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The Iron Ore Deposits of Quebec and Laborador

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THE IRON DEPOSITS OF
QUEBEC AND LABORADOR

A thesis
Presented to
the Faculty of the Department of Geology
University of North Dakota

In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science of Geology

by
DONALD STUART GILLIN

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DEVELOPMENT HISTORY

The existence of iron-bearing formations in the area of the Laborador Trough has long been known. These deposits were first reported between 1892 and 1895 by A.P. Low, when he made the first geological exploration of Laborador. He reported the existence of iron formations similar to those of the Lake Superior area (Choubersky 1957, 2 p.50). These deposits were again reported in 1929 by W. F. James and J. E. Gill when they found the first showings of iron ore (Gill, Bannerman, and Tolman 1937, p.567).

In 1936 the Laborador Mining & Exploration Company was formed and gained a concession of 20,000 plus acres were obtained from the government of Newfoundland. J. A. Retty was appointed as chief geologist. During the period 1936 and 1939 six of the current ore bodies were located (Gustafson and Moss 1953, 7 p.63). This work provided reconnaissance maps and general geological information for later parties. During the period 1940 and 1941 work was suspended due to the shortage of finances.

In 1941 the work was again resumed when the Hollinger Consolidated Gold Mine Limited obtained an option to purchase control of the former operating company plus obtaining rights to 3,900 square miles of adjacent territory in Quebec. During this time and in 1942 much work was completed of a general regional nature plus examination of several sulphide outcrops, but no new ore bodies were found, (Gustafson and Moss 1953, t p.63).

In 1942 the M. A. Hanna Company purchased an interest in the companies working in the area. In 1943 and 1946 detailed mapping and drilling were carried out on the outcrops. Twelve orebodies containing a total of 160

million tons of ore were located. During this time the work became simplified when the government published its first aerial survey maps of the area (Gustafson and Moss 1953, 7 p.64).

In 1945 the work turned entirely to the location of iron ore, prior to this time work had been carried out to locate all base metals. After 1946 work continued in the area to prove the reserves the first objective was 300 million tons. The present, 1957, proven reserve has reached 418 million tons.(Durrel 1954, 4 p.387).

In 1949 the Iron Ore Company of Canada was formed and \$250,000,000 was raised; \$100,000,000 from the several companies owning the Iron Ore Company of Canada while \$150,000,000 was obtained from American and Canadian insurance companies.

To develop the area, 357 miles of railway have been built and port terminals to handle at least 10 million tons a year (Choubersky 1957, 2 p. 52). At the present time the ore is shipped to East coast ports; but upon completion of the St. Lawrence Seaway, these ores will take the same route as the Lake Superior ores to the American steel plants.

THE GENERAL GEOLOGY

The physiography is of low rolling ridge lines with the ridges all on a general plateau, the regional elevation is about 1500 feet while the relief is about 100 feet to 500 feet (Harrison 1952, 8 p.78).

The entire area has been glaciated several times and is located near the proposed center of the Labrador ice cap, the till is thin but to



Scale
1"=50,000

*LEGEND

- Iron Ore Deposits 1 [Black box]
- Menihek Formation (Shales) [Blue box]
- Sokman Iron Formation (Ferruginous Cherts)..... [Green box]
- Ruth Lake Formation (Slates)..... [Purple box]
- Wishart Formation (Quartzites)..... [Yellow box]
- Fleming Formation (Chertbreccia)..... 1 [Orange box]
- Denault Formation (Dolomites)..... [Pink box]
- Strikes and Dip [Line with arrow]
- Faults (Mostly thrust)..... 1 [Line with wavy arrow]

Fig. 1 Geology of the mining area near Lake Knob (Gustafson and Moss, 1953)

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the differential movement of the ice it is impossible to trace the movement of the float from it's source.

The rock of the areas is Precambrian. This is overlain by a thin veneer of Pleistocene drift.

Near Lake Knob which is centrally located is the largest concentration of ore pits. There is a belt of Proterozoic rocks about 60 miles wide, that tapers both to the north and south. The southwest section is composed of sedimentary rocks, including iron formations; while the northeastern section is mainly basic volcanic rock and related intrusions.

The thickness of Proterozoic rocks has been estimated at 20,000 feet (table 1). The rocks were probably deposited in a stable, shallow basin with clastic and chemical precipitation alternating (Chouborsky 1957, 2, p.38).

The beds are flat lying on the west, then they begin an imbricated "foothill" structure with rocks folded and faulted into a complex and tight pattern. Most folds overturn to the southwest; strike faults, generally overthrust from the east to the west. (see fig. 1).

Northward from Lake Knob showing of copper, zinc, and nickel have been found in small pods or large undergraded areas, but there are no commercial showings of these elements (Chouborsky 1958, 2 p.40).

Two periods of tectonics (Chouborsky 1958, 2 p. 38) can be identified in the area of the Labrador Trough, which contains the deposit and runs from Ungava Bay in the north to Lake Walush in the South. The first is

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of late Proterozoic or early Cambrian and has given a regional folding and faulting pattern with a northwest trend affecting the iron formation and the overlying sediments. The second is of Cretaceous age identified by fossil-bearing gravels along scarp faces opened in mining. It has given rise to cross faults trending northeast-southwest and northwest-southeast.

THE IRON FORMATIONS

The iron formations consist of the Ruth Slate and the Sakoman Chert which are sub-divided as described by Choubersky, 1957, 2p40, and following:

RUTH SLATE

Silicated-Carbonate Iron Formation

Lower red cherty

Pink cherty

Metallic Iron Formation

Grey cherty

Upper red cherty

Cherty

Upper Iron Formation

Silicate carbonate

Top cherty

(a) Ruth Slate These slates are patched and occasionally absent with thicknesses in the mining areas from 60 to 100 feet. The original color is dark grey they are also not very highly metamorphosed. The constituents are hematite, chert, feldspars, iron silicates, and iron carbonate. The average Fe content is 20 per cent but varies upward to 30 per cent with desilification near the bottom. At the upper portion

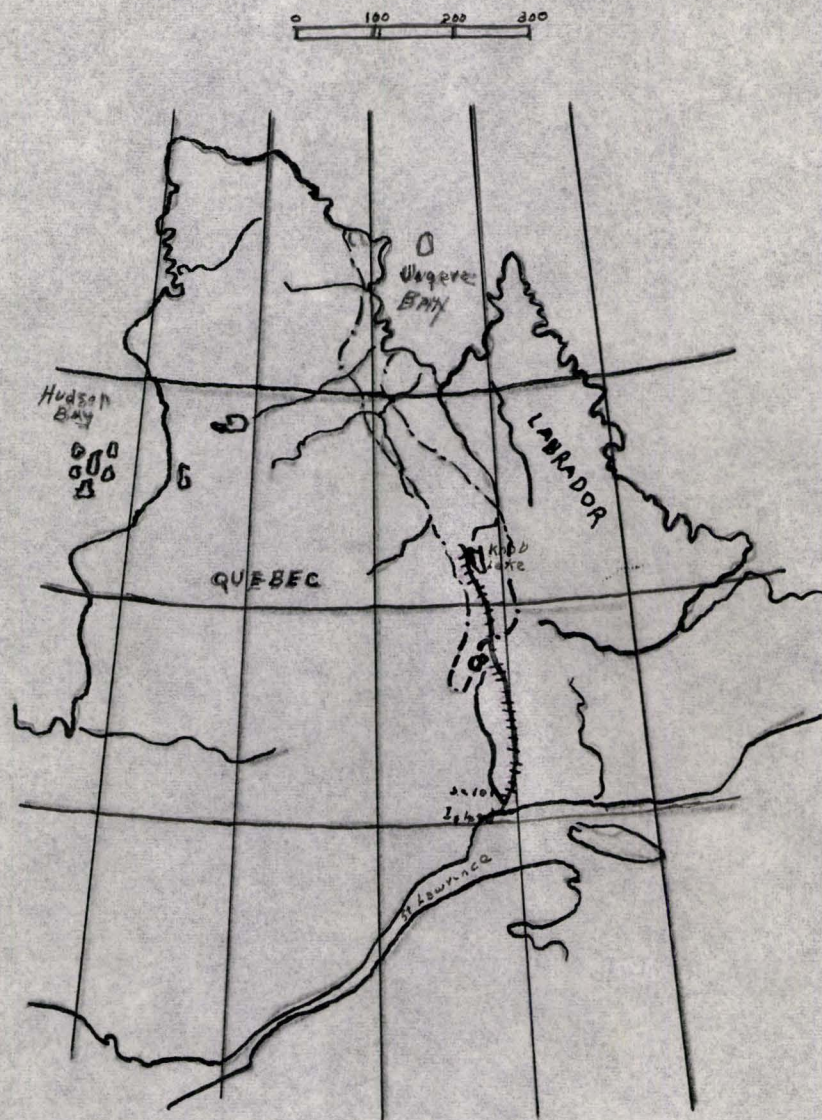


Fig.2 Sketch-map of Quebec-Labrador peninsula with outline of the Labrador trough. From A. Choubersky, (The Institution of Mining and Metallurgy November, 1957).

of the bed the Fe content may rise locally to 40 per cent .

(b) Silicate-Carbonate Iron Formation This formation is rarely absent throughout the mining area with a thickness varying between 30 and 80 feet. It is fine grained, hard, compact and thinly banded rock consisting of rounded fibrous microgranules and intergrowths of minnesotaite in a chert matrix. The chert is composed of fine crystallized magnetite and hematite. The carbonates are found in thin sections within the rounded microgranules of minnesotaite. The Fe content averages between 20 and 30 per cent and alumina is usually high.

(c) Metallic Iron Formation The unaltered rock is fine to medium-grained and consists of highly colored chert containing magnetite, marlite, and a little hematite with small but variable quantities of iron silicate and carbonates. Some levels are oolitic while others are crystalline, The oolitic areas are cherty with the hematite being recrystallized to magnetite. Bands of fine-grained hematite appear in places up to 3 inches thick often far from any areas of enrichment. The Fe content varies from 20 to 50 per cent.

(d) Upper Iron Formation The general composition is somewhat similar to the Metallic Iron Formation, but the rocks are more massive and less broken with a lower Fe content.

The outcrops of the formations are strongly foliated and local banding is pronounced. Some narrow veinlets of quartz and specularite appear.

The Silicate-carbonate Formation and the Metallic Iron Formation both give rise to high-grade ores of the first type. Ores of the second

type are most frequent in the "upper red cherty" and "lower red cherty" horizons, while the others appear to have been poor collectors.

In the **Upper Iron Formation**, the lower cherty horizon is occasionally enriched through both types of action. The second type gives rise to a particular blue ore which is also found in the "upper red cherty" horizon of the metallic iron formation. The silicate-carbonate and the upper cherty are also occasionally enriched and give rise to pockets of low-grade ore.

The passage from rock to ore is gradational over a few yards and marked by an increased porosity of the rock and a thickening of the ore bands. The iron content of the rock generally increases towards the orebodies and the surrounding formations are leached.

Below the iron formation, the Ruth Slates are seen to have acted as a stop to the downward-moving iron solutions. In the vicinity of the orebodies the Wishart arkose is strongly leached and reverts to a crumbly sandstone, but carries no trace of ore deposition except along very occasional localized fissures.

The lack of enrichment in the upper iron formation can probably be ascribed to the massive texture of the rocks and to the sporadic distribution of the original iron.

The first type of enrichment probably occurred between the proterozoic and the Cretaceous.

The Ruth Slate contains a large number of trace elements,

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nickel, vanadium, cobalt, chromium, molybdenum, titanium, germanium, tin, lead, zinc; the last three disappear in silicate carbonate rocks and the others are reduced in abundance.

Phosphorus in the Ruth Slate is patchy varying from 0.02 to 0.08 per cent while in the silicate carbonate it is from 0.06 to 0.09 per cent and in the metallic iron formation it runs from 0.01 to 0.03 per cent. The sulphur content is low and also the alumina content.

South of the Lake Knob area the outcrops narrow. High grade ore is found here and so far, all have contained titanium.

To the north the area is yet to be completely worked over but much magnetite has been found at times running to 30 per cent.

ORE ENRICHMENT

At the present, enrichment has been determined in a 90-mile strip centered at Lake Knob. It is also limited to the folded and faulted belt of the foothill structure.

The enrichment of the rocks is of two types. The first type of enrichment is silica leaching. In this type of enrichment the ore is usually hematite and there is no introduction of secondary ores.

In the Ruth Slate, the enrichment of this type is as follows, (Chouborsky, 1957, 2 p. 12).

Fe	50-60
SiO ₂	2-8
Al ₂ O ₃	12+
Mn	-1

Loss on ignition	Low
H ₂ O	10+
Total Oxides	87-90

In the Metallic Iron formations this type of ore contains:

Fe	45-60
SiO	2-24
Al O	Low
Mn	Low or absent
Loss on ignition	Negligible
H O	4-8
Total Oxides	94-97

In the second type, new minerals, principally goethite and pyrolusite, have been introduced along fissures perpendicular or parallel to the bedding. Such zones of enrichment are very frequent and occur along the crests of anticlinal folds and warps, along tensional zones in faults, at fault intersections, and in brecciated areas.

Phosphorus and the tracer elements also migrate. The phosphorus rises to as much as 0.15 per cent and the trace elements increase by a decimal point.

In this process, the composition of the host rock is not affected and the action is limited by the extent of local fissuring. It produces areas of ore of variable size and composition dependent on the extent and degree of original composition of the host rock.

In the Ruth Slate originally containing 40 per cent Fe this process gives ores containing:

Fe	45-50
SiO ₂	8-18
Al ₂ O ₃	8-12
Mn	2-15
Loss on ignition	approx. 6
Moisture	10-18
Total Oxides	approx. 86 (including insolubles)

In the Metallic Iron Formation the resulting ores will contain:

Fe	60-63
SiO	3-5
Al O	3 (occasionally to 10)
Moisture	less than 10

In the Ruth Slates enrichment of the first type is infrequent and rarely reaches ore grade. Enrichment of the second type is also infrequent and when it occurs, is limited to the top of the formation. In fact, only one workable orebody is known in this formation and this only because of its high manganese content.

The late Proterozoic or early Cambrian movements have produced premineralization folds and faults.

The Cretaceous movements are seen to cut the actual ore in several working faces. The fault scarps in the ore are filled with gravel

containing Cretaceous plants and boulders of dolomite, chert breccia, iron formation and ore, frequently re-cemented by ore.

It seems probable that this type of ore is paleozoic, as there has been no considerable change in the topography of the area since those times and the orebodies, at whatever elevation they may outcrop-bottom, with rare exceptions, at the same depths from the ground surface.

NATURE OF THE ORE

The ore that is found in the trough area is derived from two unrelated processes, acting under different conditions but tied to the pattern of tectonics in the area.

The ore bodies that result from these processes are therefore of a highly irregular nature. Changes of ore grade occurring suddenly and with no definite pattern, except for the fault trends are found throughout the area. The same face may show, without change of physical texture, sharp contacts between a light yellow highly aluminous ore, a black goethite ore and a jet black manganese ore (Gustafson & Moss 1953, 7 p. 63).

The desilification increases the porosity of the rock, reduces its cohesion and tends to set free the individual grains, while the second type of enrichment presupposes strong fissuring and will generally be insufficient to reconsolidate the rock.

The ore in the area is very easily broken up even though they may have a massive appearance. This is due to the fact that the rock is porous and fissured containing many minerals and a large amount of water plus the fact that the area is waterlogged and in the winter the area is frozen to a great depth, thus disintegrating the ore.

Lumpy ore is an exception and at present, run-of-mine average

only about 10 per cent is material above 5 inches.

The ore is divided into three classes from mining purposes, these are Bessemer, Non Bessemer, and Manganiferous. All ore above 50 per cent iron and less than 20 per cent silica is mined.

Ore Averages

	Bessemer		Non Bessemer		Managiferous	
	Limits %	Overall average %	Limits %	Overall average %	Limits %	Overall average
Fe	50.0-67.1	60.73	53.8-61.6	57.53	44.5-54.4	50.70
Mn	0.08-1.04	0.29	0.06-1.29	0.53	3.14-11.70	7.64
P	0.014-0.043	0.027	0.048-0.211	0.118	0.012-0.196	0.109
SiO ₂	2.26-18.24	8.71	9.19-13.33	8.07	3.25-17.50	7.92
CaO	0.05-0.25	0.09	0.05-0.24	0.11	0.04-0.20	0.10
MgO	0.04-0.11	0.05	0.04-0.10	0.06	0.04-0.09	0.06
Al ₂ O ₃	0.13-2.53	0.59	0.25-3.60	1.47	0.26-2.20	1.32
S	0.009-0.023	0.012	0.009-0.034	0.012	0.005-0.042	0.012
Loss on ignition	0.27-9.55	2.88	2.00-10.29	6.34	1.13-10.25	6.65
Total tonnage proved	227,908,000		136,433,000		53,366,000	

(Choubersky 1957, 2 p. 45)

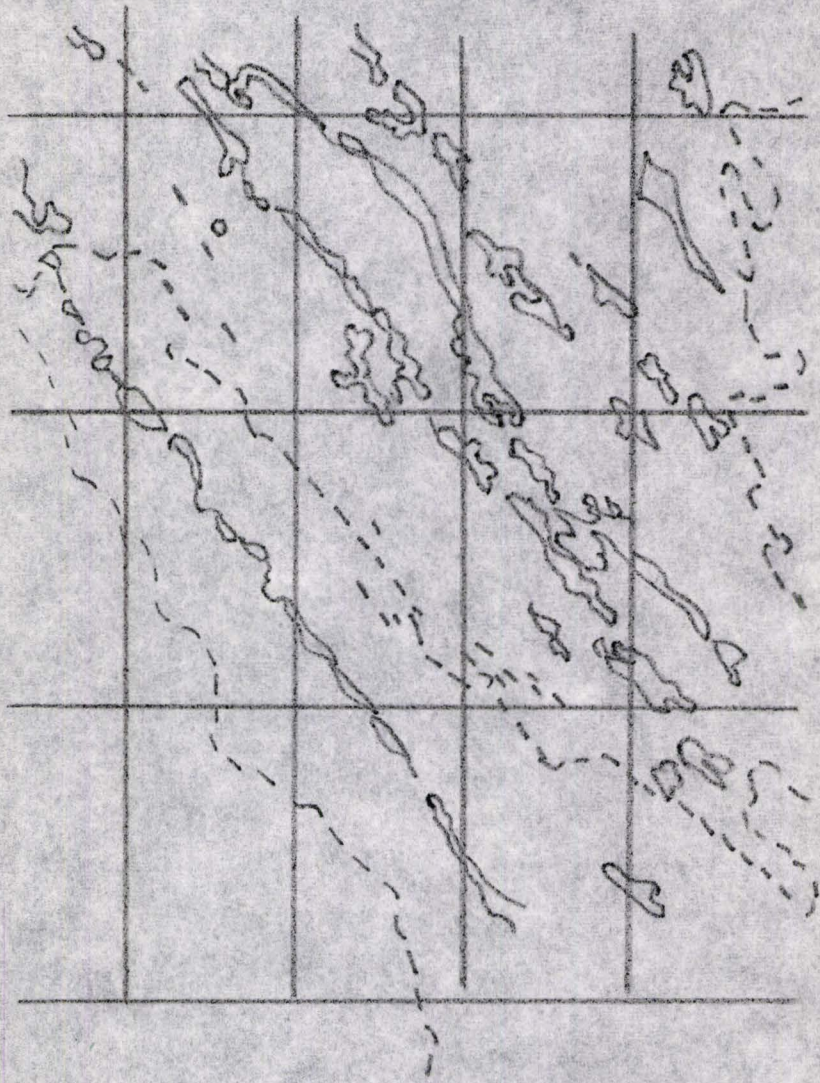
OREBODIES

The end of the 1957 season prospecting had proven the existence of 44 orebodies that were of a size sufficient enough to warrant mining and with ore of quality to fulfill necessary requirements. These orebodies contain a total of 418 million tons and are miles wide extending north and south of Lake Knob (Choubersky 1957, 2 p.50)

Thirty of the ore bodies containing 283 million tons of ore located in an area 20 miles long and 8 miles wide around Lake Knob.

The size of the orebodies varies greatly (Choubersky 1957, 2 p. 51):

- 2 Orebodies contain less than 1,000,000 tons
- 12 orebodies contain between 3 & 3 million tons
- 5 orebodies contain between 3 & 5 million tons



7
0

11 orebodies contain between 5 & 10 million tons
 3 orebodies contain between 10 & 15 million tons
 4 orebodies contain between 15 & 20 million tons
 5 orebodies contain between 20 & 25 million tons
 1 orebody contains between 30 & 35 million tons
 1 orebody contains 52 million tons

The distribution of various ore types within the ore bodies is very uneven.

The orebodies containing over 10 per cent manganiferous ore are mostly located in the southern area of the ore field around Lake Knob and Burnt Creek. **Three** bodies further north around Sunny Lake, either contain none of less than 10 per cent manganiferous ores.

The best bessemer ore or the bodies containing large percentage of Bessemer ores are found in the Flening and Sunny Lake areas. The orebodies around Lake Knob contain less bessemer ore.

Most of the outcrops found so far lie on the Quebec-Labrador watershed which constitutes a plateau some 500 feet above the adjoining country within this plateau, 13 deposits crop out along the flanks of hills, 24 are situated in gently rolling country, 3 lie along ridges and 3 are found in low vallies.

All the orebodies lie in steeply dipping strata and in strongly folded and faulted formation. Their elongation is along the strike of the rocks and the ore generally bordered on one or both sides by strike faults. Tight synclinal structures appear favorable; along the strike the ore grades into unaltered iron formations.

No matter at what elevation that the bodies appear they seem to extend downward 300 feet below the surface level. one orebody (Choubersky 1957, 2 p.49) has been drilled to 600 feet and is expected to borrom at 800 feet. Grade does not change with depth.

RESERVES

To date most of the orebodies found so far have iether outcropped on high ground or have given surface indication of their presence such as frost float(Gustafson & Moss 1953 7 p. 67) Large areas covered by thick drift, bods and lakes still remaine to be explored in detail. Taking into account the area left in the 90 mile area containg the orebodies. The present reserves may be greatly increased.

In 1952, (Iron Ore Company of Canada) a figure of 3000million tons, similar to that for Mesabe was indicated as the amount of direct shipping ore contained in the trough area. To date the work completed in the area is insufficient ot disprove this figure; at least it appears somewhat high for the proven reseves (choubersky 1957 2 p. 50).

To date their have been no estimates made on the amount of concentration ores in the area but due to the nature of the host rocks this should be very great. Several companies are studying the area just north and south of the mining area.

CONCLUSION

The iron formations of theLaborador Trough area has been compared to the Lake Superior area and especially to the Mesabe Range of that area from the very earliest.

This summation is true in reference to the leached area where there are large areas of rich hematite ore. The similarity in other ore bodies is like that of Lake Superior due to the fact of its high manganese content up to 13% in Laborador area while 8% is top for Lake Superior. The ore in the Two areas is different in that the Laborador ore changes from one type to the other rapidly while the Lake Superior ore is more uniform and grades more evenly in type. The Laborador area also has a large amount of magnetite ore bodies.

The ore bodies in the two areas also have different structural bases. The Laborador area being synclinal while Mesabi is anticlinal. Laborador has close folding and much faulting while the Mesabi shows no close folding, except, in the eastern end and only two large faults.

The Mesabi area has bodies going deeper than 900 feet while the greatest depth for Laborador is 800 and in most bodies only 300 feet deep.

The fact that the Laborador are so shallow is accounted for on the depth of the permafrost this also so accounts for the uniformity of depth on the deposits with other factors effecting the ore deposit that differs

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