conglomerate and also in the laminated member. From information furnished by Mr.

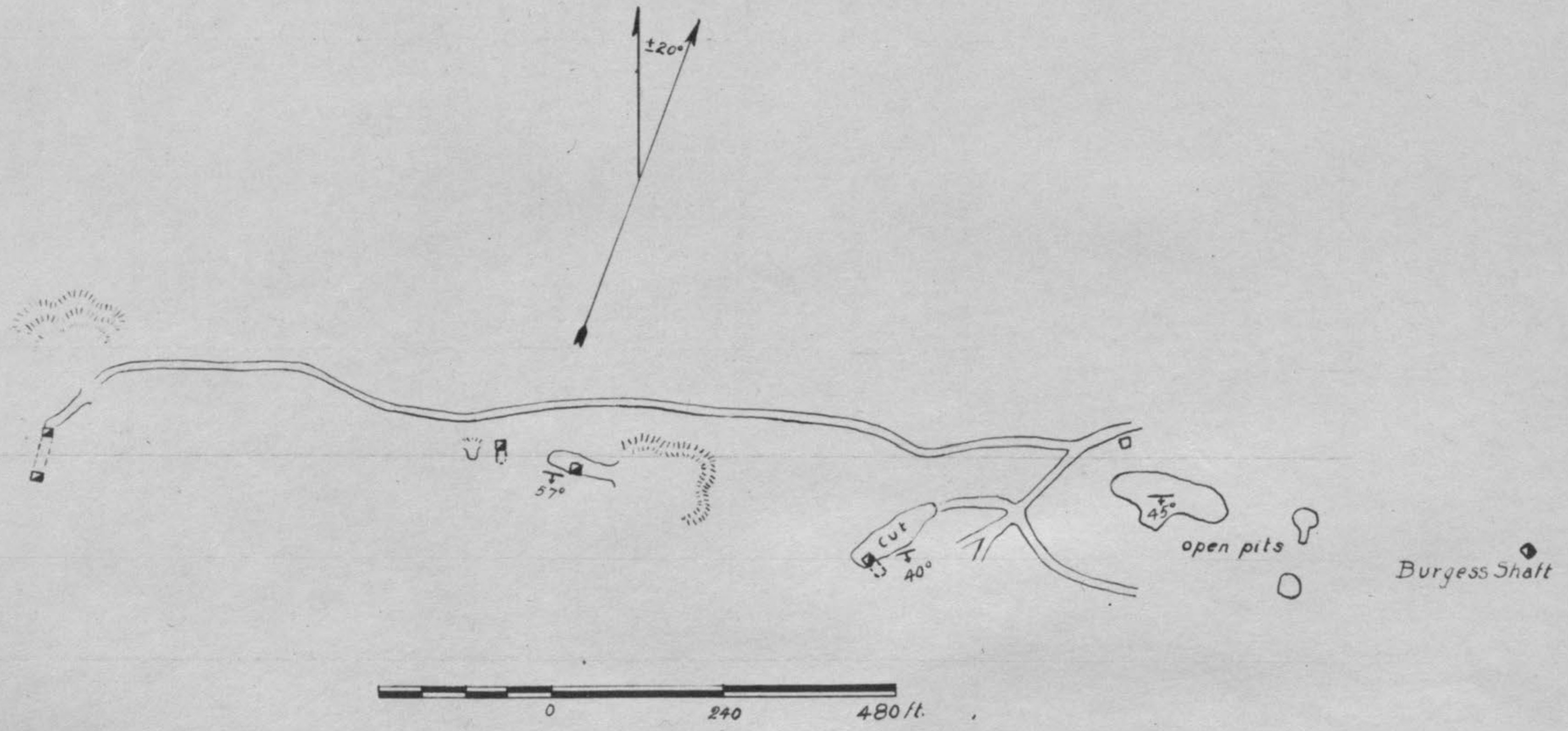

Fig. 14 Stephens Mine

Stephens and also by one who worked on the property, the best ore was obtained from the laminated limestone member. This shows jointing approximately perpendicular to the bedding and extending down the dip. These joints in places have been enlarged by solution and lined with dog tooth spar. The ore was found in nests and pockets, along these joints which in places were sufficiently large to yield one ton or so from a pocket.

Very little ore was seen on the dumps and still less in place. What was seen consisted of pyrolusite and manganite, and occurred as narrow stringers, cutting the limestone, and as films along joints.

Development and Production.- A compass and pace survey of the workings are shown in Fig. 14. The earlier work was confined to the open cuts on the eastern end of the property. Later the various shafts were sunk along the strike of the strata - in general these follow down the dip, averaging about 40 feet in depth on the incline. It is claimed that in later years the best ore was obtained from shaft 4 and a little from shafts 5 and 6. These workings are now in bad condition, and with the exception of 6 are inaccessible and mostly filled with water.

The total production from this property has been small, perhaps not exceeding 50 tons, according to information received from W.F.Stephens, and this production was scattered over a period of 25 to 30 years.

BURGESS SHAFT. The Burgess shaft is just east of the Stephens property as shown in Fig. 14. It is claimed that very good crystal ore was obtained from this shaft, but the quantity was small. The shaft is now caved and inaccessible.

It is reported in this district that manganese boulders are frequently turned up while ploughing the fields.

DAVIS PIT. On Fletcher's map, Walton sheet #74, there is an occurrence of manganese mark at W.Long. 64° 01' 20". N.Lat. 45° 13 '. This is labelled "Davis Pit" and is just south of the main road, about half way between Pembroke and Walton. It could not be located and no one in the district could furnish any information concerning it.

"STURGIS" MINE. Location.- The occurrence marked "Sturgis Mine" on the Walton sheet #74, is two miles south of Pembroke and a little to the east of it. W.Long, 64° 02' 30". N.Lat. 45° 11' 45". There are here two separate properties within 100 yards of one another and known locally as the Sturgis and the Feuchtwanger mines, respectively. (Fig. 15).

Topography.- These occurrences are situated in a small drainage basin, surrounded by knobs and low hills well covered with birch, alders, and conifers. The general slope of the ground is from the Sturgis to the Feuchtwanger, i.e., from west to east.

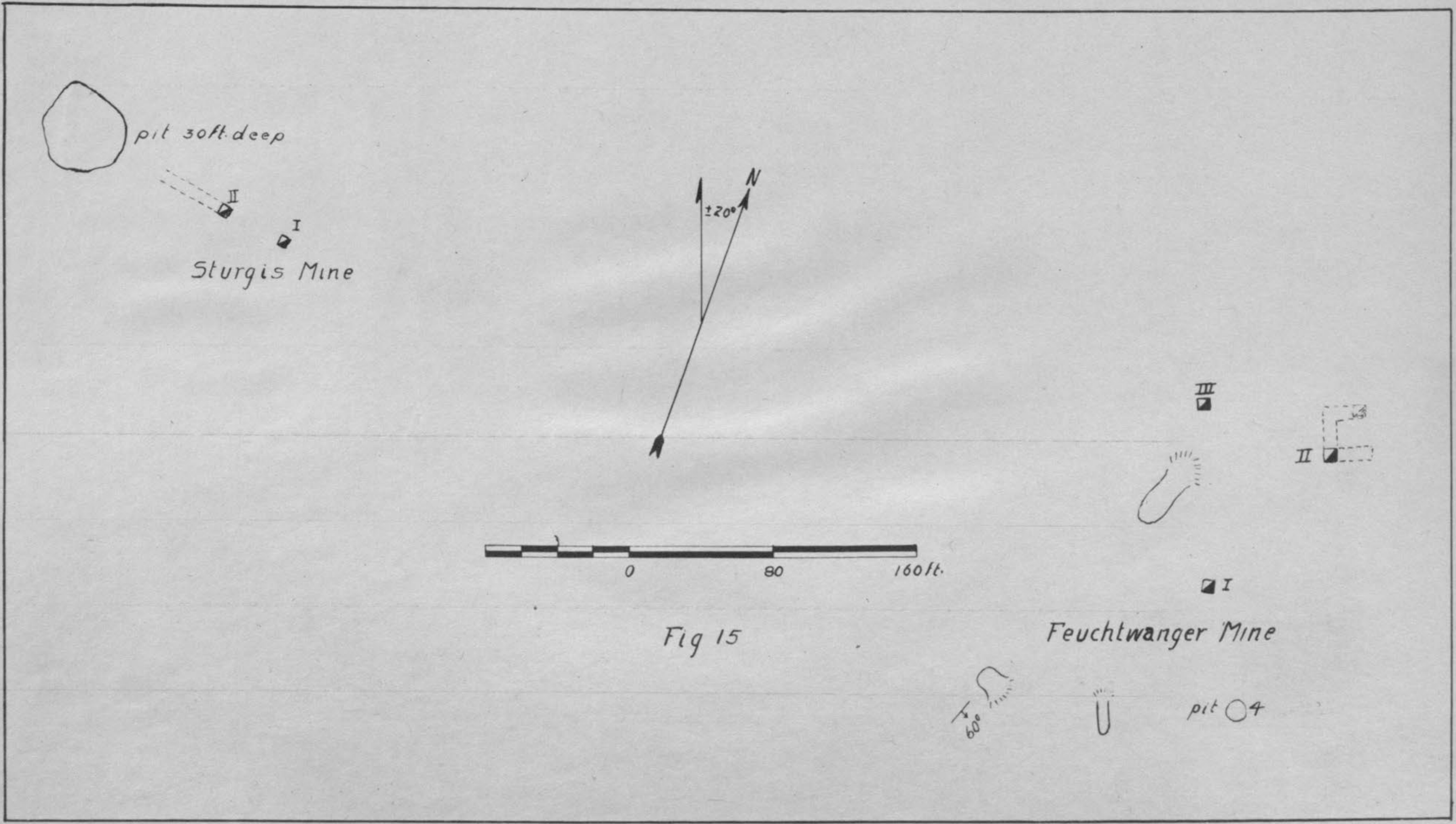
pit 30ft. deep
II
I
Sturgis Mine
N
±20°
0
80
160 ft.
III
II
I
Feuchtwanger Mine
60°
pit
4

Fig 15

Sturgis Property. History and Production.- The Sturgis property was worked intermittently by the owner from 1877 to 1882 but very little, if any, ore was shipped. From 1917 to 1918 a Mr. E.Chisholm did considerable work here and is said to have removed about 86 barrels of ore averaging 400 pounds per barrel.

Geology, Occurrence, and Mineralogy.- The ore is found in a brownish weathering quartzite which underlies the Carboniferous limestone. Pyrolusite and limonite are found along the joints in the quartzite and appear to be replacing it forming many coalescing and irregular veinlets, sometimes several inches across.

A polished section of this ore shows that the amount of ore is more apparent than real. The black, sinuous interlocking veinlets are seen to be composed mostly of quartz grains; the interstices are filled with pyrolusite and limonite and transmits to the clear quartz an anomolous black color so that it is difficult to detect the quartz from ore minerals unless polished.

The quartzite is a light grey with a faint reddish cast to it. The manganese oxides may occur in sharp contact with this and form a direct replacement, but the most common occurrence appeared to be that in which the oxides were separated from the unaltered rock by a zone varying in color from a brown to deep red, the former representing the preliminary stage of alteration by limonite developing along cracks and interstitial spaces, and the latter the more advance stage of oxidation and in which the concentration of the manganese oxides is becoming apparent; small splotches of manganese oxides may be seen here and there in the red zone.

Origin.- This deposit was formed as a result of surface waters seeping along the joints and fissures in the quartzite and from these working into the interstitial spaces between the quartz grains. The initial alteration consisted in a concentration of limonite, between the quartz grains, in cracks and any open spaces as films and minute colloform masses. Later solutions effected a replacement of the limonite by pyrolusite. The quartz appears to be corroded in places by both the limonite and pyrolusite.

The source of the manganese and the time of its concentration are believed to be the same as those resulting in the formation of the Feuchtwanger occurrence which is in Carboniferous limestone. It is possible that a similar deposit in limestone at one time existed over the present occurrence in sandstone, and in this case the hypothesis is advanced that the Sturgis occurrence represents the roots of this pre-existing deposit which has been subsequently removed by erosion, and shows the resulting reactions of the solutions after having passed through the limestone, depositing most of their lode there and being correspondingly modified.

Feuchtwanger Property. History and Production.- The Feuchtwanger property was worked from 1885 to 1894 by F.Ward, of Windsor, who did most of the work, now represented by the shafts, cuts, etc. A considerable tonnage of good ore was obtained from this work. Again in 1917 to 1918 E.Chisholm pumped out shaft II (Fig. 15) and recovered a ton or two of ore from this.

Geology, Mineralogy, and Occurrence.- The ore is found in a thinly laminated Lower Carboniferous limestone, striking N. 39° E. (Mag), dip 60°SE. It is found as stringers up to 5 inches in width and as small pockets and nests, and consists of pyrolusite crystallized in needles and platy grains, and also as a fine pulverant mass. Limonite exhibiting colloform structure, is associated with it in varying amounts, and is replaced by the pyrolusite.

Origin.- The origin is similar to that described under the general heading of "Origin".

Workings.- The workings of the Sturgis and Feuchtwanger properties are shown in Fig. 15. Shaft I on the Sturgis is said to represent the earlier work. The miniature glory hole, shaft II and tunnel were made by Chisholm. On the Feuchtwanger property good ore is said to have been obtained from Pit 4, and from all the shafts. The largest amount being derived from shaft II and its underground workings. In the sump at the end of the NE workings of shaft II a 5-inch vein of good pyrolusite is reported. All the shafts are filled with water and the trenches are caved.

TOMLINSON MINE. Location.- The Tomlinson mine is three miles almost due south of Pembroke, at W.Long. 64° 03'. N.Lat. 45° 10' 45". Access may be had to Pembroke over a very poor dirt road.

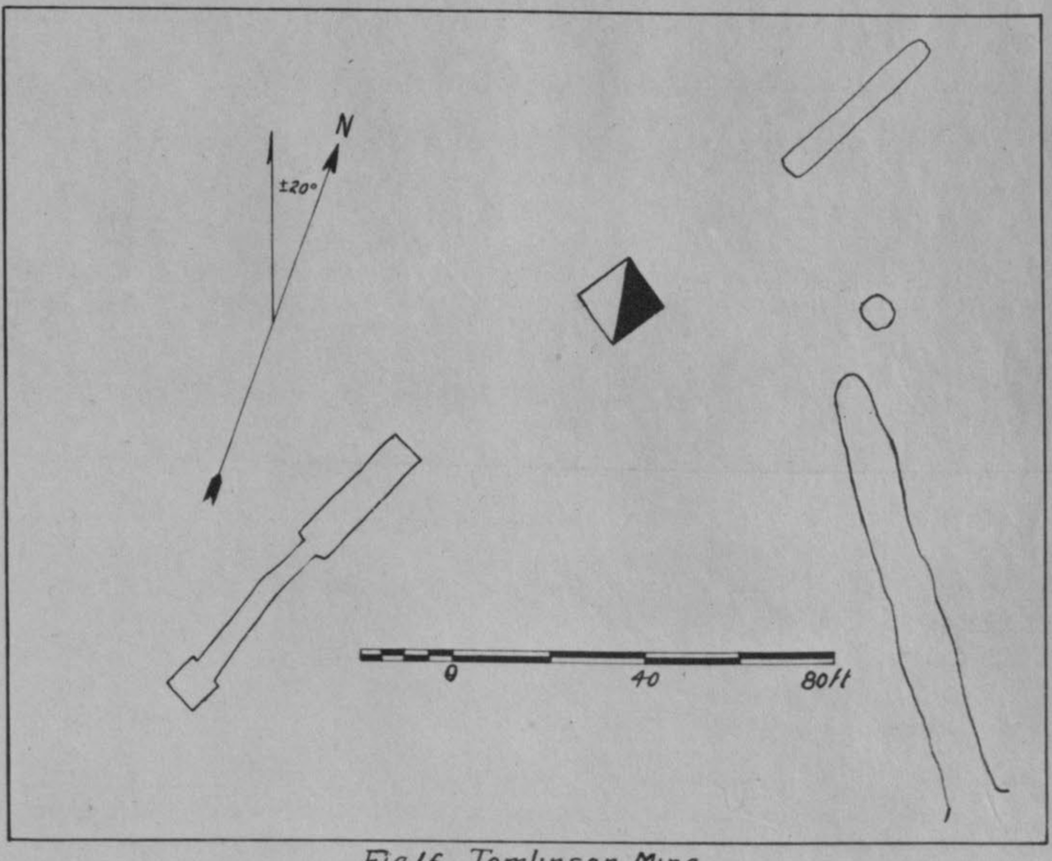

Fig 16 Tomlinson Mine

Description of Property.- The workings (Fig. 16) have exposed a ferruginous sandstone which on weathering has yielded a surface product of siliceous limonite. Along the dumps there may be picked up masses of cherty limonite with small amounts of specularite and some psilomelane, but none of this was observed in place.

The manganese occurrence marked on the Walton sheet #74, one-half mile north of the Tomlinson mine, could not be found and old inhabitants had no recollections of it.

LANTZ MINE. The Lantz mine is marked at W.Long. 64° 04' 45". N.Lat. 45° 10' 20", Walton sheet #74. The only evidence that could be found in this location was a series of pits which had exposed a bedrock of limestone; some sandstone fragments were also lying about. Early reports claim that fine specimens of pyrolusite were obtained from here, but there were no indications of manganese on any of the dumps, nor was any seen in the pits.

GOSHEN IRON MINES. As far as could be ascertained no manganese ore was ever recovered from the old Goshen Iron mines.

SMITH'S PROPERTY. Mr. William Smith, who owns a farm near the Goshen Iron mines, reports that he occasionally turns up bog manganese when ploughing in the lower ground of his farm.

BURNT BARRENS AND SUGAR WOODS. The occurrence at Burnt Barren W.Long. 63° 06' 45". N.Lat. 45° 09' 40", and Sugar Woods N.Long. 64° 09' 30". N.Lat. 45° 08' are bog ores occurring either at the surface or under a thin mantle of soil and vegetation. Charles Wilcox claims to have hauled about 100 tons of bog ore from the Sugar Woods occurrence but this was never shipped.

MCDOUGAL'S PROPERTY. J.McDougal says that at times he turns up bog ore while ploughing his fields. This farm is about 1/2 to 3.4 west of the Burnt Barren.

MILL BROOK. Manganese is reported occurring in limestone along the shores of the small lake on Mill Brook just southeast of Brookville, but this could not be located.

CHEVERIE. Location.- Manganese minerals occur at the mouth of Cheverie Creek on the south shore W.Long. 64° 10' 15". N.Lat. 45° 09' 40". There are two occurrences here known locally as the Brown and the Lake occurrence. That on the property of Mr. Brown is just west of the main post road, while the Lake occurrence is some 200 to 300 yards farther west and is found near the northern end of the sea cliffs that border the farm formerly held by Mrs. Lester Lake, but now owned (1927) by Mr. T.Macumber.

History.- These deposits were worked from 30 to 40 years ago, and local reports say that about 100 tons were recovered.

Geology.- The rocks are a series of Lower Carboniferous limestone and lime breccia, which apparently underlie the gypsum strata in this area.

Mineralogy and Occurrence.- The ore minerals are manganite, pyrolusite and psilomelane in association with calcite, and barite. On the Brown property they occur as veinlets and nests in a brown crystalline limestone and on the Lake property the ore minerals are found in the lime breccia, about the fragments, in narrow veinlets or in irregular masses up to 6 inches or more in diameter. While the ore is quite pure in itself, it is sporadic and of small amount. An analysis quoted by How (1) gives Mn_2O_3, 86.89 per cent; H_2O 10 per cent; (Si + Ba) 1.14 per cent; Fe, etc. 2.05 per cent.

Development.-The production of manganese was obtained from a series of open cuts and one large pit.

The Custom's official at Cheverie informed the writer that manganese occurs in the knobs of rock protruding through the mud, about 1/4 mile out from the shore at Cheverie. These rocks are grits, red shales, and limestones, in which the ore was found as small stringers. The two barrels of ore, claimed to have been removed from here in 1915, were inspected and showed the ore to be mostly fine acicular pyrolusite. Considerable time was spent hunting for the pits from which this ore was obtained but they could not be located.

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(1) H.How, Mineralogy of Nova Scotia, 1868.

KENNETCOOK CORNER. On the Kennetcook sheet #65, Hants County, there are two doubtful occurrences of manganese marked 1/4 mile and 1 mile north of Kennetcook Corner. The northerly of these is on the property of Mr. Dalrymple and the southern one on Mr. Anthony's farm. The manganese found here consisted of "float" that has been turned up periodically when ploughing the fields. Several pits have been sunk from time to time to depths of 10 feet or more, but none of these encountered bedrock.

MCPHEE CORNER. One and one-half miles SW of McPhee Corner at W.Long. 63° 33' 30". N.Lat. 45° 06' there is marked on the Kennetcook sheet #65 another doubtful occurrence of manganese. This is on the property of Mr. Brassel. Float, consisting of manganite and pyrolusite, has been found here but nothing in place was ever recorded.

RAWDON. About 1 1/2 miles NW of Rawdon and 1 1/4 miles west of Walkerville, on the Windsor sheet #73, Hants Co., there is marked at W.Long. 63° 51' 45". N.Lat. 45° 03' 30" an occurrence of manganese. About 20 years ago some small pits were dug here, which encountered sandstone and shale. There may have been manganese in small seams and cracks, but no evidence of its presence could be found on the dumps of the pits.

SOUTH UNIACKE. There has been reported an occurrence of manganese on the property of Mr. Maxwell about one-half way between South Uniacke and Fennerty. According to old reports (1) about 100 pounds were removed from here in 1858. The ore was pyrolusite yielding 70 per cent MnO_2, occurring as small seams in the sandstones and shales.

The small creek that flows by the Maxwell mill is said to contain small patches of bog manganese here and there along its course, but none could be found. Float manganese is also reported in this locality.

Halifax County

Manganese in the form of wad is reported by E. Gilpin (2) to occur at Jeddor, Ships Harbour, and St.Margarets Bay, and veinlets of pyrolusite are said to occur in the granite at Musquodobaut, and Ships Harbour. These occurrences were investigated but little could be obtained concerning them as the inhabitants at the respective places apparently knew nothing about them.

It is reported on good authority that amythest is to be found in the granite near Governs Lake 6 miles from Halifax on the St,Margarets Bay road. Amythestine quartz, evidently a pegmatitic segregation or vein in the granite occurs on Raines farm.

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(1) H.How, Mineralogy of Nova Scotia, 1868.

(2) Trans.Royal Society Canada, Sect. IV, vol. 2, 1884.

Lunenburg County

The manganese veins at New Ross Mines, Lunenburg County, form one, if not the most important manganese occurrence in Nova Scotia. Besides this, bog ore is known in various parts of the country as at Conquerall, Hebbville and Chester Basin.

CONQUERALL AND HEBBVILLE. About two miles north of Conquerall station, on the farm of Auber Hebb, bog manganese occurs in the marshes and low ground. It is found as a layer of varying thickness up to 8 or 10 inches and is in a semi-consolidated state. The ore is of very good quality for bog ore, yielding Mn 34.16 per cent; Fe, 11.51 per cent; Insol. +SiO_2, 4.53 per cent(1). Immediately underlying the ore there is generally a layer of lime forming a crust on the bed-rock slates and phyllites. These two layers, i.e., bog ore and lime, are frequently in sharp contact with one another, but there is also an intermixing of the two. This association suggests that the waters forming the bog deposits of this area, are carbonate solutions and the manganese has been transported as a bicarbonate. In the flat or marshy places opportunities have been presented for the displacement of the weak carbonic acid, by stronger organic ones, with a resultant precipitation of the lime and manganese formerly held in solution.

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(1) A.Sadler, Dept. Mines, 1927, Analyst, specimen submitted by writer.

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; X-ray powder photographs substantiate this view. There are distinctly two minerals present but what they are is not known, and they are grouped under the general term "wad".

Similar occurrences have been noted on and adjoining, the farm of Andy Hebb, of Hebbville, a few miles farther north.

LA HAVE AND CHESTER BASIN. The occurrence of bog manganese at La Have could not be found and nobody about the place seems to have any recollection of it. Bog ore is reported at Chester Basin yielding 20 per cent MnO_2 (1).

NEW ROSS. Location and Access.- The manganese mines of New Ross occur in the northern corner of Lunenburg County, about the center of the "Dean and Chapter Grant". They may be reached by two routes, the first, and best, is from Windsor; the second, from Chester Basin on Mahone Bay. Leaving Windsor one proceeds to Upper Falmouth over 6 miles of very good dirt road, and thence over 14 miles of road that is now grown in with considerable brush, but the road bed is firm and in very good condition. On leaving Chester Basin one travels

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(1) H.How, Mineralogy of Nova Scotia, 1868.

an intercounty road to New Ross, and then takes a very rough and poor road, 7 miles in length, to the mines.

Topography.- About the mines the low rounded bare rocky hills are spaced with depressions filled with debris, soil, and frequently small marshes. The higher ground and knobs are either bare rock, or else the granite bedrock is covered by a few inches of coarse sandy soil. Boulders of all sizes are quite plentiful. At one time well-wooded, this section was ravaged by fire which cleaned off all vestige of vegetation, and the area became known as the "barrens". At present there is a plentiful growth of young hard wood and conifers over a great deal of the area.

History.- The following historical sketch and description of the underground workings were furnished by Dr. Lavers, New Ross, owner of the Nova Scotia Manganese Company.

There are three workings within two miles of one another, and known locally as the Nova Scotia Manganese Company, the New Ross Manganese Company, and the International Manganese Company. The Nova Scotia Manganese Company holds the most northerly occurrence,- or the "New Mine". This was first discovered by Mr. E.Turner, in 1907, who in the following year sunk two shafts, reported to be 25 feet and 30 feet deep. In 1910 the Nova Scotia Manganese Company was organized with Dr. Cain as manager and this took over the "New Mine", obtained a 99 year lease of 5500 acres in the Dean and Chapter Grant, including all mining rights together with privilege of cutting timber for fuel and mining purposes, royalties to be paid on all mineral removed. Besides, the exclusive rights to search for manganese and iron over five square miles in this vicinity were obtained from the Provincial Government. During the nest two years active operations were carried out, a surface plant, of boiler house, saw-mill, concentrating mill, shaft house, office, mess-house, etc. was built; mining operations continued, the shaft being sunk to 155 feet and levels driven east and west at 150 feet. Good ore was encountered at 20 feet to 30 feet below the collar of the shaft and this continued in depth. By this time the company was in financial difficulties and work ceased during 1912. In the fall of that year the mill was destroyed by fire.

Until about 1917 the property lay idle and then activities began again. The shaft was sunk to 215 feet, and a level driven at 215 feet (west for 60 to 80 feet, east 200 feet). Stoping commenced on the lower level, extending out to 155 feet, and this was carried through to the 150 foot level and in places continued up to within 30 feet of the surface. It is claimed that 3,000 tons or more of good ore were removed and shipped during this operation.

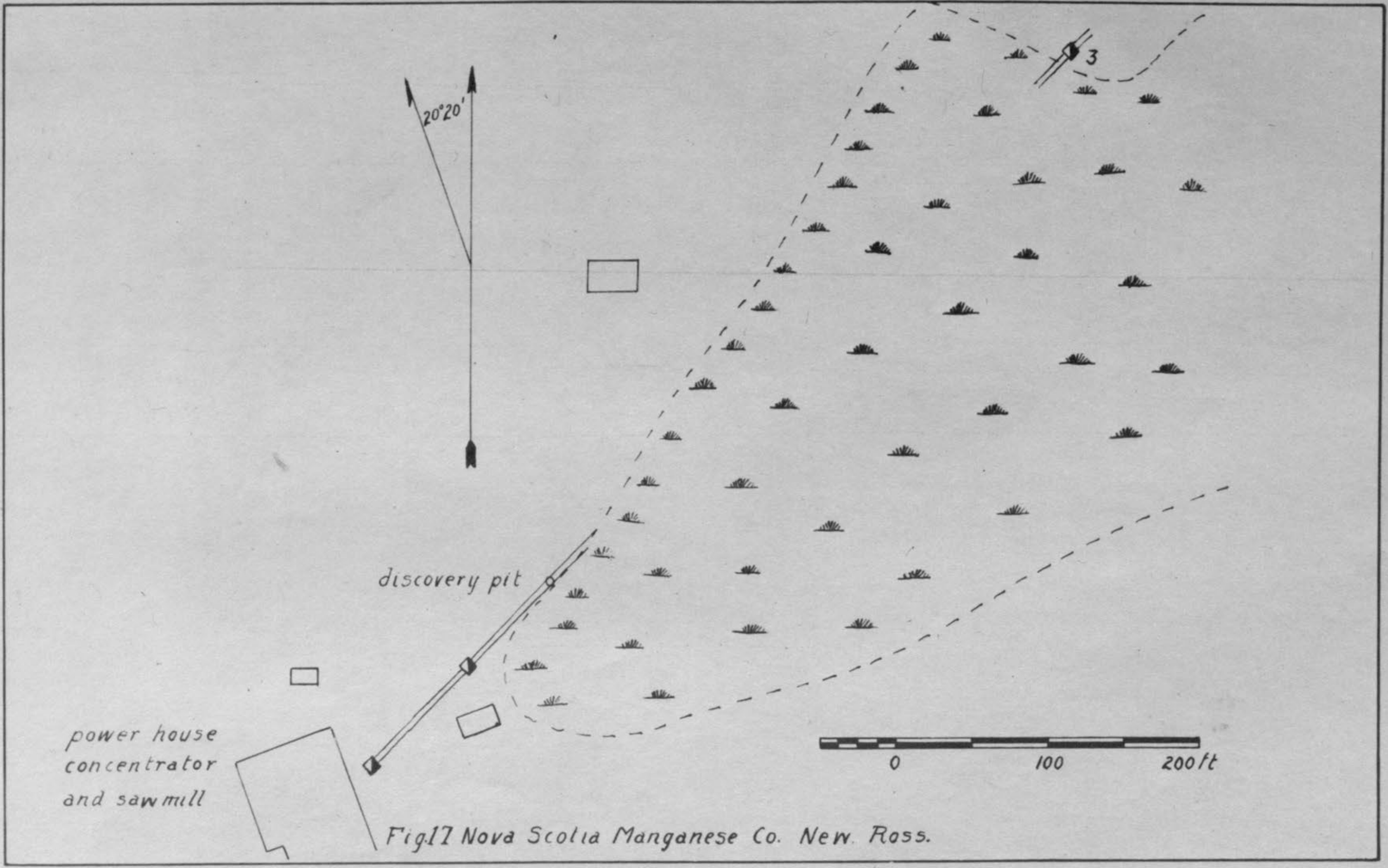

Fig 17 Nova Scotia Manganese Co. New Ross.

In 1920 Dr. Lavers and Mr. Prisk obtained control of the property and sunk the shaft nearest the swamp (See Fig. 17). This encountered ore at approximately 10 feet and remained in it to 90 feet. In 1921, the Consolidated Manganese Company (Boston, U.S.A.) took an option on the property and continued the shaft to 230 feet, and drifted east and west. This company also sunk shaft 3 and are said to have found good ore at the bottom (15 feet deep). The option reverted to Dr. Lavers.

The New Ross Manganese Company owns the ground about 1 3/4 miles south of the above property, and this was first known as the "Old Mine". It was discovered by W.Rafuse about 1891, who worked it for a while and then T.Foster of Halifax obtained control about 1893. In turn, he sold to the New Ross Manganese Company about 1894. This company sunk a shaft to 45 feet and then drifted about 80 feet each way; later operations continued the shaft to 90 feet. About 700 tons were removed by this work.

About 1903 litigation commenced regarding the ownership of the land, and the property remained idle until the Consolidated Manganese Company took it over in 1921. This company sunk the shaft to 115 feet, and drifted on the 45 and 95 foot levels, removing about 1500 tons of ore, which were concentrated in the mill that they erected in 1921, and shipped it to U.S.A.

The International Manganese Company (Boston) obtained some ground just south of the New Ross mine, and sunk a shaft on a carbonate vein, but did not obtain any ore. This property ran out and was put up for tax sale.

<u>Geology</u>.- The rocks of the New Ross map(1) area are a biotite granite, intruded by a muscovite granite batholith; both these are intrusive into the gold-bearing series which now exist as irregular masses partially separating the granites. The recrystallization along the contacts has been so profound that the sedimentary rocks in many instances have assumed a fine-grained igneous texture. In other places they have been so reworked by the granitic material that it is difficult to determine the boundary between sediments and igneous rock.

The biotite granite is a porphyritic rock made up of phenocrysts of microcline two and three inches long set in a medium-grained grayish matrix of plagioclase, quartz, orthoclase, and biotite - named in order of relative abundance. It shows, in general, no contact changes in texture or appearance. The muscovite granite is quite similar, but plagioclase and orthoclase are about equal and both muscovite and biotite are present in the groundmass. This granite shows marked contact phases being fine-grained over a zone up to

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(1) W.J.Wright, Unpublished report on New Ross map area, 1912.

one mile in width from the contact, and in which a large amount of aplitic and pegmatitic material is developed. "This (1) phenomena indicates that the muscovite granite was accompanied by large amounts of vapours....

Mineralogy and Occurrence.- The mines are located on a group of carbonate veins striking generally N. 45° E. and dipping steeply NW. The orebodies are a series of lenses varying in width from 0 to a maximum of 60 inches, averaging perhaps 17 to 18 inches of manganese ore. Associated with the manganese oxides are the various oxides of iron, which in general, are segregated to themselves on one or the other of the walls or they may occupy the entire fissure. While the manganese oxides are relatively free of iron, yet the iron oxides always contain a varying amount of manganese distributed through them. Professor J.W.Phelan (2), owner of the New Ross mine, states that the lenses of ore in his mine always occurred along the footwall of the vein, which in general was more soft and showed a greater degree of oxidation than did the hanging wall.

The old reports (3) state that at the surface the veins consisted of hard, botryoidal masses of iron oxides,

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(1) W.J.Wright, Op. cit.

(2) J.W.Phelan, Professor in Chemistry, Mass.Inst.Technology, Cambridge, Mass.

(3) W.J.Wright, idem.
H.E.Kramm, Trans. Canadian Min.Inst. 15, pp.210-217.
J.Oblaski, private report.

which persisted to varying depths up to 30 feet; with the increase of manganese the iron oxides changed to soft pulverent masses segregated to themselves. Moreover, it appears from these reports that the manganese minerals showed a zoning, from the soft pyrolusite at the top through a mixture of pyrolusite and manganite to manganite and this in turn to psilomelane, which exists at the bottom of the workings. Such a zoning is contributed to the degree of oxidation to which the deposits have been subjected; the psilomelane being the lowest and least oxidized whereas the manganite and pyrolusite represent progressively higher degrees of oxidation. Professor Phelan claims that hard ore was to be encountered at various depths, but this existed as lenses within the pyrolusite.

The minerals present are pyrolusite, manganite, and psilomelane, associated with hematite, limonite, and other hydrous oxides of iron. The original minerals present were calcite and an iron, manganese carbonate, remnants of which may be seen here and there throughout the ore on the dumps. The walls of the veins may be sharp but there is generally a transition zone between the vein proper and the granite, in which the manganese, and iron, oxides are seen to be intergrown with the granite minerals and apparently replacing them.

The manganese ore is in places compact but is commonly quite cellular and vuggy, especially is it porous in the pyrolusite variety.

Economic Possibilities.- Up to the fall of 1912, underground workings had showed the ore zone on the Nova Scotia Manganese Company's ground to exist over a horizontal distance of 300 feet and vertically for a depth of 120 feet. The surface prospecting indicated a vein fissure, containing ore, of 1,500 feet in length, but this was by no means proved. The orebody of the New Ross Mining Company's ground was shown to be very similar, but of somewhat smaller extent, so far as work up to that time indicated. Subsequent work on both properties was chiefly on surface plant with underground work confined mainly to the extraction of ore already partially blocked out; a small amount of advance development was carried on. A depth of 215 feet was reached on the Nova Scotia Manganese mine, and the present owners claim that the workings were still in good ore.

Origin.- It is suggested that the fissures now containing the manganese oxide ore were originally filled with a carbonate mass, chiefly calcium carbonate, with admixed iron and manganese; secondary processes of weathering caused an oxidation and downward enrichment along the veins finally resulting in the present ores.

The relative amounts of vein filling and replacement of the walls during the primary deposition of the carbonates is not known, but a replacement of the granite is clearly indicated. Well within a carbonate vein, a specimen was collected which showed remnants of biotite, feldspar, and quartz. The biotite within the carbonate is the same as that contained within the granite. Hydrothermal alteration is indicated by the change of biotite to chlorite without development of limonite, and the change of the feldspar to sericite, which in some cases, has progressed so far that flakes of muscovite have developed. Examination of specimens collected adjacent to and far removed from the veins showed that the alteration was similar in both but more pronounced in the former. In such thermal alteration is sought the explanation of the heavily oxidized wall rock in places and the intergrowth of the oxides with the granite minerals. This primary alteration left the containing wall rock in such a state of decomposition that later surface solutions found little difficulty in completing the destruction, and effecting the replacement by the oxides of iron and manganese. Corroborative evidence is furnished by the action of the granite removed from the workings; in place it was so solid and hard that blasting was necessary but when exposed on the surface on dumps it altered to a clayey crumbling mass within a week.(1)

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(1) W.J.Wright, op. cit.

In the other reports the source of the manganese was sought either in the biotite within the granite or in the assumed overlying Paleozoic limestones now eroded, or in both. During the erosion of such assumed overlying sediments and of the batholith itself, the supergene waters of the time are assumed to have taken into solution the manganese and iron of the rocks, and then when (1) freely exposed to the action of air, which would be the case in fissures, were forced to precipitate their mineral content, which was deposited in the form of oxides or carbonates of manganese and iron. W.J. Wright favors the existence of an original carbonate gangue containing siderite and rhodochrosite.

Detailed optical examination was made of a considerable number of carbonate specimens taken from the various dumps and in all cases the indices of the carbonate tested were those of calcite, or so close to it that the differences were hard to detect. 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, this latter mineral had the normal indices of calcite. Examination under the high power (X 384 to 500) revealed the development of

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(1) H.E.Kramm, Trans. Canadian Min.Inst. 15, 1912, p.216.

exceedingly fine crystals of an opaque mineral (manganite). Immediately surrounding such crystals or crystal groups the calcite assumed a brownish tint, but such areas were too minute to segregate and test the indices. Chemical tests for manganese on the specimens of carbonate yielded a positive result in all cases, the darker greys, browns, and reddish varieties giving stronger reactions. From these observations it does not appear certain that either rhodochrosite or siderite exist as carbonates corresponding to their respective formulae, but rather that a small but persistent amount of iron and manganese are present in the calcite as isomorphous mixtures.

Optical examination of the biotite found within the carbonate vein, as remnants within the oxide ore along the walls of the orebodies, and in the granite adjacent to and at a considerable distance away from the deposits, showed that this mineral in each instance was the same, and to have suffered similar hydrothermal alteration. The products of surface weathering were most pronounced in the biotite within the ore, this showing in many instances a development of minute crystals of manganese oxide, similar in appearance and occurrence to those found in the carbonate of the vein and within the altered feldspars of the granite adjacent to the ore; such a replacement showed a preference to develop in the alteration products, hypogene and supergene, of the minerals.

Chemical tests on the mica of the normal and altered granite near the veins showed a manganese content in each case.

Reviewing the evidence it seems that the manganese oxide ores at New Ross mines had as the first stage of their formation a development of carbonate veins along fractures in the biotite granite, possibly with fissure filling and certainly to some extent by a replacement of the containing granite. The carbonate was an isomorphous intergrowth of calcium, iron and manganese and the solutions forming these veins originated either from the biotite granite, or from its differentiate phase the muscovite granite of somewhat later age. The existence of manganese within these rocks is shown by its presence in the biotite, by the development of amethystine quartz in pegmatites, and the association of hubnerite in deposits, connected with the granites. On the exposure of the carbonate veins to atmospheric agents, a weathering and secondary concentration was initiated, which by continuous and progressive downward enrichment of the manganese and iron, finally resulted in the presetn oxide ores.

Queens County

Mr. Almond Parks, of Riverport, reports the occurrence of bog manganese on his farm at Pleasant River, Queens County. The bog ore occurs in swamps and low places forming a layer of variable thickness up to 7 or 8 inches. No work has been done to obtain the extent of this occurrence.

Shelburne County

"Bog iron and manganese (1) ..... are reported to have been found in digging wells on the east shore of Shelburne Harbour, between Shelbourne town and Sandy Point. Sink holes indicating the possible presence of gypsum or limestone were also observed on this part of the shore of Shelbourne Harbour. A spring of sulphuretted mineral water is situated on Pace Walls farm just south of the railway one mile east of Shelburne."

Kings County

Manganese is known to occur in Kings County in the Triassic traps bordering the Bay of Fundy, in the bedded Triassic rocks near Cornwallis and Wolfville, in the steeply dipping Siluro-Devonian quartzites and slates about Greenwich and in strata of similar age in the vicinity of Nicholsville. (Aylesford Deposit).

The occurrence near Cornwallis and Wolfville could not be located but Ed. Gilpin (2) says that manganese is found in bedded form associated with the Triassic rocks in this locality.

Tests for manganese made on several samples of Triassic trap rocks, all gave positive reactions; amethysts

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(1) E.R.Faribault, Canada Geol.Survey, Summ.Rept., 1917, p.19F.

(2) Trans. Royal Society Canada, vol. 2, sect. IV, 1884.

are common and manganese oxides associated with the zeolites of the volcanic rocks have frequently been reported. While such occurrences are of no economic value, yet they afford an interesting example of a possible primary source of manganese.

At Greenwich, about three miles south of Wolfville, pyrolusite and psilomelane occurs in narrow veinlets and seams cutting the Siluro-Devonian quartzites and slates. It is reported (1) that in 1864 about one ton of ore was obtained from this occurrence.

AYLESFORD MANGANESE DEPOSIT. Location.- The Aylesford manganese deposit is on the Wentzell farm, 1 1/2 miles west of Nicholsville, and is on the north side of Zebe Creek. Access may be had from Aylesford, on the Dominion Atlantic railroad, by measn of a good dirt road 4 or 5 miles long.

Ownership and History.- In 1885, Mr. A.McPhail did considerable surface stripping and obtained about three barrels of ore. Little was done after this until 1918 when Mr. W.A.Bishop of Wolfville took over the property, sunk an exploratory shaft for some 25 feet, and then organized the Aylesford Manganese Mining Company Ltd. to carry on the work. Activities lapsed, and now the property and company are controlled by Mr. Bishop.

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(1) H.How, Mineralogy of Nova Scotia, 1868.

Geology, Mineralogy, and Occurrence.- The rocks in this vicinity are pinkish quartzites, red arenaceous slates and phyllites containing fossils of Dictyomema. These strike approximately east and west and dip steeply to the south, and are invaded by a dyke of gabbro which weathers to a reddish hue. This dike appears to be schisted near the borders, parallel to the slaty cleavage. The ore minerals are hard, black psilomelane, manganite and pyrolusite. The ore is not of chemical grade, but with treatment it might give an ore suitable for metallurgical purposes. The ore occurs as lenses and stringers following in general the strike of the strata; the largest vein, near the old shaft is 3 1/2 feet wide, and associated with this are three smaller veinlets totalling one foot.

Workings.- The workings consist of two shafts and a long trench. The former are filled with water and the trench is somewhat caved. The creek adjoining the workings gives a good section.

Origin.- E.R.Faribault favors the hypothesis that the ores are of secondary origin, the manganese having been derived from the associated gabbro mass and carried in solution to its present site, where it replaced a calcareous belt within the phyllites.

Mr. Jennison, who has been associated with the company, is of the opinion that this occurrence is of similar origin to that of the Nicteaux-Torbrook iron ores which occur in the same series about 8 miles to the south. These iron ores show a varying amount of manganese (1), the content varying up to 1 per cent MnO_2 and in places running as much as 9 per cent and 21 per cent MnO_2.

BERWICK. The deposit of manganese sometimes mentioned in reports as occurring at Berwick, is evidently that which is found one-half mile south of Morristown (3 miles south of Berwick). In 1910, a manganese vein was reported as occurring here, but outside of the central test pit, nothing further seems to have been done.

Annapolis County

The iron ores of Nicteaux and Torbrook contain a variable manganese content which ranges from a fraction of 1 per cent to 15 to 20 per cent. For a comprehensive report on these occurrences the reader is referred to "The Iron Ores of Nova Scotia" by J.E.Woodman, Dept. Mines Canada, Mines Branch, 1909, pt. 1.

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(1) J.E.Woodman, Iron Ore Deposits of Nova Scotia, Dept. Mines, Mines Branch, 1909.

CHAPTER IV

XII MANGANESE OCCURRENCES IN NEW BRUNSWICK.

Gloucester County

TÊTE À GAUCHE FALLS. About the falls on Tête à Gauche River, 9 miles north and west of Bathurst, manganese minerals occur in the red argillites and slates, probably of Cambrian age. The minerals are dense and finely crystalline pyrolusite along with some psilomelane, and these are found in narrow veinlets one-fourth inch to one-inch in thickness in the slates, or forming thin films along the joints and fracture cleavage faces of the rock. Old reports (1) claim that the veinlets in places attained a width of 8 inches.

This occurrence was the original discovery of manganese within the province of New Brunswick, and considerable work was done. This is now represented by numerous pits on both sides of the river a shaft and a tunnel, all in very had condition.

Westmorland County

UPPER NORTH BRANCH CANAAN RIVER. The Canaan River bog ores were critically examined by the late Dr. W.L.Uglow in 1918, and the following description and map are taken from his report on them (2).

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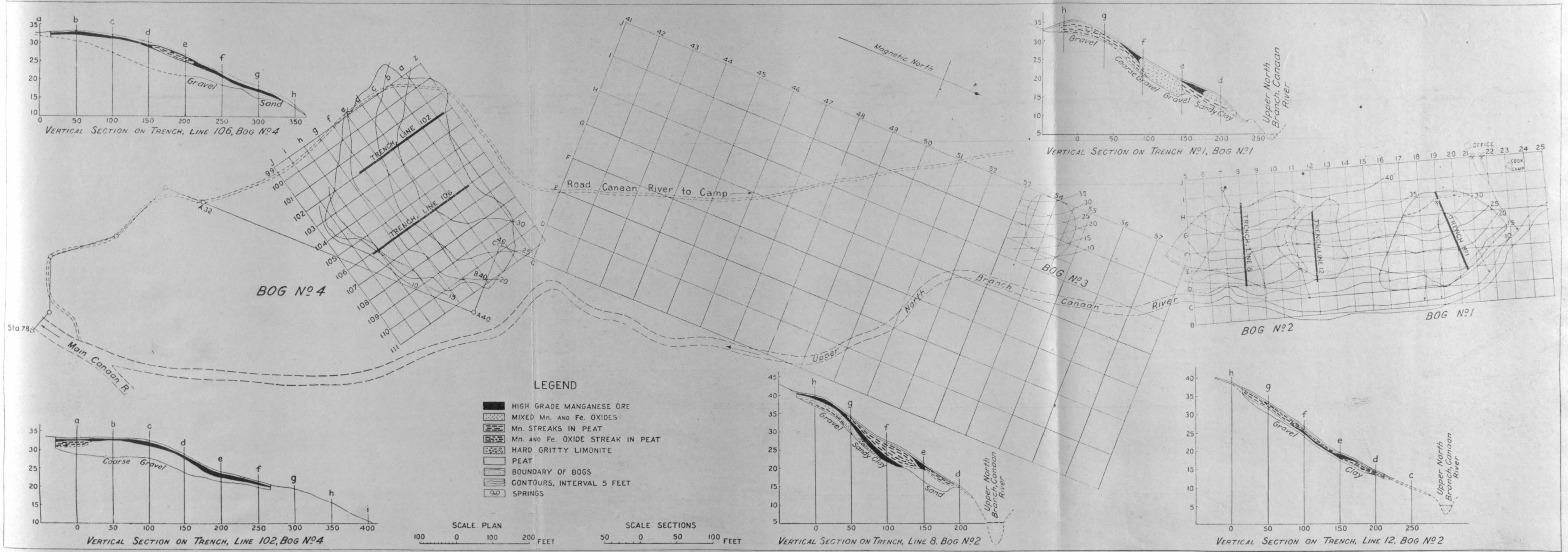
(1) L.W.Bailey, Ann.Rept., Canada Geol.Survey, 1897, pt.M,p.43M.

(2) W.L.Uglow, Munition Resources Commission Canada, Final Report, 1920, p.65.



Plan and sections, Bog Manganese deposits, Upper North branch, Canaan river, New Brunswick.

Fig 18 After W. L. Uglow

Location.- "Deposits of bog ore are located in Westmorland County, New Brunswick, along the main Canaan River and its upper north and middle north branches.

"The present investigation has been confined to the deposits which occur on the west bank of the upper North Branch." The bogs are five in number (Fig. 18) and are about half way between the Intercolonial and the Transcontinental systems of the Canadian Government railways.

Ownership.-Mr. F.E.Jonah, of Moncton, New Brunswick, held the license to search at that time, but the information is not available as to whether his title is still in good standing or not.

Accessibility.- The nearest railway facilities are at Canaan Station on the Intercolonial railway, 4 1/2 miles from the southern end of bog 4. Access is had over a brush road, which is marshy in places but in general has a good hard and sandy clay bottom.

Topography.- "All the ground on which the bogs are located slopes gently toward the river bottom with gradients varying from 5 to 12 1/2 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."

Character of Bogs.- "These manganese bogs are situated on valley slopes below the orifices of a series of 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.......fan-shaped with their narrow ends at the mouths of the springs and their thickest portions directly below the mouths. Laterally, and at the lowest portions, the manganese ore gradually pinches to nothing...."

"The bogs......vary in thickness from less than a foot to upwards of 7 feet...."

"In some of the bogs, as in bog 4, the only manganese dioxide that can be observed occurs in a somewhat hard compact layer immediately beneath the grass and tree roots." The rest of the bog consists of peaty matter varying in constituency from partially rotted logs to completely decomposed fine material. This part carries little or no manganese dioxide.

Tonnage Estimates.- The broken line boundaries (Fig. 18) outline the are of "available tonnage".

Bog Manganese Deposits, Canaan River, N.B.

Ore Summary (1)

	Wet Ore				Dry Ore			
	Tons	Mn%	Fe%	Moisture	Tons	Mn%	Fe	Loss on ignition
Bog #1	5859.5	5.53	2.49	75.68	1425.0	22.70	10.22	39.14
Bog #2A	5485.0	3.42	1.41	81.70	1004.0	18.68	7.70	45.40
Bog#2B	902.0	4.65	0.83	80.40	176.8	23.70	4.23	42.10
Bog #3	1218.0	4.49	0.61	76.55	285.7	19.15	2.59	53.92
Bog #4 (1)	6825.0	5.98	0.39	70.50	2013.0	20.27	1.33	57.41
Totals.	20289.5				4904.5			
Averages		5.01	1.305			20.71	5.40	

Ignited Ore

	Tons	Mn%	Fe%
Bog #1	867.5	37.31	16.79
Bog #2A	548.0	34.20	14.11
Bog #2B	102.4	40.94	7.31
Bog #3	131.7	41.55	5.62
Bog #4 (2)	857.0	47.50	3.12
Totals..	2506.6		
Averages		40.45	10.49

(1) W.L.Uglow, op. cit.

(2) The estimate of available tonnage derived from samples taken from the upper or manganiferous portion of the bog.

Physical Characters Related to Mining.- "The bogs have well-defined, hard compact footwalls from which, in most cases, the material can be readily separated by shovelling."

"The grass and tree roots as a general rule lie upon the manganese layer and not imbedded in it."

"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 of from 5 to 12 1/2 per cent which gives sufficient slope for drainage purposes."

PETITCODIAC. Davis Farm. Location.- There is an occurrence of manganese on the farm of Sam Davis, Hillsgrove, which is about 4 1/2 miles west of Petitcodiac, on the southeast side of Holmes brook.

Geology, Mineralogy, and Occurrence.- The deposit is in Carboniferous strata, represented by brownish limestones and calcareous sandstones and conglomerates which in the shaft strike N. 60° E. (Mag) dip 60 to 70°SE. The ore is found in a set of parallel joints striking N. 40° W. (Mag) dip 45° + NE. It appears that the solutions descended along these joints, and working out from them into the calcareous beds, deposited their manganese content both in the joints and solution cavities formed. The ore is dense and finely crystalline pyrolusite with a little barite and calcite associated with it. Slickensiding in the ore shows that slight movement has occurred since its deposition.

Workings.- The work was confined principally to a surface cut, and a shaft, about 40 feet deep and quite crooked. A small shipment was made from here about 25 years ago.

Kays Farm. Mr. Joseph Kays reports that he has found nodules of manganese ore on his farm 1 1/2 to 2 miles east of Petitcodiac on the Elgin road.

Albert County

DAWSON SETTLEMENT. Location and Accessibility.- The bog ores of Dawson Settlement occur about one-half mile south of the settlement of that name and some 6 to 7 miles northwest of Hillsboro. These bogs are within 1 1/2 miles of the Salisbury and Harvey branch of the Canadian National Railways, and are connected with them by means of a good dirt road 1 1/2 miles in length to Stony Creek crossing. About 1897 a spur track 1 1/2 miles in length ran from the bogs to the railroad but now only the grade is left.

History, Ownership, and Production.- These deposits were first worked about 1887 and at that time the product was dried and shipped direct for the manufacture of ferromanganese. In 1897 the Minerals Products Company erected a briquetting plant and shipped the product to the Preston Charcoal Company, Bridgeville, Nova Scotia, for the manufacture of ferromanganese. After two years of successful operation the plant closed.

At present the ground is held by F.M.Thompson and associates of Hillsboro, who have the "license to search" in this district. In 1922, 1923, 1924 and 1927, Mr. Thompson shipped the bog ore to the National Brick Company of Laprairie, Laprairie, P.Q.; in 1926 small shipments were sent to the National Sales Corporation, Cincinnati, Ohio, and in 1926 and 1927, the St. Lawrence Brick Company, Montreal, P.Q. acquired small amounts. In all, about 1875 tons of the bog ore have been shipped to these companies. The ore is shipped direct without any preliminary treatment.(1)

Topography.- The bogs occur on the south side of Hopper Creek which flows eastward into Wheldon Creek. "The lower(2) extremities of the bogs are in general not more than

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(1) Courtesy of Mr. Bligh, Hillsboro.

(2) W.L.Uglow, Munition Resource Commission, Canada, Final Report, 1920.

20 feet above the level of the creek, and from their bases the bogs extend up the hillside for a horizontal distance of 600 to 800 feet, with gradients of 9 to 17 per cent. This general slope continues above the bogs until the southern slope of Hopper Creek attains a height of 250 feet or more above the creek level".

The northern slope of the creek is cleared and under cultivation but the south slope is still timbered. "The two bogs(1), which are separated by a barren strip of ground about 100 feet wide, are largely cleared of timber, except for small portions near their upper and central boundaries."

Character of the Bogs.- The manganese bogs are situated mostly below the orifices of mineral springs, and assume rough fan-shaped outlines, spreading out from a few feet above the springs. The thickness of the ore varies from 1 foot to 15 feet, being thickest about the orifices of the springs. Laterally and at the lower extremities the ore thins out to nothing.

The bogs are made up of a soft, pulverent, soggy mass of manganese oxides and limonite through which may be seen roots of various types of vegetation, mostly moss and grass. The limonite occurs as irregular beds of varying thickness (1/8 to 2 inches), or as partings, and also as

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(1) W.L.Uglow, op. cit.

coatings along cracks. The manganese oxides in places are confined to relatively pure bands marked off from the rest of the material but for the most part they are distributed throughout the mass.

The bogs are covered by a thin mantle of grass and shrubs, and are underlain by a sticky reddish brown arenaceous clay containing boulders of sandstone. The demarkation of the wad at its upper and lower limits is sharp.

Analyses of Ore.- Analyses made for Dr. W.L.Uglow(1) showed that the ore carried from 60 to 85 per cent moisture, and that the residual dried material consisted of 16 to 70 per cent of peat, the best grade of ore in its natural state rarely contained more than 10 per cent manganese. A table of ore analyses is included:

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(1) W.L.Uglow, op. cit.

Ore Summary

	Crude Wet Ore			Dry Ore			Ignited Ore		
	Tons	Mn%	Fe%	Tons	Mn%	Fe%	Tons	Mn%	Fe%
Bog #1	22,370	6.98	6.74	7677	20.33	19.65	5436	28.71	27.75
Bog #2	20,320	6.96	2.80	5446	25.98	10.44	3408	41.51	16.68
Totals..	42,690			13,123			8844		

Origin.- It is evident that the springs have been responsible for these deposits. Groundwaters percolating through the underlying lower Carboniferous terrain undoubtedly dissolved the manganese content in these rocks, and escaping from the strata at this locality deposited their content of iron and manganese through loss of CO_2 and subsequent oxidiation and by organic agencies producing a precipitation. The spring on the more easterly bog (Bog 1, Spring 1) has caused some slight erosion of the bog near its orifice, which is sintered to a medium hard mass just breakable with the hands, but where cascading over miniature falls limonite is depositing. The western spring on the western bog (Bog 2, Spring 2) is surrounded by spongy mossy ground and the water trickles out from the moss in several places. The water in both springs is very cold. A partial analysis of these waters is given below:(1)

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(1) E.H.Thompson, Analyst, Dept.Mines, Ottawa, 1927.

	Spring #1 (parts per million)	Spring #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 & alumina	trace	trace
Silica	"	"
	114.6	114.6

Through a misunderstanding these samples were not tested for their manganese content.

The following is an analysis (1) of a sample of water from these springs, submitted by Mr. F.M.Thompson, in March, 1928. The change in the sodium and chlorine content is considerable. Unfortunately in the first analyses the radical composition is not given.

"As received, the sample contained a small quantity of flocculent organic matter in suspension which was easily removed by filtration.

"The filtered water was clear and bright and of a pale pink colour.

"Its specific gravity at 15,50°C. was 1001.5 (Pure water being expressed as 1000).

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(1) E.A.Thompson, Analyst.

"One million parts by weight of the filtered water were found to contain:

Potassium - K -	...	none	
Sodium - Na -	...	trace	
Iron as Fe_2O_3	...	3.0	parts
Alumina - Al_2O_3	....	3.0	"
		12.0	"
Manganese - Mn -	...	21.4	"
Calcium - Ca -	...		
Magnesium - Mg -	...	none	
Sulphuric Acid - SO_4	...	33.0	parts
Bicarbonic Acid - HCO_3 -	...	49.9	"
Chlorine - Cl -	...	trace	
Silica - SiO_2 -	...	1.8	parts
		124.1	

Hypothetical combination:-

Manganese sulphate - $MnSO_4$ -	32.9	p.p.m.
Calcium sulphate - $CaSO_4$ -	17.1	"
Calcium bicarbonate - Ca (HCO_3)	266.4	"
Ferric oxide - Fe_2O_3	3.	"
Alumina - Al_2O_3 -	3.	"
Silica - SiO_2 -	1.8	"
Sodium Chloride - NaCl -	trace	
	124.2	

In view of outside reading regarding the transportation of manganese in natural waters, the writer is inclined to recalculate the hypothetical combination of the second analysis as:

Calcium sulphate $CaSO_4$	46.77
Calcium bicarbonate $Ca(HCO_3)_2$	30;88
Manganese " $Mn(HCO_3)_2$	38.80
Ferric oxide Fe_2O_3	3.00
Alumina Al_2O_3	3.00
Silica SiO_2	1.80
Sodium chloride NaCl	trace
	124.25

However, since in dilute solutions the salts are considered to be ionized, it is probable that the calcium and manganese exist both as the bicarbonate and sulphate in the ratio of their solubility product constants.

Workings.- The old workings consisted of a series of long trenches running approximately N-S, which served to drain the bogs, and large open cut in Bog 1. At one time a mill and briquetting plant were on the property, but there is now only the foundation of the old plant and one dilapidated barn.

The present workings consist of a large open pit near the eastern edge of Bog 1, and from this considerable material has been removed since 1922.

SHEPODY MOUNTAIN. Location.- The Shepody Mountain occurrence, known in the early days as the Hopewell Manganese Mines, is about 3 miles out on the "Chemical road" from Hopewell Hill. The workings are along the bottom of a small creek that flows by the road.

History and Ownership.- Mr. Steadman(1), of Hopewell, first worked this occurrence in 1860, and during this work an adit some 500 feet in length was driven into the limestone strata and from this about 500 tons of very good ore were was obtained.

Apparently there was nothing further done until 1926, when Mr. J.C.Wright, in partnership with B.J.Fales, took out the right of search in this locality. They have done a little surface work, and started a shaft in the limestone bed.

Geology.- The lower part of Shepody Mountain is composed of chloritic schists while the upper portion is made up of Lower Carboniferous conglomerates, sandstones, shales and limestones. In the vicinity of the mine it appears that the chloritic schists are overlain by a thinly laminated limestone and this in turn is separated from the overlying conglomerate, containing pebbles of granite schists and sedimentary rocks, by a thin irregular bed of reddish clay. The sediments appeared to be dipping about 45° into the hill.

Occurrence and Mineralogy.- The manganese is present chiefly as pyrolusite which is both dense and finely crystalline. Manganite is sparingly present as small residual remnants in the pyrolusite.

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(1) L.W.Bailey, op. cit.

Dr. Bailey (1) states that the ore occurred both in veins and beds within the limestone. In discussing the occurrence of the ore with Mr. Fales, who worked in the mine in its early days, he stated that the ore occurred as nodules in a red to greyish sticky clay which was found between the limestone and the higher conglomerate and this clay was rather sharply marked off from both these rocks. While admitting that a little ore was occasionally found in the limestone in streaks he said it was never mined. Only the circular to elliptical clay pockets were mined, and these thinned towards the edges and were irregularly spaced but were connected one with the other by thin seams of clay which sometimes had a little manganese in it. At times within the lenses of clay large masses of ore would be found, which resembled somewhat "the trunk of a tree 10 feet or more in length and roughly elliptical with a very uneven surface."

The red clay that Mr. Fales mentioned can be seen in the new shaft they have started and in this there are nodular masses of ore.

An examination of the specimens collected shows two types of occurrence. One of these is in a finely laminated limestone, the alternate laminae of which show various degrees

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(1) L.W.Bailey, op. cit.

of replacement of pyrolusite. The other type of occurrence is that in which the oxides are found in more or less rounded nodular masses, which upon being broken, show a very vesiscular structure and drusy characteristics. On breaking a botryoidal prominence it may be observed that the drusy surface is implanted upon a shell of finely interlocking grains of pyrolusite. Within this outer shell there may be nothing but a small amount of pulverent material or again there may exist a core, in general slightly separated from the outer shell, and made up of a porous crumbling mass of fine pyrolusite as if the original core had been removed and the pyrolusite preserved the skeletal framework. Remnants of lime may be observed here and there and this frequently exhibits a cellular structure and in places the walls of these cells have been replaced by the manganese oxide and in places incrustations have formed on them.

Origin.- From the description furnished by Mr.Fales it seems possible that this deposit might represent a concentration on an old Carboniferous land surface on which sink holes were developed and in these residual clays collected along with manganese ore set free by the weathering away of the containing limestone. The subsequent deposition of the overlying conglomerate dated the age of formation of the occurrence and preserved it. It might be mentioned, in passing that the chloritic schists immediately below the limestone gave quite strong manganese tests and in these the source of the manganese may be sought.

If the foregoing presentation of facts is sufficient to warrant the conclusion that this deposit represents a residual deposit formed in Carboniferous time, then it and the Memel mine are the only ones visited in the Maritime Provinces that furnish any direct evidence for their time of concentration. Many others occur in Lower Carboniferous strata but in none of the localities are there younger strata overlying the deposits in such a way as to date the formation of the manganese deposits prior to their deposition.

Workings.- The earlier workings are in complete destruction. The new work was started higher up the creek and consisted of a trench and the starting of a small shaft. From these workings about 1 1/2 tons of very good ore was obtained and this was laying on the dump. It was in nodular form, the nodules varying in size up to 5 to 8 inches in diameter.

MEMEL MINE. The Memel Mine is on the west side of Saw Mill Creek, about 1 1/2 miles from the Hopewell Hill postoffice. The rock is a reddish conglomerate of Carboniferous age (Millstone grit ?) dipping NW and is very similar to that at the Shepody Mountain occurrence. Good needle ore is said to have been obtained from here; it occurred as pebbles within the conglomerate.

The old workings as seen at the time of examination (1927) consisted of a series of open cuts and two tunnels hardly more than started. The manganese oxides observed were chiefly psilomelane with some fine pyrolusite associated with it. These occurred as pebbles within the conglomerate and appeared to have been incorporated into it in the same manner as the rest of the material.

WATERSIDE, SALISBURY BAY. On the property of Harris Copp, Waterside there are a number of pits and a tunnel representing a deposit of manganese, which in 1870, or thereabouts, is claimed to have produced considerable ore. At present the workings are entirely caved, and all that can be seen on the dumps are narrow stringers of psilomelane cutting a reddish sandstone, presumably of Lower Carboniferous age.

GOWLAND MOUNTAIN. Location.- The manganese occurrence at Gowland Mountain is on the farm of Seward Harrison about four miles east of Elgin. The earliest work reported at the locality was done about 30 years ago and several tons of good ore were shipped. Some ten years ago F.M.Thompson of Hillsboro did some work on this occurence.

Geology, Mineralogy, and Occurrence.- The ore is found as stringers and small bunches in a buff colored medium-grained granite. It exhibits colloform banding, which on a polished section is emphasized, and it is seen that the original mineral has been transformed into crystalline aggregates and clusters. This crystallization has been in places more or less regular and perpendicular to the original banding but quite commonly there is an aggregate of grains in heterogeneous orientation within the original bands. The original mineral was not determined definitely and for want of a better name it is called "psilomelane". The recrystallization has resulted in braunite, and possibly manganite and pyrolusite. These latter two minerals are present as alterations of the braunite. Limonite is associated with the ore in varying amounts.

Origin.- The source of the manganese is not known. The deposition appears to have taken place in open cracks in the granite forming original non-crystalline colloform masses, which later crystallized to the present minerals, which have retained the original structure in part.

Kings County

JORDAN MOUNTAIN. Location.- This deposit is on the southern slope of Jordan Mountain about 7 1/2 to 8 miles north of Sussex, which is on the Canadian National Railway. The property was reached by taking the South Creek road from Sussex to Newtown, and then at about 8 1/2 miles turning west on the Jordan Mountain road and proceeding to the farm of Mr. J. Tait.

Topography.- Jordan Mountain is a rounded, well-timbered hill, some 700 feet in elevation, that extends along the western side of Smith Creek. The topography is rounded and smooth with few outcrops. The occurrence is found near the southeastern part of Mr. Tait's farm at the head of a small brook flowing generally N. 70° E. (Mag).

History, and Ownership.- According to L.W.Bailey (1) this deposit was first mined in 1882, although reference is made of this occurrence in 1878 by L.W.Bailey, G.F.Mathews, and R.W.Ells (2). "From the available records of production it would appear that the Jordan Mountain mine shipped between 400 and 500 tons of high grade ore between the years 1889 and 1900, although it is said that several thousand tons were extracted" (3). The surface rights are said to be held by Mrs. B. E. Kingman, of New York, but the license to search in this area was taken out and is held now by L.E.Tait and William A. Simonds of St. John, N.B.

Geology.- The ground in the vicinity of the working is well timbered and covered with soil so that outcrops are few. The tunnel (Fig. 19) has been driven in a hard reddish brown argillite fractures, in which are filled with small veinlets of calcite. No definite strike or dip could be obtained.

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(1) Op. cit.

(2) Geol.Survey Canada 1878-1879, p. 24D.

(3) T.C.Denis, Summ.Rept., Mines Bureau, 1900, p.60.

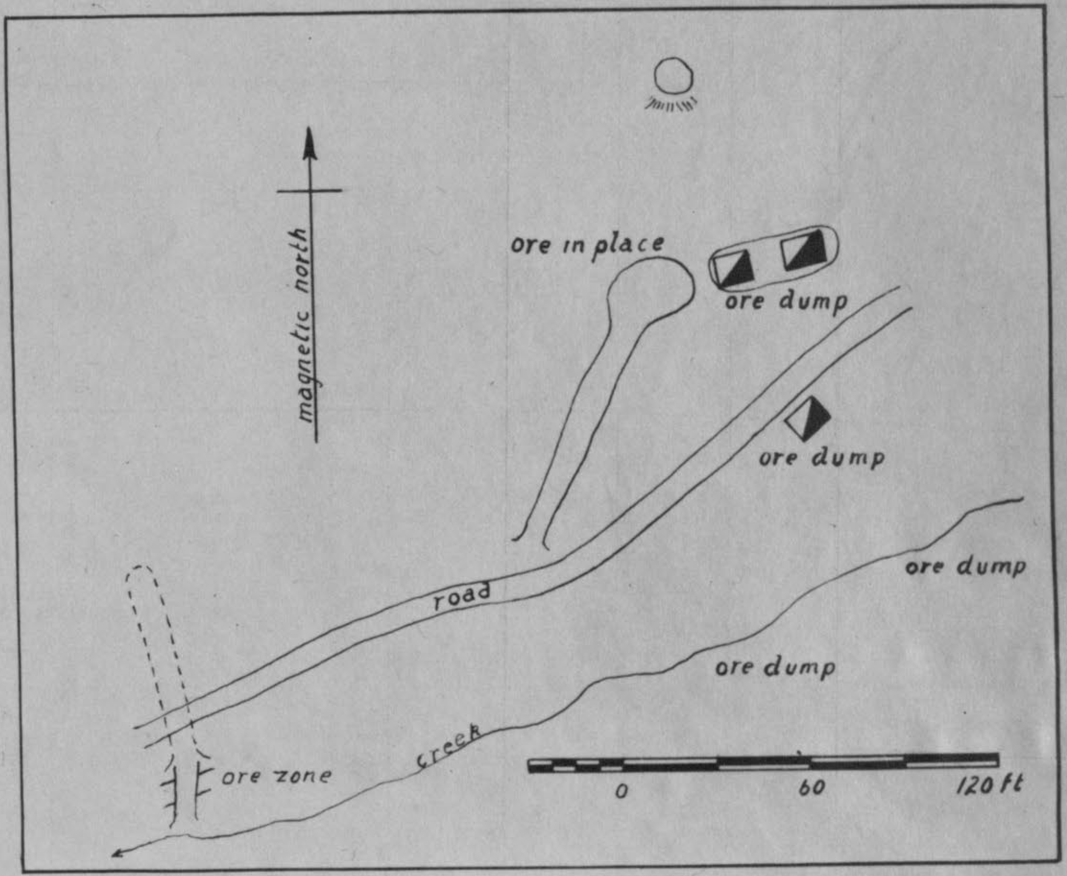

Fig 19 Jordan Mountain

The dumps about the workings showed a breccia composed of sharp angular fragments of a reddish to grey, highly metamorphosed rock. Some of the fragments of this are composed of an exceedingly fine quartzite, and others have a schistosity due to the development of a micaceous material (sericite?).

The cement of this breccia as seen on the dump is mostly manganese oxides; where these are absent the rhomboidal fragments appear to be embedded in a gritty matrix of material quite similar to themselves.

The relation of these two rocks could not be obtained, but the breccia might well have been formed from the argillite previously mentioned.

Mineralogy and Occurrence.- The ore, laying about the dumps, is taken as representative of the mineralogy and occurrence. This shows the ore to be a mixture of psilomelane (?), manganite, pyrolusite and hausmannite in a dense fine-grained mass. Of these minerals manganite is dominant, and is usually found as minute interlocking grains, although occasionally small clusters of acicular crystals are found. Pyrolusite has a similar habit. Hausmannite occurs as small isolated grains here and there through the ore mass. Barite was the only gangue mineral noted at the time of examination, but others may occur.

The ore minerals in places form narrow veinlets cutting the argillites but they occur principally as a cement to an argillite breccia. In thin section a replacement of the rock minerals is also evident. The proportion of rock to ore varies over wide limits from place to place but in the better ore there is 50 per cent and over of manganese oxides.

Very little information as to the extent of the ore could be obtained but from the distribution of pits, shafts, etc., it would appear as though the ore followed a zone near the surface of the argillites and varied in width and thickness. At the mouth of the tunnel it was observed that the ore occurred in a zone some four feet wide and was more plentiful near the top than at the bottom of the cut.

The following quotation from L.W.Bailey's (1) report is perhaps the most authentic description of the occurrence as it was made during the operation of the mine. "The mine, so-called, is merely a trench, which at the time of examination, several years ago (written 1898) was found to be about 70 feet in length with a depth of from 10 to 12 feet. The sides of this trench show shaly conglomerates......while 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." "In approaching the ends of the cutting the ore was found to thin out rapidly and to alternate with the conglomerates, but the trench had not been opened sufficiently far to enable one to form a very accurate idea either as to its extent or character."

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(1) Op. cit., p.50M.

Workings, and Analyses of Ore.- The main workings are shown on the accompanying map (Fig. 19). Apparently most of the ore was obtained from the trench and three main shafts. The dumps about these still contain a considerable amount of ore-bearing rock scattered about them (probably 100 tons all told). Analyses of the ore quoted by L.W.Bailey are as follows:

	1	2	3
Manganese	54.57	52.88	57.37
Manganese dioxide	86.08		
Iron oxide	0.87		
Iron		1.18	
Silica	2,86	9.70	0.23
Sulphur			0.61
Phosphorus		0.014	0.015

(1) Professor P. B. Wilson, Baltimore, Md., analyst.

(2) Dr. Otto Wirth, Pittsburgh, Pa., analyst.

(3) Pennsylvania Steel Company.

GLEBE MINE. Location.- The Glebe mine is found on the farm of Mr. S. Boyles, some 8 miles southeast of Sussex, on the Canadian National Railroad. Access to the occurrence is had over the Sussex-Waterford road for 6 miles and thence south along the Parlie Creek road for one mile. From here a branch road is followed for about two miles, which is steep and in places poor.

History.- Local reports say that work on this place stopped about 45 years ago but prior to that it had been worked intermittently for 15 years. The production was very small in comparison to the amount of work done, not more than 40 tons being recovered.

Geology, Mineralogy, and Occurrence.- The rocks are nearly flat lying Carboniferous limestones and conglomerates overlying older presumably pre-Cambrian rocks. The Paleozoic limestone shows slight rolls and is much jointed. The ore is found as nests and veinlets sparingly scattered through a fluted, massive to thin-bedded grayish weathering limestone that overlies a hard flinty conglomerate. The ore minerals are dense and finely crystalline manganite and pyrolusite.

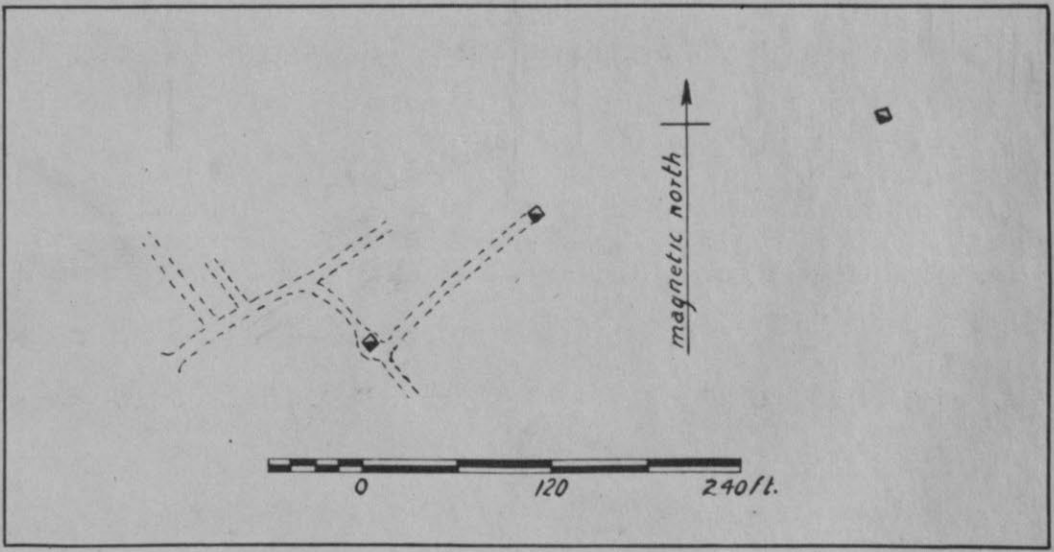

Fig 20 Sketch map of Glebe Mine

Workings.- The workings consist of a number of shafts and an adit shown in Fig. 20. Access may be had to the adit, but it has caved considerably in places. Surprisingly little ore is seen in these workings. The tunnel follows along the contact of the limestone and underlying conglomerate, and the shafts stop at the conglomerate bed.

MARKHAMVILLE. Location.- The Markhamville mines are situated near the head of Hammond River about 10 miles south of Sussex. The workings are on the farm of Charles D. Illsley of Markhamville.

Topography.- The country at the mine is hilly, and the workings are found along and near the bottom of the south-eastern side of the Hammon River valley. A great deal of the surrounding country is under cultivation.

History and Ownership and Development.- (1) "The earliest discoveries of manganese in this vicinity are said to have been made by Mr. T. F. Mathew, the property being subsequently leased by Mr. William Davidson, of St. John. The first systematic operations for the extraction of ore were, however, undertaken by Col. A. Markhamville about the year 1864 and to his energy and perseverance is to be credited the large development which they subsequently underwent.

"The deposits first removed were superficial ones, consisting of ore enclosed.....in pockets in beds of clay...

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(1) L.W.Bailey, op. cit. p.44M.

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 of the ore was found to be most irregular....."

Due to the irregular development of ore, activities ceased about 1895. During the active life of the mine from 1864-1894, the production varied from 500 to 1500 tons per year, with a total output of over 23,000 tons.

In 1926, J. S. Gibbon took out the license to search in this district and it was still in good standing in August, 1927.

Geology.- The rocks are Carboniferous limestones and conglomerate overlying a pre-Cambrian basement complex. "The ore-bearing limestone is generally of a gray color, but at times is pink or buff and is associated with shaly strata. It contains veins of crystalline calcite, in which masses of pyrolusite are frequently found...."(1). The thickness of the limestone varies up to 55 feet or more. The strata have been considerably distorted but at the mine the general strike is NE-SW and dipping NW. Surface decomposition has produced a residual clay and underground circulation has developed a series of underground caverns and passages.

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(1) R.A.F.Penrose, Ann.Rept., Arkansas Geol.Survey, 1890.

Occurrence.- While masses of pyrolusite are found in veinlets of calcite, "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.....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 generally are smaller than the others and are probably due to a secondary chemical action by which they have been derived from the bedded ores."(1)

"The residual clay formed by surface weathering frequently contains deposits of ore derived by the weathering away of the limestone originally containing them. Such deposits are rarely more than from 8 to 20 feet in thickness but the ore in them is cheaply worked and they have supplied a large part of the output of the Markhamville mine"(2).

Where the underground water channels intersected bodies of ore, the floor of the cavern was found to be covered with loose fragments of ore. Kidney-shaped masses of glossy black limonite were frequently found with the cave deposits.

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(1) R.A.F.Penrose, op. cit.

(2) idem.

Mineralogy.- The minerals noted during the examination of the property and of specimens collected were (psilomelane?), pyrolusite, manganite, hausmannite and braunite associated with limonite, hematite, calcite and barite. The braunite occurs as dense finely crystalline nodular or veinlike masses, or irregular replacements in the limestone. The latter mode of occurrence frequently shows a colloform structure; the small pyramidal crystals in the various bands are arranged in random orientation. The manganite and pyrolusite are in veins and nodular masses within the limestone. The specimen of hausmannite collected showed a similar occurrence. Pyrolusite appears to be an alteration product of these minerals.

The limonite and hematite may occur by themselves, or the former is sometimes found intermixed to a small extent with some of the ore, and in such instances may be scattered through the ore, or form a thin layer between the manganese oxides and the limestone.

Origin.- It is suggested that the Markhamville deposit has been formed from meteoric waters depositing their manganese content in solution cavities and by replacement in the limestone, forming the lenticular and bedded masses of psilomelane, braunite, pyrolusite and manganite, and associated hausmannite. Subsequent changes within the ore resulted in the change of psilomelane to, perhaps braunite, pyrolusite and manganite, and also various isomorphous readjustments between pyrolusite and manganite.

Workings and Analyses.- The workings of the Markhamville deposit consist of a large number of open pits now caved and grown in and many underground drifts which in part are accessible. Very little ore is to be seen in place now.

Old reports (1) give as analyses of ore shipped from here the following data:

	1	2	3
Manganese binoxide	98.70		
Manganese peroxide		97.25	96.62
Silica	0.55		
Iron	0.75		
Iron Peroxide		0.85	0.78
Barium	trace		
Baryta and Silica		0.95	0.85
Water		trace	trace
Loss		0.95	1.75

The ores were treated in a well equipped mill.

HILLSDALE. Enquiry at Hillsdale regarding any manganese occurrence in the vicinity furnished the information that about 25 years ago chunks of manganese weighing 10 to 15 pounds were found in "Gold mine Gulch", but the source of these were never ascertained.

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(1) E.D.Ingall, Report of Progress, Canada Geological Survey, 1890-1891, p.94S.

St. Johns County

QUACO HEAD. Location.- The manganese deposit occurs in the sea cliffs, which form the southeastern extremity of Quaco Head, a long promentory jutting out into the Bay of Fundy and forming the southern shore of Quaco Harbour. A branch line of the Canadian National Railways connects St. Martins with Hampton on the St. John-Moncton line of the Canadian National Railway. The occurrence is about two miles due south of St. Martins.

Topography.- Quaco Head is terminated by cliffs which in places attain a height of 100 feet or more. At high tide the base of these cliffs is covered by the sea, but at low water one may walk along the shingle beach from the village of Quaco to the lighthouse on Quaco Head. This gives an excellent vertical section of the rocks. The land above the cliffs is gently rolling agricultural land a large part of which has been allowed to return to second growth timber.

History and Production.- The early work in this locality started some 40 to 50 years ago, and continued at intervals. Up to 1889, it is said that several hundred tons of ore had been removed. At this time the Brunswick Manganese Company took over the ground and erected a mill with crusher rolls, jigs and screens, etc., but no data of production by this company could be obtained. About 10 years ago work was again started but nothing came of it.

Geology.- The early reports by Penrose, Bailey, and others interpreted the geology as a Carboniferous series of limestone, shale and conglomerate, intruded by a mass of igneous material (diabase) which caused severe distortion of the overlying rocks. Unconformably overlying the Carboniferous are the brownish, poorly cemented Triassic conglomerate and sandstone.

The late Dr. W.L.Uglow has depicted in his notes, made during his examination of this occurrence in 1925, the same general relation of the Triassic and Carboniferous series, but does not agree with the earlier authors in regard to the "igneous intrusion". This mass of rock he considers to be either a very siliceous series of argillites or else a felsitic breccia.

The present writer agrees with Dr. Uglow that the mass of rock formerly considered an igneous intrusion is not such, and favors the view that this mass of rock represents a series which is older than the Carboniferous limestones, and that it is probably of volcanic origin.

A generalized NW-SE section as seen along the cliff face is given below (Fig. 21).

Fig. 21

1. Volcanic breccia

2 Light grey to pink limestone

3 Sheared zone

4 Massive conglomerate

5 Triassic sediments.

Carboniferous

(1) Volcanic series

This is a dark mass of rock varying in color from black through various dark shades of green to red. It is not uniform in character or composition; in places it is apparently massive and of a homogeneous composition and in others a fragmental nature is clearly seen. The whole has been badly crushed and sheared and the joints are covered with a thin veneer of hematite.

(2) Limestone

This is a band of light grey to pink limestone that weathers almost white. In places it shows a brecciated character, and in others it is thinly laminated.

The contact between 1 and 2 varies in its characteristics from a sharp, well-defined line to a brecciated zone up to two feet in width in which there is a rude transition from one rock to the other. In this breccia zone one passes from a matrix of limestone through which a few sharp angular fragments of volcanics are found into a zone in which the lime and igneous material are of about equal amounts, and finally, into a zone in which only a few fragments of lime are found. In places where the contact is sharp, the limestone frequently shows shearing parallel to the contact, or again there may be very sharp step-like breaks, at each of which the rocks have been faulted into each other. The original relation of these two rocks at their contact has been so obscured and modified by diastrophic movements that it is not possible to state definitely their original attitude to one another.

(3) Sheared zone

The sheared zone contains (a) a brown to brick red shaly limestone; (b) a conglomerate containing pebbles of quartzite, volcanic porphyry, schists, limestone, limestone partly replaced by manganese, and manganese oxides set in a limestone matrix which may in places compose the largest proportion in this rock; (c) a red shale member; and (d) a brown limestone showing gritty characteristics in places.

These members have been mentioned in the order of what may have been their original sequence, but faulting has cut this section so badly that it is hardly possible to say just what was the original relation of these rocks to one another.

(4) Conglomerate

This is a very thick massive series of conglomerate with grits and sandy strata here and there. The general color assumes a reddish tone due to the number of pebbles of red granite contained in it; these are cemented by a greenish to grey grit.

The whole series of rocks from 1 to 4 inclusive has been badly fractured and disturbed by faulting. The displacements do not appear to be large but the oscillatory movements have caused severe fracturing and a general mixing up of the various members, particularly in member (3).

(5) Triassic

The Triassic consists of a series of brownish conglomerates and sandstones unconformably overlying the Carboniferous rocks.

Mineralogy.- The minerals noted during the examination were psilomelane, pyrolusite and manganite in association with barite and calcite. The pyrolusite and manganite occur either as interlocking crystalline grains or as small acicular crystals lining vugs within the ore.

Occurrence.- The manganese minerals occur mostly in the "sheared zone", and within this appear to be most plentiful is the shale member (c), which has been so badly sheared that it now forms a crumbling mass of rhomboidal fragments. In this member the ore is found in isolated fragments varying in size from that of a pear to lens-shaped masses one foot to two feet in largest diameter. The ore is mostly "hard" ore - psilomelane and some manganite - and the larger pieces show the same rhomboidal cleavage as the containing rock. Some fragments of limestone may be seen and these show various stages of replacement by manganese minerals.

Some fragments of manganese oxides were observed in the conglomerate member (b) and nodules of ore were seen in the brown limestone (a). Veinlets of calcite and irregular lenses of ore were observed in the lowest member (a) of the "sheared zone" (3).

The white, thinly laminated limestone (1) contains thin irregular veinlets of manganese oxides, and the joints in this rock are frequently healed by manganese minerals. It was observed in places that the white limestone showed brecciation with white fragments and brown cement and from this the amount of brownish material increased until finally the rock passed into a brown limestone. This suggests that the color varieties of the limestones may not be wholly due to conditions of original deposition but to varying degrees of alteration by later surface solutions.

Origin.- It is believed that originally descending surface solutions deposited their manganese content along joint planes, and as irregular lenses and nodules here and there throughout the limestone and shaly limestone members. Subsequent faulting broke up the normal rock sequence, mixing the various members together and in so doing included the contained manganese masses, forming the deposit as it is now.

OTHER LOCALITIES IN NEW BRUNSWICK. Other localities in New Brunswick at which manganese is said to occur are, Richibucto (Kent Co.); Bull Moose Hill (Kings Co.); Queensbury (York Co.); Moores Mills (Charlotte Co.); and in the vicinity of Woodstock (Carleton County)(1). These are deposits of bog manganese. A deposit of bog ore, of very good quality (58.85 per cent Mn) is reported by W.E.McMullen, Inspector of Mines, Fredericton, New Brunswick, as occurring in the vicinity of Fredericton.

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(1) L.W.Bailey, op. cit., p.57M.

CHAPTER V

XIII MINERALOGY

This chapter on Mineralogy is devoted mainly to the microchemical and X-ray spectrographic examination of several of the more common manganese oxide minerals. At the end a short review of the mineralogy occurrence and economic aspects of the occurrences in the Maritime Provinces is given. There is also a brief summary of a number of hausmannite occurrences.

MICROCHEMICAL ANALYSIS. The minerals that were examined critically included manganite, pyrolusite, hausmannite, braunite, and bementite; psilomelane and wad were also investigated, but due to the nature of these minerals the results may be ambiguous if compared with those obtained from specimens selected from other localities.

In determining the microchemical reactions the reagents used by Thiel(1) were employed. The ones found to be most applicable were:

(1) Hydrochloric acid (HCl) N/6 and concentrated.
(2) Sulphuric acid (H_2SO_4) concentrated.
(3) Hydrogen peroxide (H_2O_2) 30 per cent. Ordinary commercial H_2O_2 gave no reactions except with pyrolusite.
(4) Stannous chloride ($SnCl_2$) dilute and concentrated.
(5) Ferrous chloride ($FeCl_2$) concentrated.

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(1) G.A.Thiel, The manganese minerals: their identification and paragenesis, Econ.Geology, 19, 1924, pp.107-145.

Type specimens, well crystallized, of the different minerals were chosen from the Museum Collection. These were carefully polished, and then the reactions on them, due to the above named reagents, were noted, and these results were used as a basis for the examination of the ores collected by the writer during his field work.

In polishing, the best results were obtained by first grinding the specimens until they were ready for finishing with fine optical alundum, followed by chromium oxide, or rouge. At this stage the specimens were impregnated with bakelite and then dried thoroughly. After this the final fine grinding and polishing were completed. A well polished surface is necessary to obtain uniform results; if the surface is poorly polished with scratches and pits prominent anomolous results will be obtained even with the same specimen.

In checking through the ores collected in the field it was observed that where two oxides were intimately associated, or finely intergrown with one another - usually pyrolusite forming as an alteration product - the microchemical tests became somewhat unsatisfactory and tended to assume the characteristics of the more active (towards reagents used) mineral provided this was present in fair amount. This discrepancy is most pronounced with an intergrowth of manganite and pyrolusite. However, where the minerals are well-crystallized and are not intimately intergrown - as can easily be determined by the color contrast on a well polished surface - the microchemical tests, so far as could be determined, appeared to give reliable results.

Manganite.- The specimen chosen as typical of manganite came from Ilefeld, Harz, Germany. This specimen consists of numerous prismatic crystals, up to one centimeter in length, and 2 to 3 millimeters in cross section, set upon a mass of small interlocking, prismatic and platy crystals. The prismatic faces of the crystals are well striated, parallel to the elongation. The basal pinacoids exhibit series of fine striations parallel to the longer diameter (b axis crystallographic) suggestive of multiple twinning but etching failed to develop any such structure. Examination under the reflecting microscope showed that the basal pinacoid of any one of these large crystals is not a homogeneous surface; instead many minute diamond-shaped outlines could be distinguished. This suggested that the large crystals are not single individuals but rather composite masses of many small acicular crystals in parallel growth. Laue photographs of the specimen bear this out.

The chemical analysis(1) of the specimen is:

		Corrected	Recalculated(2)
Fe2O3	.15	.150	
MnO	80.50	80.575	80.694
O	9.06	9.068	9.082
H_2O	10.20	10.207	10.224
	99.91	100.000	100.000

The results of the microchemical tests are given below:

Color - steel grey.

Hardness - medium.

Streak - brown. Shades of brown by transmitted light.

HCl (dil.) - drop slowly turns pale green. Prolonged reaction may produce a very slightly darker shade of gray after washing specimen.

HCl (conc.) - drop turns green and as reaction proceeds assumes a yellow to brown cast. This color change takes place first along grain boundaries, scratches, and cracks. Washes to a surface on which the scratches are slightly emphasized, and that is a slightly darker shade of grey than the original.

H_2SO_4 (conc.) - negative.

H_2O_2 -30 per cent very slight efforvescence. Surface washes to a slightly darker grey.

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(1) F.A.Gonyer, Washington, D.C., analyst.

(2) Considering Fe_2O_3 as impurity of hematite. Theoretical percentage of MnO in manganite = 80.668.

$SnCl_2$ (dil.) - on face 1.00. Slowly etches under drop to a darker surface. Washes to a dark dirty grey surface which shows the development of scratches. On face 010. Slow etching under drop. Washes to a surface showing scratches emphasized but only slightly darker than original. Drop appears to have eaten into mineral without destroying polish. On face 001. Similar to 100 but less pronounced. 100 darkens very quickly and washes to a very dark grey surface. If action is not allowed to go too far it will be seen that areas between scratches retain their polish. The dark shade of grey due to innumerable exceedingly fine scratches that are developed along with the coarse scratches. This holds for other sections too.

$SnCl_2$ (conc.) 010. drop eats into crystal with little or no etching. Surface retains polish and is only slightly darker than original. Effect more pronounced than with dil. $SnCl_2$.

001. similar to 100. Cracks and scratches develop. Cracks suggest the cleavage 010 but this is not definite.

$FeCl_2$ Same as $SnCl_2$ but less pronounced.

In the ores examined the above effects were slightly more pronounced. The hardness varied from medium to hard and the streak from yellowish brown to dark brown.

Thiel's results were: "Color greyish white, $SnCl_2$. a few seconds after application the needle-like grains of mineral are brought out. Extended action produces a dark surface deeply etched with an irregular patter. H_2SO_4 fumes tarnish slightly. Rubs to a brown surface. H_2O_2 (commercial) slight efforvescense if allowed to act a minute or more. Tarnishes to a darker grey, especially with H_2O_2 + H_2SO_4 . $AuCl_3$ neg."

Pyrolusite.- Type specimen from New Brunswick; locality not listed. This is soft well-crystallized ore with the pyrolusite in platy crystals. Analysis (1) of the pyrolusite gave:

		Corrected
SiO_2	.88	.879
Fe_2O_3	.64	.639
Al_2O_3	.08	.08
CaO	2.40	2.397
MgO	.60	.599
MnO	77.94	77.831
- O	16.40	16.377
H_2O	1.20	1.198
	100.14	100.000

Microchemical tests gave:

Polished surface showed an aggregate of needle-like crystals and platy forms showing marked cleavage (or parting) parallel to sides. Needles showed cleavage (or parting) normal to and at angles to long axis.

Color - cream white.

Hardness - quite soft.

Streak - black. Opaque to transmitted light.

HCl (dil.) - drop slowly turns green to greenish brown and gradually darkens in brown shade. Washes clean. No etching.

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(1) F.A.Gonyer, op. cit.

HCl (conc.) - immediately turns greenish brown and then darkens to brown rather quickly. Washes clean with slight development of scratches and slight darkening of surface.

H_2SO_4 (conc.) - apparently no effect. After some time a very slight effect may take place. No etching. Washes clean. No darkening.

H_2O_2- 30 per cent. Violent efforvescence. After reaction has proceeded for some time specimen washes clean and shows a slightly darkened surface under drop.

$SnCl_2$ (dil.) - very slowly etches and brings out scratches and grain boundaries. Washes to a brown surface under drop.

$SnCl_2$ (conc.) - immediately etches black. Produces excessive etching, Washes and rubs to black deeply etched surface.

$FeCl_2$ - similar to $SnCl_2$ but less pronounced.

The hardness of the pyrolusite in the ores varied considerably from soft to medium and in one or two instances to hard. Whether the hard varieties corresponded to polianite is not known as chemical analysis was not possible.

In the ores, especially the fine-grained soft varieties, the reactions corresponded or became slightly emphasized, but in the harder ores the reactions were modified and approached those of manganite. However, H_2O_2 and $SnCl_2$ (conc.) always produced decided reactions.

Associated with some of the pyrolusite there was a mineral that, on polished surface, was slightly harder than the pyrolusite and polished to a white surface. The microchemical reactions of this mineral were exactly the same as those of pyrolusite.

Thiel's results were: "Color brownish white. $SnCl_2$ fumes tarnish brown. Solution becomes dark. Rubs to a deeply etched pitted black surface. H_2O_2 efforvesces profusely. $H_2O_2 + H_2SO_4$ efforvesces with etching. $AuCl_3$ plates in 48 hours. Specimens with a hardness of 3 are partially covered with minute grains of gold on polished surface."

Hausmannite.- The specimen used as typical of this mineral came from the occurrence on McVicar's farm, Cape Breton Island. It is a crystalline massive ore with which is associated calcite and rhodochrosite. Where the carbonate has been leached away, small simple and twinned tetragonal pyramids are exposed.

The mineral polishes to a smooth surface. Under the microscope the majority of grains are smooth, but a considerable number show various shades of grey and close examination reveals this to be due to innumerable fine flaws on the surface. The regularity of arrangement of these pits suggest either an intimate intergrowth of two minerals, or a fine chipping of the surface along a crystal direction during the polishing. This latter hypothesis is favored by the writer.

The results of observations on the above specimen were checked against hausmannite from Långban, Sweden, and were found to coincide. The same variation in color from white to various shades of grey are to be noted in the Långban ore and these variations are associated with those grains that exhibit twinning.

Analysis (1) of the specimen from Cape Breton gave:

		Corrected	Recalculated (2)
Fe_2O_3	.04	.04	
MnO	92.72	92.925	93.055
O	6.92	6.935	6.945
H_2O	.10	.100	
	99.78	100.000	100.000

The best analyses (3) listed from different occurrences are given in the following table. Other analyses given show the MnO content to range from 83.4 per cent to 86.5 per cent.

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(1) F.A.Gonyer, op. cit.

(2) Fe_2O_3 + H_2O impurities as limonite and water. Theoretical amount of MnO in hausmannite = 93.015 per cent.

(3) C.Doelter, Handbuch der Mineralchemie, 1926.

	a	b	c	d	e
Alkaline			0.45		
O	7.10	6.95	6.54	7.78	8.87
MgO		0.41	0.30	trace	
CaO		0.14	0.44	trace	
MnO	92.48	92.12	87.34	91.38	90.40
ZnO			0.70		
BaO	0.14	0.13	0.07	0.26	
PbO			-		
Fe_2O_3			3.47		
CO_2			0.19		
SO_3			-		
P_2O_5			-		
H_2O		0.34	-	0.62	1.03
SiO_2	0.17				0.10
Gang			0.90		
Iron and alumina					0.48
	99.89	100.09	100.40	100.04	100.88

(a) Ilmenau, pure crystal.

(b) Filipstad, Wermland, Sweden, crystal in limestone.

(c) Långban, part crystal, part dense.

(d)
(e) Batesville, Arkansas, U.S.A. H.D.Miser and J.G.Fairchild, Washington Academy Science, Journal, 1920, pp.1-8.

The microchemical reactions are:

Color - appears white when a uniform field is seen but in contrast to replacing pyrolusite it shows up as a light grey with a bluish cast to it.

Hardness - hard.

Streak - rich chestnut brown. Deep cherry red by transmitted light.

HCl (dil.) - drop slowly turns a pale green and then darkens around edges in shades of yellowish brown. Washes clean surface remains bright.

HCl (conc.) - drop quickly turns green about periphery and then darkens in shades of yellow and brown; more pronounced than with dilute HCl. If drop left for some 1 to 2 min,, and then washed, surface is etched to a very light brown with development of fine scratches. Otherwise washes clean with slight development of scratches.

H_2SO_4 (conc.) - neg.

H_2O_2 30 per cent - very slight efforvescence. No tarnishing.

H_2O_2 + H_2SO_4 - quickly efforvesces and after reaction has proceeded for 1 to 2 min., if washed, surface shows a slight tarnishing to light brown and the development of small irregularly rounded bodies along cracks, scratches, etc. This is due to a precipitation as a crack may be observed to pass under several such bodies and continue between and on either side of the precipitate.

$SnCl_2$ (dil.) - same as $SnCl_2$ (conc.) but less pronounced and slower reactions.

$SnCl_2$(conc.) - quickly etches with development of scratches. Washes and rubs to a grey brown scratched surface. Grain boundaries and cracks developed. If action proceeds for 1 or 2 minutes iridescent surface obtained.

$FeCl_2$ - same as $SnCl_2$ but slightly less pronounced.

Thiel's results: "Color grey white. $SnCl_2$ fumes tarnish with iridescence. Surface brown, rubs to coarse reticulate etched pattern. Many grains have appearance of latticework.. Cleavage brought out. H_2O_2 . Very slight efforvescence. No tarnish. $AuCl_3$ neg. on fresh surface. Plated on surface of amorphous material produced by roasting psilomelane."

Braunite.- Type specimen came from Långban, Sweden, and is well crystallized. In the ores examined the braunite occurred as fine dense masses, but always well crystallized in small prisms with pyramidal terminations.

Microchemical tests:

Color - white when by itself. In association with pyrolusite appears light grey with blue tinge.

Hardness - very hard.

Streak - black or a brownish black. Powder slightly magnetic.

HCl (dil. and conc.) - neg. H_2SO_4 (conc.) neg. H_2O_2, 30 per cent. Slight efforvescence, along cracks. $H_2SO_4 + H_2O_2$ very slight efforvescence. No tarnish.

$SnCl_2$ (dil.) - very slight, almost negative reaction after long time of reaction. Effects are similar to conc. $SnCl_2$ but less pronounced.

$SnCl_2$ (conc.) - etches to a brownish grey surface with slight development of scratches and grain boundaries.

$FeCl_2$ - similar to $SnCl_2$

Thiel's results: "Color light greyish white. $SnCl_2$ turns greyish brown; rubs to a very slightly etched surface. H_2O_2 efforvesces very slowly and that is confined to fractures. $AuCl_3$ negative on fresh surface. Negative on same surface following roast."

Bementite.- The specimen of bementite examined was submitted through the courtesy of J.T.Pardee, and was collected by him in 1918 from the Apex Claim, north fork of Skakomish River, Washington. It is a mottled rock, varying in color from a light greenish grey to various shades of brown; the slickensided faces are a dark ruby red; and veinlets and specks of calcite are common. The specimen does not appear to be a uniform mineral. Microscopic examination revealed a mineral with indices 1.625+ and 1.650+, these agreeing with the α and γ of the bementite from the Trotter Mine, Franklin Furnace.(1) This mineral in the specimen from Washington was a very fine-grained aggregate and it was not possible to obtain further optical data on it.

A powder photograph was made of a fine powdered sample of this specimen and is included in Fig. 22. The

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(1) E.S.Larsen, Microscopic examination of non-opaque minerals. U.S.Geol. Survey, Bull.672, 1921, p.46.

writer thinks this should be accepted with reserve as representing a powder photograph of pure bementite.

Psilomelane.- The specimen examined as representing psilomelane came from Crimora, Virginia, and is a dense ore showing concentric layers of varying shades of black; here and there minute veinlets and specks of crystalline ore (pyrolusite) may be seen in the specimen. A polished surface emphasizes the concentric structure. Under the reflecting microscope the main groundmass is composed of concentric layers of a grey brown dense material of hardness about 4.5. Ramifying through this is a mineral that polishes to a white color and is harder than the matrix. This evidently represents a secondary change within the ore after its deposition.

The microchemical tests obtained on the smoothly polished white mineral were:

HCl (dil.)-etches and washes to a grey scratched surface.

HCl (conc.) - same reaction as dil. HCl, but more pronounced and quicker. More pronounced in surrounding material, in both cases.

H_2SO_4 (conc.) - slowly darkens under drop and washes and rubs to a greyish to brown surface.

H_2O_2 30 per cent - slight and slow efforvescence. After reaction proceeded for about 1 min. washes to a slightly darker shade. Surrounding material efforvesces freely and darkens.

$H2O2 + H_2SO_4$ - efforvesces and darkening, washes and rubs to a dirty grey surface. Surrounding material etches black.

$SnCl_2$ (dil.) - neg.

$SnCl_2$ (conc.) - immediately blackens and etches deeply.

$FeCl_2$ - same as $SnCl_2$ - somewhat less pronounced. Effect on surrounding material more intense in both cases.

Thiel's results: "Color, light grey white, $SnCl_2$ tarnishes with etching, rubs to a grey finely textured etched figure. H_2SO_4 tarnishes brown, rubs to a pale brown with slight etching. H_2O_2 efforvesces profusely, rubs clean. $AuCl_3$ no plating on freshly polished surface, but with electric roast to,, 950° followed by $AuCl_3$, a film of metallic gold and manganese oxide is deposited."

Wad.- The specimen of wad examined came from the occurrence on Mr. Hebb's farm, Conquerall, Nova Scotia. The polished section shows a very intimate intergrowth of two minerals, one is white and the other is a pale blue to light grey blue. The microchemical reactions obtained on these two are:

Hardness - both quite soft.

HCl (dil.) - blue mineral darkens more quickly than white but on washing and rubbing, white is more deeply etched. Action quick.

HCl (conc.) - same relative action but effects more pronounced.

H_2SO_4 (conc.) - minerals slowly darken under drop; on washing and rubbing greyish blue mineral appears to be more deeply etched; white also etched and darkened.

H_2O_2 30 per cent - efforvescence starts on grey blue mineral and then over whole drop concealing reaction on minerals. Washes and rubs to darker surface on both minerals.

$SnCl_2$ (dil.) - grey blue mineral darkens quickly, white stand out, washing quickly and rubbing shows grey blue mineral to be etched almost to a black, while white mineral is darkened but little or no etching.

$SnCl_2$ (conc.) - both darken immediately. On washing and rubbing white mineral is less deeply etched than the other.

From the observations made during the above reactions the writer suspects the presence of more minerals than mentioned but the color contrast is too small and the intergrowth too delicate to allow for distinction.

X-RAY ANALYSIS. Discussion of Results.- X-ray spectographs of the type specimens were obtained by the powdered method. The specimens were finely ground and then mounted on hairs. The results obtained were definite and quite characteristic of the different minerals. Powder photographs of the specimens used are plotted in Fig. 22. The height of a line represents the intensity of that line on the film. The horizontal distance is plotted on a logarithmic

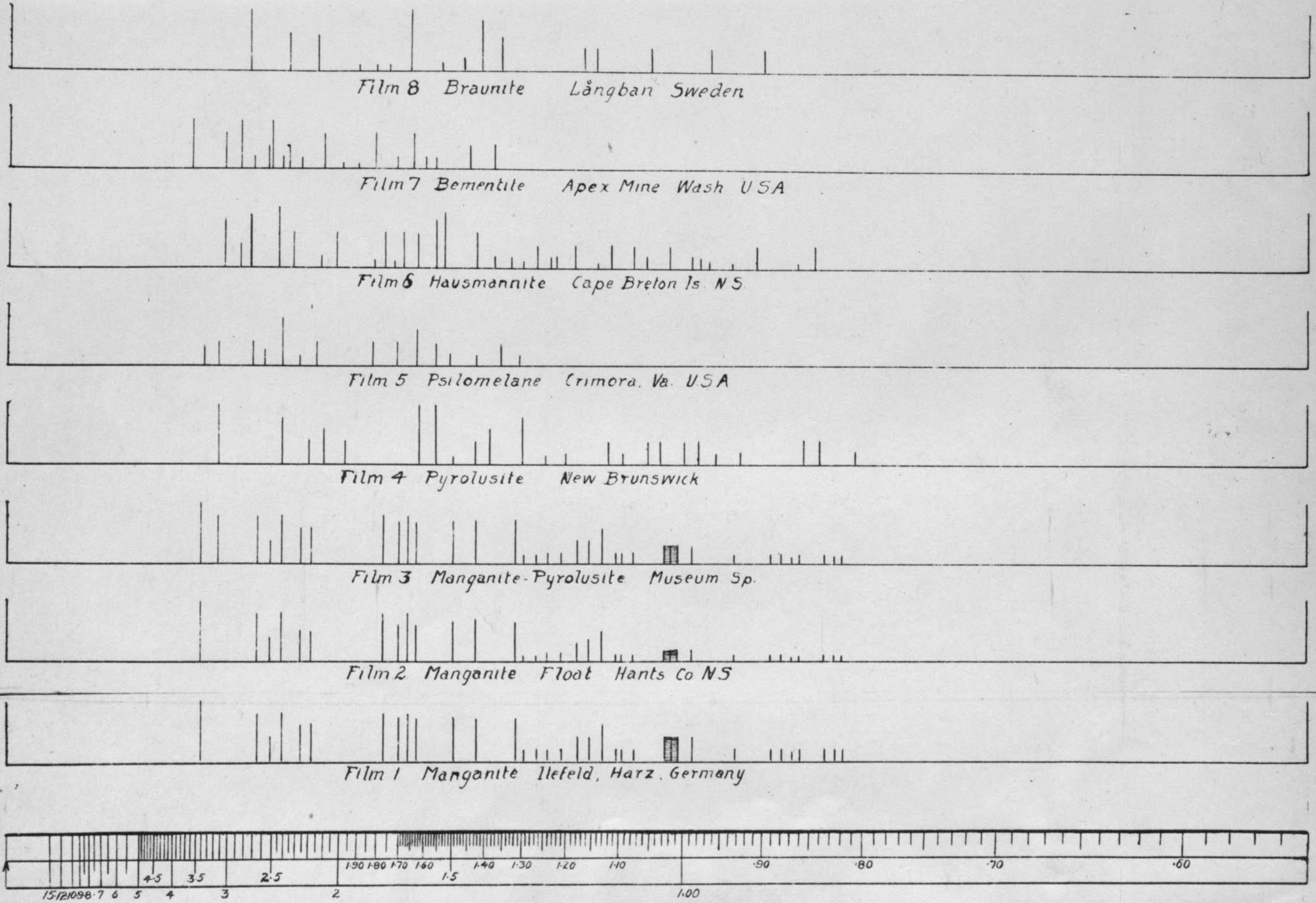
Film 8 Braunite Långban Sweden
Film 7 Bementite Apex Mine Wash USA
Film 6 Hausmannite Cape Breton Is. NS
Film 5 Psilomelane Crimora. Va. USA
Film 4 Pyrolusite New Brunswick
Film 3 Manganite-Pyrolusite Museum Sp.
Film 2 Manganite Float Hants Co NS
Film 1 Manganite Ilefeld, Harz. Germany
4·5
3·5
2·5
1·90
1·80
1·70
1·60
1·5
1·40
1·30
1·20
1·10
·90
·80
·70
·60
15 12 10 9 8 ·7 6 5 4 3 2
1·00
Å

Fig 22

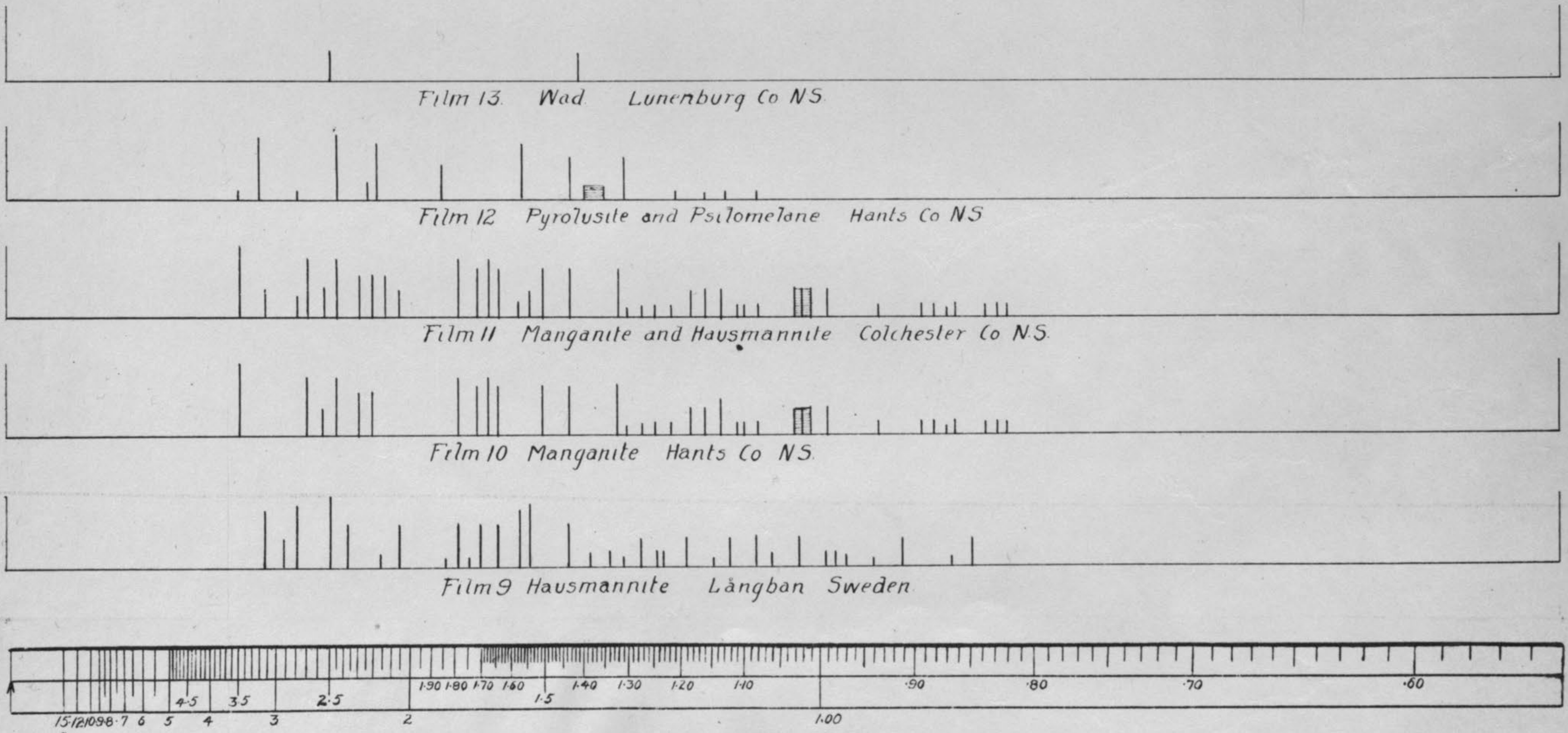
Film 13. Wad Lunenburg Co N.S.
Film 12 Pyrolusite and Psilomelane Hants Co NS
Film 11 Manganite and Hausmannite Colchester Co N.S.
Film 10 Manganite Hants Co NS.
Film 9 Hausmannite Långban Sweden
4·5
3·5
2·5
1·90 1·80 1·70 1·60
1·5
1·40
1·30
1·20
1·10
·90
·80
·70
·60
15 12 10 9 8 7 6 5 4 3 2
1.00
Å

Fig 22

scale and the distance, as measured on the scale gives, in Ångstrom units (10^{-8} cm.), the spacing of the atomic planes in the mineral.

Films 1, 4, 5, 6, 7, 8, and 13 represent the type specimens of manganite, pyrolusite, psilomelane, hausmannite (Cape Breton), bementite, braunite, and wad, respectively. The other films were made as checks against various specimens of ore collected by the writer, the minerals of which were first determined by microchemical tests.

Film 2 represents the specimen of manganite float found by Mr. L.Reynolds, about five miles south of the Faulkner mine (p. 133). Film 3 was made as a check on a museum specimen marked pyrolusite, but determined microchemically as predominantly manganite, with a small amount of pyrolusite forming as an alteration product. The second line on this film corresponds to the first pyrolusite line; the remaining ones being either too faint to show, or else covered up by the manganite lines. Film 8 is hausmannite from Långban, Sweden. The lines on the film are streaked and coarse, due to the powder being too coarse. Film 10 is a specimen of dense hard manganite from the Stephen's mine, Hants County, Nova Scotia. Film 11 is a specimen of ore from Black Rock, Colchester County, Nova Scotia. This specimen shows remnants of colloform banding and the crystallized minerals were determined microchemically as manganite, mainly, altering to pyrolusite which is in subordinate amount and usually as a very fine intergrowth. The presence of hausmannite was not suspected until after a study of the film, and on this the lines at spacings 3.07, 2.74, 2.11, 2.03, 1.57 and 1.53 are taken as representing the hausmannite lines.

Re-examination microscopically revealed the hausmannite as minute grains and clusters here and there through the specimen. The relation of the hausmannite to the manganite can not be determined definitely. Film 12 is the powder photograph of a specimen of hard ore from the Tennycape estuary and is mainly pyrolusite with a little psilomelane present. Film 13 of wad bears out the statement on page 163 that there is no evidence of crystalline structure in the wad, showing it to be made up of colloidal (?) particles.

The measurements of the lines on the films are given in the following table:

Measurements of Powder Photograph Films.-

MANGANITE

	(1)
3.4	H
2.65	m
2.52	v.w.
2.41	m
2.26	w
2.18	w
1.77	m
1.70	w+
1.665	m
1.63	w+
1.495	m-
1.425	m-
1.317	m-
1.292	e.w.
1.263	e.w.
1.24	e.w.
1.210	e.w.
1.177	v.w.
1.155	v.w.
1.13	w
1.113	e.w.
1.095	e.w.
1.076	e.w.
1.027-1.007	v.w.
wide blur	
0.987	v.w.
0.932	e.w.
0.89	e.w.
0.878	e.w.
0.867	e.w.
0.86	e.w.
0.835	e.w.
0.826	e.w.
0.819	e.w.

Films 1, 2, 10.

Film 3, same as 1, with line at 3.13.

Film 11, same as 1, with lines at

Hausmannite lines

3.07	v.w.
2.74	e.w.
2.11	w
2.03	v.w.
1.57	e.w.
1.53	v.w.

(1)
h = heavy
m = medium
w = weak
v.w. = very weak
ew = exceedingly weak

PYROLUSITE

3.12	h
2.41	m
2.20	v.w.+
2.10	w
1.970	v.w.
1.620	h
1.555	h
1.50	?
1.435	v.w.
1.385	w
1.30	
1.245	?
1.20	?
1.12	v.w.
1.09	e.w.
1.052	v.w.
1.032	v.w.
0.998	v.w.
0.979	v.w.
0.955	v.w.
0.926	e.w.
0.857	v.w.
0.84	v.w.
0.807	e.w.

Film 4.

Film 12, mostly pyrolusite with
psilomelane lines at 2.73
2.15
1.83

Measurements of Film 12 -

3.11	m-
2.73	e.w.
2.39+	m+
2.21	e.w.
2.15	m
1.98	e.w.?
1.83	w
1.55	m-
1.42	w
1.387-134	wide band e.w.
1.30	w
1.20	?
1.155	
1.121	
1.075	

PSILOMELANE

3.35	v.w.	1.72	v.w.
3.12	v.w.	1.63	w (wide)
2.7	w (wide)	1.56	v.w.
2.58	e.w.	1.51	e.w.
2.43	m (wide)	1.425	e.w.
2.275	e.w. ?	1.355	v.w. (wide)
2.15	v.w.	1.31	e.w.
1.82	v.w.		

Film 5

Some lines also present
on Film 12.

WAD

2.45	v.w.	diffused
1.401	v.w.	

Film 13.

HAUSMANNITE

3.07	m
2.85	v.w.
2.73	h
2.45	h
2.33	w
2.125	e.w.
2.025	w+
1.815	?
1.77	w
1.725	e.w.
1.685	w
1.625	w
1.56	m
1.53	h-
1.427	w
1.375	e.w.
1.33+	e.w.
1.30	e.w.?
1.265	v.w.
1.235	e.w.
1.224	e.w.?
1.185	v.w.
1.14	?
1.115	v.w.
1.076	v.w.
1.055	e.w.?
1.02	v.w. (wide)
0.987	e.w.
0.978	e.w.
0.965	e.w.?
0.936	e.w.?
0.907	v.w.
0.861	e.w.
0.845	v.w.

Films 6 and 9.

Lines on Film 9 wide and streaked.

BRAUNITE

2.75	h (wide)
2.37	w "
2.15	w "
1.9	e.w.
1.81	e.w.
1.75	e.w.
1.66	h (wide)
1.54	e.w.
1.465	e.w.
1.415	m (wide)
1.36	w

Film 8

BEMENTITE

3.6	h
3.05	w
2.85	m (wide)
2.70	e.w.
2.56	v.w.
2.52	m (wide)
2.425	e.w.
2.37	v.w.
2.265	e.w.
2.10	w
1.98	?
1.90	?
1.810	w (wide)
1.735	e.w.
1.645	w+
1.597	e.w.
1.56	e.w.
1.445	v.w.
1.375	v.w.

Film 7

MINERALOGY OF THE ORES OF THE MARITIME PROVINCES.

The manganese minerals distinguished in the ores of the Maritime Provinces are pyrolusite, manganite, hausmannite, braunite, psilomelane, wad and rhodochrosite. Associated gangue minerals are calcite, barite, selenite, limonite, hematite, and the various minerals of a granite rock.

Of the ore minerals pyrolusite is present in all the occurrences, except perhaps the deposits of wad, and varies in amount, frequently forming the predominating oxide mineral. It is believed to represent an alteration of other manganese oxides, mainly manganite, but also hausmannite and braunite. In these latter instances the writer can not say definitely whether the pyrolusite has been formed from an intermediate stage of manganite, or not, but in one or two instances such a transition was suggested.

Manganite is the next most common mineral and is found in the majority of the deposits, frequently being the most prevalent oxide present. This mineral was noted to form as an alteration of hausmannite and braunite, but in most cases it appeared to be the original mineral. Its alteration to pyrolusite is quite characteristic and all stages of replacement may be observed.

Psilomelane is a term that was used in the field to represent dense, hard material with a dark brown to black streak. Later microscopic work showed that some of the material so described was really braunite or dense hard manganite. As used in this paper it is modified, generally, to include hard dense material that gave no definite chemical reactions, and also is retained from field notes in some cases where no specimens were taken to represent this phase of the ore.

Hausmannite was distinguished in the ore from the occurrences at McCuish, and McVicar's farms, Cape Breton Island, Black Rock, Colchester County, Nova Scotia, and at Jordan Mountain and Markhamville, New Brunswick. At McVicar's farm, it is the predominating manganese mineral, with associated rhodochrosite and minor amounts of manganite and pyrolusite. At the other localities it is present in minor amounts.

Braunite was distinguished in the ore from Terra Nova, Cape Breton Island and Gowland Mountain and Markhamville, New Brunswick.

The only occurrence of rhodochrosite noted is at McVicar's farm in association with hausmannite and the carbonate has been formed later than the oxide mineral.

Of the gangue minerals calcite is always present in varying amounts. Barite and selenite are likewise common but not as persistent. Where present the barite is of local occurrence, and appears to have formed at an intermediate stage in the oxide deposition as crystals of this mineral are frequently observed in vugs within the ore and then minute crystals of the ore minerals can be seen on the barite. In thin sections of ores the barite is replaced by the manganese minerals. Much of the barite tested yielded traces of strontium. Selenite is frequently mentioned in the old reports from many of the occurrences but the writer did not see much of this mineral.

Limonite is common in varying amounts in a number of deposits, and in such occurrences as Bridgeville, Londonderry, Clifton, and Torbrook, it is the main mineral with the manganese oxides as subsiduary occurrences. Hematite (probably goethite) is associated with these in the latter instances. In all cases observed the limonite was the earlier mineral, deposited in beautiful colloform structure; the manganese oxides are later and have been deposited in cracks and replaced the limonite in crystalline aggregates.

The sequence in the manganese oxides appears to have been hausmannite or braunite, altering to manganite and this to pyrolusite. In some instances braunite appears to be developing from some earlier deposited mineral, but what this is, is not known. The intermediate stage of manganite is not definitely established. Commonly manganite is the primary oxide deposited and this alters to pyrolusite. The sequence of the gangue minerals is not known but as has been stated, calcite has been replaced by the oxides and is at times intermediate. Rhodochrosite formed after hausmannite and replaces it or forms incrustations in cavities in the ore. Barite and selenite are local and apparently an intermediate product of deposition. Limonite is invariably older than the manganese minerals in these deposits.

OCCURRENCE OF THE ORES OF THE MARITIME PROVINCES.

The most common occurrence of the ores is in the Lower Carboniferous limestone with its associated gypsum, shale, sandstones and grits. The limestone is widespread throughout the Maritime Provinces, and is generally believed to underlie the beds of gypsum. This Lower Carboniferous limestone is persistently magnesian in contrast to the later Carboniferous limestone members which have little or no magnesium in them. Analyses of this member made by E.Gilpin, Jr.(1), from Cape Breton, Pictou, and Tennycape, showed the manganese content (determined as $MnCO_3$) to vary between 1.38 to 14.58 per cent. In these strata the ores occur as veinlets, nodules, and irregular replacements of the limestone,

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(1) Trans. Royal Society Canada, Sect. IV, Vol.II, 1884.

and when in contact with an underlying shale, there is the tendency for it to spread out along the shale-limestone contact. Ore in veins and nodules is also found in the shale, and thin stringers occur in sandstone, but these are of minor importance as compared to the limestone occurrences. Occurrences are found in older and younger sedimentary rocks and in the Triassic traps but these are of no importance economically. At New Ross valuable deposits of manganese oxides are found as veins in granite, and represent a replacement of carbonate veins by meteoric waters concentrating the original manganese content of these veins. Other deposits occurring in granite are located in Cape Breton, N.S., and at Gowland Mt., N.B., but these appear to have been formed on the surface of the granite mass in contrast to the New Ross occurrence. Bog ores are widespread throughout the provinces and in places are sufficiently large to form possible economic deposits of limited extent.

ECONOMIC VALUE OF MARITIME OCCURRENCES. Reviewing the deposits from an economic side it may be said that the ores are high grade and in most instances are well adapted to the chemical trade; the harder varieties would be suitable for metallurgical use; also the large bog deposits might be used for the latter industry if suitable methods of briquetting could be adapted. However, it must be remembered that all the deposits are of limited extent, and the better ones have already been depleted or partly depleted of their ore.

The best reserve of ore is at New Ross, N.S., where the oxides occur as replacements in carbonate veins. A considerable quantity of ore has already been removed from here but the latest reports on these properties, made just prior to their closing, and also the statements of the owners, claim that the bottom of the oxide zone had not been reached, and the ore was still of good grade. Similar veins are reported in the same district, but were not seen by the writer. The Jordan Mountain occurrence contains good ore but the amount is likely to be limited. The dumps and "footwall" at Tennycape contain a considerable quantity of good ore, but this is small in comparison to the amount of rock present. The occurrence at McVicar's farm is a probable source of manganese, but is of unknown extent. The other occurrences examined are small and of a pockety nature; from some of these small amounts may be extracted by individuals from time to time.

The bog ores on Boularderie Island are of considerable extent and might be of importance under certain market conditions. The same may be said of the bog ores at Dawson Settlement and Canaan River. A bog ore of very good quality occurs near Frederickton. A sample of this ore was submitted to the writer by Mr. McMullen, Inspector of Mines for New Brunswick, and it consisted of minute crystals of manganite intergrown with and implanted upon an earthy aggregate. The extent of this occurrence is not known.

NOTES ON THE OCCURRENCES OF HAUSMANNITE. Hausmannite, while not rare, is somewhat of an uncommon manganese mineral, so far as references in literature are concerned. The localities listed are Långban, Sweden, Ilfeld, Harz, and Ilmenan, Thuringia, Germany. Hausmannite is reported to occur at Batesville, Arkansas; Bromide, Oklahoma; San Jose, California, and Crescent Mine, Washington, in the United States; the occurrences in the Maritime Provinces have already been mentioned (page 241).

Långban, Sweden(1).- At Långban there are iron and manganese deposits in close association but the manganese ores are practically free of iron and vice versa. The ore-bodies occur in interrupted but bedded deposits in a bed of dolomite which extends for some 4 kilometers along the strike. Magnusson considers that both types are replacements in the dolomite. First iron was deposited as oxide, along with

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(1) Långbansmineralien fran geologisk synpunkt. N.H.Magnusson, Review Econ.Geology, 19, 1924, p.687.

Beck-Berg, Abriss der Lehre von den Erzlagerstätten, 1922, p.56.

silica forming a jasperoid, and manganese as oxide and carbonate. A later rise in temperature changed the hematite to magnetite and braunite to hausmannite with accompany skarn minerals (hornblendes, pyroxenes and garnets). Beck considers that the deposits have resulted from contact metamorphism of original intercalated iron and manganese ores in the dolomite, with little or no introduction of material. The massive hausmannite is considered to have formed from braunite, while the disseminated hausmannite is supposed to be derived from pre-existing manganosite; both alterations taking place at high temperatures.

Ilfeld, Harz (1).- In the Ilfeld district, the Rotliegendes is composed of alternating conglomerates, and sandy and clayey sediments with intercalated porphyrite extrusions. Overlying the Rotliegendes unconformably is the Zechstein. The manganese ores are found in association with iron ores, forming vein fillings and breccias in the porphyrite rocks. The mineral association is manganite, pyrolusite, varvisite, braunite, hausmannite, psilomelane and wad, with gangue minerals of calcite, barite, altered feldspar and in one case rhodochrosite. Iron oxides are likewise intimately associated. The hausmannite is most

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(1) Beyschlag, Vogt and Krusch, - Truscott, Vol. 2, 1916.

plentiful in the upper part of the deposits; in depth, the iron ore, consisting of clayey hematite and kidney ore, increases in amount whereas the manganese content decreases.

It is thought that the manganese and iron lodes have been formed from descending solutions which derived their metal content from the overlying Zechstein and Rotliegendes.

Ilmenau, Thuringia (1) .- At Ilmenau, iron and manganese ores are found, which have a similar occurrence to those at Ilfeld, and which are regarded to have a similar origin. The mineral association is hausmannite, braunite, radial and fibrous pyrolusite and psilomelane; barite is characteristic with calcite and brecciated country rock. Limonite and hematite are occasionally associated, and in one occurrence take the place of the manganese minerals in depth.

Batesville, Arkansas (2) .- The deposits in the Batesville region occur in the Fernvale limestone and the Cason shale, or in residual clays derived mainly from these two formations. The oxides occur as replacement masses, mostly in clay but also in limestone, shale, chert, and

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(1) Truscott, op. cit.

(2) H.D.Miser, and J.G.Fairchild, Washington Academy Sci. Jour. 10, 1920.

sandstone. The mineral association is psilomelane, hausmannite, braunite, manganite, pyrolusite, and wad. Miser considers that "the oxides have been derived from manganese-bearing carbonates near the surface and have been deposited by cold waters of meteoric origin.

Others, perhaps, are of the opinion that the hausmannite has been formed by rising warm waters.

Bromide, Oklahoma (1) .- The occurrences of hausmannite in Oklahoma are found near Bromide. The ore occurs in limestone strata of Paleozoic age, and consists of hausmannite and psilomelane in association with calcite, siderite, and a manganese, magnesium, calcium carbonate; quartz, pyrite, and chalcopyrite may also be present. The hausmannite occurs either as fine crystallized masses of minute crystals, or as plumose masses, intergrown with the manganiferous carbonate.

Hewett states that the deposits are found in river valleys 100 to 150 feet below the surrounding plateau surface and that the country rock is very little weathered. The ore occurs along fractures or faults, or lies bedded with the strata. He concludes that the hausmannite deposits have been formed "by the deposition of manganese minerals by warm waters rising along fractures", but does not commit himself to the origin of these waters. He intimates that they might be rising meteoric waters.

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(1) D.F.Hewett, U.S.Geol.Survey, Bull.725-E, 1921.

San Jose, California (1) .- At one time, near San Jose, California, a large boulder of manganese oxides existed, but this was broken up and shipped as manganese ore in 1918. The mineral association in this boulder was tephroite, hausmannite, rhodochrosite, pyrochroite and psilomelane, named in their paragenetic order.

Rogers considers that this boulder had become detached from a manganese deposit in the Franciscan formation. "Although some doubt is attached to the original occurrence of this manganese ore, the presence of tephroite and hausmannite points to the high temperature nature of the deposit."

Washington (2) .- At the Cresent Mine, Washington, hausmannite is found in association with bementite and manganiferous carbonate along with quartz and iron oxides. The orebodies are found in an impure red limestone of probable Franciscan age, and are overlain by volcanic rocks of Tertiary age. The manganese is believed to have been originally deposited with the limestone as a carbonate. Later hot solutions migrating from the effusive rocks or their magma, converted the manganese present, in the limestone, into hausmannite and bementite.

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(1) A.F.Rogers, Am.Jour.Sci. (4) 48, 1919.

(2) J.T.Pardee, U.S.Geol.Survey, Bull.795-A, 1927.

CHAPTER VI

XIV POSSIBLE ORIGIN AND MODE OF CONCENTRATION OF THE MANGANESE ORES IN THE MARITIME PROVINCES.

Time of Concentration

In the preceding chapter it was noted that the majority of the manganese deposits were associated with the Lower Carboniferous limestone. Because of this association the earlier reports assumed that the concentration of manganese took place during the minor epochs of elevation within the later Carboniferous and mainly in the general emergence during Permian time.

During the field investigation the writer observed little evidence to substantiate this view. The only deposits which might be used as evidence for this early concentration are those at Shepody Mountain, and Memel, Albert County, N.B. At these localities the oxides occur in such a manner that they suggest that the deposits were formed prior to, or accompanying the deposition of a Carboniferous conglomerate. In none of the other occurrences in the Carboniferous rocks are there younger strata overlying the ores in such a manner that they date the ore concentration prior to the deposition of the younger rocks.

At Tennycape estuary, and the Wheadon occurrence in Hants County, near Wolfville, Kings County, and along the north shore of Cobequid Bay, occurrences are found in which the manganese oxides, occur as veinlets in Triassic sediments, or as a replacement of the cement of these rocks. The widespread occurrence of bog ores throughout the Maritime Provinces is evidence of recent transportation and deposition of manganese. Again in reviewing the literature on the occurrences in the Appalachian Province and Arkansas it is to be noted that the concentration of manganese which resulted in the present deposits in these regions is considered to have taken place during Cretaceous and Tertiary times.

From such evidence as this the writer suggests that the concentration of manganese into the deposits as now found in the Maritime Provinces, took place subsequent to the Permian, perhaps in Tertiary time.

Source of the Manganese

The source of the manganese is somewhat vague, and various strata and rock units are called upon to furnish the supply. Among these are the Lower Carboniferous sediments and their intercalated volcanics, and the effusive rocks of Triassic age.

Mode of Concentration

In general it is believed that the manganese deposits of Nova Scotia and New Brunswick have been formed by meteoric waters which derived the manganese from the rocks through which they percolated, and deposited it in the form of the present orebodies. Those occurrences which contain hausmannite, may be possible exceptions to this general statement.

In reviewing the literature relating to a number of occurrences of hausmannite, and also from personal discussion with Dr. W. Lindgren, it seems that hausmannite is generally conceded to have been formed by rising warm or hot waters. The deposits at Långban certainly point to high temperature formation. In the hausmannite occurrences of the Maritime Provinces, there is/no evidence for or against such a view. If one assumes that they have been formed by warm or hot waters, then the source of these must be established.

Since the deposits were formed in Lower Carboniferous strata, subsequent to their consolidation, the only igneous activity that can be assumed to have furnished the heat necessary, is the Triassic eruptive rocks. If these rocks furnished the heat, and perhaps also the solutions that resulted in the deposition of the hausmannite,then it seems to the writer that deposits containing hausmannite should be found in proximity to the occurrences of the Triassic effusives. However, in reviewing the location of the hausmannite occurrences in respect to their geological enivornment it is seen that they are considerably removed from an occurrence of Triassic flow rocks, and moreover, those deposits of manganese which are found in close proximity to the effusive rocks, contain no hausmannite. The exception to these statements is the occurrence at Black Rock, Colchester County, Nova Scotia, which is in close association with the Triassic members. In this occurrence the hausmannite is found in small scattered bunches within the other manganese oxides, but it might be well to mention here that the manganese oxides have been deposited later than associated limonite.

In conclusion the writer does not like to say that the hausmannite in the Maritime occurrences has not been deposited by heated waters, but at the same time he does not think there is much evidence to support the view that it has been formed in this way.

The bog ores are considered to have formed, and to be forming now, from meteoric waters that have derived their manganese content from the underlying strata. Deposition of the manganese minerals results from bacterial action, reaction with organic acids and decomposing organic material and by oxidation.

The remaining deposits have been formed from descending surface waters which after seeping through the surrounding rocks and dissolving the manganese contained in them, became concentrated (in direction of flow) along the better established lines of underground drainage, and here deposited their content by replacement of the adjoining limestone and by oxidation. Such deposition need not have taken place in the zone of active oxidation but probably occurred at greater depths.

Transportation of the Manganese

The manner in which the manganese was transported, prior to its deposition in the deposits of the Maritime Provinces, is a subject that is open to speculation and the writer approaches the problem with timidity and offers the following suggestions for what they are worth.

That the bicarbonate of manganese plays an important role in the transportation of manganese is amply borne out by many instances in nature,- deposits of iron and manganese about mineral springs,- and by experimental data (1).

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(1) M.V.Vincent, Compte Rendu, 162, 1916, p.259.

L.Dieulafait, idem, 101, 1885, quoted by F.W.Clarke, U.S.Geol.Survey Bull.695, 1920, p.533.

The manganous sulphate is quite soluble (53.2 parts per 100 of cold water (1)) and moreover J.W.Mellor (2) states that manganous salts are stable in neutral or acid solutions. The experiments of F.P.Dunnington (3) also show that, given a source of sulphuric acid, the sulphate may be an important agent in the transportation of the manganese. These experiments also showed that manganous sulphate solution was not affected by air alone, but in the presence of $CaCO_3$ manganese oxide was formed.

It has been noted in the preceding pages that the manganese deposits in the Lower Carboniferous strata, are frequently in close association with gypsum beds. Moreover as evidenced by springs issuing from the gypsum-bearing horizons, chemical changes within the gypsum are now producing H_2S, and free sulphur, and very likely there is produced some H_2SO_4. Such waters as these, in percolating through a manganiferous limestone, would produce a chemical re-adjustment resulting in the formation of calcium sulphate, and carbon dioxide. With these substances present the manganese could enter into solution either as the bicarbonate

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(1) Handbook of Chemistry and Physics, 12th Ed., 1927.

(2) Modern Inorganic Chemistry, London, 1914, p.478.

(3) Am.Jour.Sci. (3) 136, 1888, p.175.

or sulphate. If there was a deficiency or lack of air at the place of solution, the sulphate would remain dissolved until the channels of main underground circulation were reached, and here, in the presence of oxygen and calcium carbonate, would precipitate as the oxide. The manganese bicarbonate might also be oxidized at the same time.

At this point it may be recalled that many of the occurrences in the Lower Carboniferous limestones are found as irregular veinlets trending down the general dip of the beds and nearly at right angles to the bedding. In the vicinity of shale strata the attitude of the orebody changes and it widens out and extends down the dip parallel to the bedding. In other places the oxides may form the cement to a calcareous breccia. Also the old reports remark that the ore was sometimes found on a water worn surface of limestone. Ed. Gilpin, Jr. (1) states of the Tennycape mine, "The ore occurs in irregular nests, and in seams eroded on the bedding planes and cross fractures....the ore has been deposited....in the openings worn by the action of water on the limestones. Specimens may be obtained showing pyrolusite, cementing water worn pieces of limestone, and surrounding nodules of the bedrock which have resisted erosion."

From these considerations the writer suggests that the manganese was transported not only as the bicarbonate but also as the sulphate.

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(1) Trans. Royal Society Canada, vol.II, pt. IV, 1884, p.10.

BIOGRAPHICAL NOTE

WILLIAM VICKERS SMITHERINGALE
Born: October 2, 1901
Slocan, British Columbia.

Awarded the degree of Bachelor of Applied Science (Mining Engineering) in 1924, and of Master of Applied Science (Geological Engineering) in 1925 from the University of British Columbia. From 1925-1928 graduate work at the Massachusetts Institute of Technology towards degree of Doctor of Philosophy in Geology. Field experience gained with the Geological Survey of Canada at Copper Mountain, B.C., 1923; Tatlayoko, Chilco and Taseko Lakes district, B.C., 1924; Eutsuk Lake district, B.C., 1925; economic work in mining at Stewart, B.C., 1926. Investigation of the manganese deposits of the Maritime Provinces, Canada, 1927. Presented to the Faculty of the Massachusetts Institute of Technology, in May 1928, for the degree of Doctor of Philosophy in Geology, a thesis entitled, "The Manganese Occurrences of the Maritime Provinces, Canada".

ABSTRACT OF THESIS ON "THE MANGANESE OCCURRENCES OF THE MARITIME PROVINCES, CANADA" by William V. Smitheringale.

The Geological Survey of Canada is preparing a series of economic reports on the metals of Canada and their occurrences. The subject of "manganese" was assigned to the writer, and during the summer months of 1927, the field examination of the manganese occurrences in the Maritime Provinces, Canada, was carried on.

The first chapter of this report is devoted to a general consideration of manganese and its uses, particularly in respect to the steel industry. There is also present a short synopsis of the marketing and production of manganese ores. The production in Canada from 1873 to 1924 is given at the end of this chapter.

The geologic occurrence of the main manganese ore deposits of the world, is taken up in the second chapter. The treatment of each is of necessity brief. The economic deposits of Brazil, India, and the Gold Coast of Africa appear to be oxidized outcrops of metamorphosed manganiferous sediments of pre-Cambrian age. The ores of Russia are interstratified with Eocene sediments, and they are believed to be of sedimentary origin. All these countries have large reserves of high grade ore. A number of smaller occurrences in Egypt,

Australia, and South America are likewise described. A summary of the manganese deposits in the different regions of the United States is given in conclusion.

The occurrences in Nova Scotia and New Brunswick are taken up in considerable detail in Chapters III and IV. The results of laboratory investigation are given in Chapter V.

Up to the present the microscopic methods of determining the various manganese oxides have been somewhat indefinite. The principal original contribution of this paper is the standardizing of a series of microchemical reactions by means of which the more common manganese oxide minerals may be recognized. Type specimens of the different oxide minerals were chosen and the reactions on these due to chemical reagents were noted. Chemical analyses of the type specimens were obtained, and X-ray powder photographs made as checks. With this information as a basis, the mineralogy of the ores of the Maritime Provinces was investigated. The results were definite, and the reactions previously established were characteristic of the different minerals.

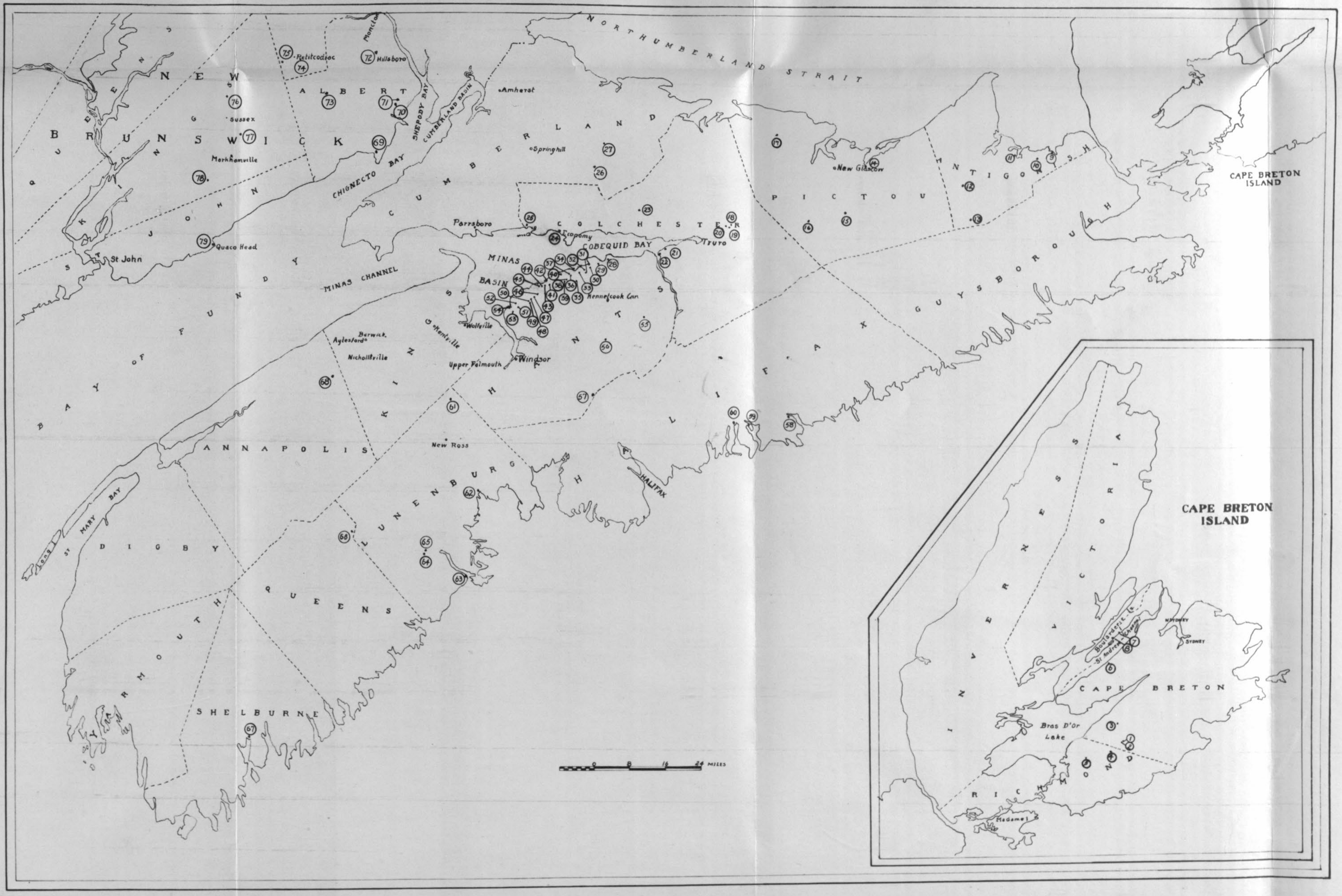
Hausmannite is rather an uncommon mineral of manganese, and it is reported as occurring in relatively few places. In the United States only four authentic occurrences are known,- Batesville Region, Arkansas; Bromide, Oklahoma; San Jose, California; and Crescent Mine, Washington. This mineral was detected in five of the occurrences in the Maritime Provinces.

The occurrence of the ores in Nova Scotia and New Brunswick is mainly in the Lower Carboniferous limestone, but deposits are also found in carbonate veins in granite and as narrow stringers in Triassic rocks. Bog ores are very common throughout the provinces and in three places are of sufficient size to be of economic importance.

From an economic standpoint the deposits are of limited extent and no large or long production from them can be expected. The ores, however, are very high grade.

Short notes on the occurrences of hausmannite are given at the end of this section.

The last part of the paper discusses the possible origin and mode of concentration of the manganese ores in the Maritime Provinces. Suggestions are made concerning the time of concentration, the source, the manner of concentration and the transportation of the manganese.



1 Morrison Property
2 McCuish Property
3 Terra Nova
4 McVicars Property
5 Tom's Brook
6 Beaver Cove
7 McNeil's Property
8 O'Handly's Property
9 Tracadie
10 Afton
11 Pomquet
12 Ohio
13 Lochaber
14 Sutherland
15 Bridgeville
16 Glengarry
17 Meadowville
18 Borden Property
19 Manganese Mines
20 East Mountain
21 Clifton
22 Black Rock
23 Londonderry
24 Lower Economy
25 Lower Five Islands
26 Rose
27 Jersey
28 East Noel
29 Wright Property
30 McDonald Property
31 Capt. Scott's Mine
32 Morton Reynolds Property
33 Faulkner Mine
34 Tennycape Estuary
35 McLellan Meadow
36 Tennycape Mine
37 Parker Mine
38 Bog Ore Occurrence
39 Hibernia
40 Wheadon Occurrence

41 Jennison Pit
42 Whale Creek
43 Shaw + Churchill Mine
44 Stephen's Mine + Burgess
45 Davis Pit
46 Sturgis Mine
47 Tomlinson Mine
48 Lantz Mine
49 Smith's Property
50 Goshen Iron Mine
51 Burnt Barrens
52 Mill Brook
53 Sugar Woods
54 Cheverie
55 McPhee Corner
56 Rawdon
57 South Uniacke
58 Ships Harbour
59 Jeddor
60 Musquodoboit
61 New Ross Mines
62 Chester Basin
63 La Have
64 Conquerall
65 Hebbville
66 Pleasant River
67 Shelbourne
68 Torbrook
69 Waterside
70 Memel
71 Shepody Mountain
72 Dawson Settlement
73 Gowland Mountain
74 Kays Farm
75 Davis Farm
76 Jordon Mountain
77 Glebe Mine
78 Hillsdale
79 Quaco Head