Scientific and Industrial Research Council — *Report No. 7*

FOURTH ANNUAL REPORT
ON THE
MINERAL RESOURCES OF ALBERTA, 1922

PART II.

AN OCCURRENCE OF IRON ON LAKE ATHABASKA

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LETTER OF TRANSMITTAL

HONOURABLE HERBERT GREENFIELD,

Provincial Secretary,

Edmonton, Alberta.

Sir:—I have the honour to transmit herewith Part II. of the Fourth Annual Report on the Mineral Resources of Alberta for the calendar year 1922.

This report deals with "*An Occurrence of Iron on Lake Athabaska*", and is accompanied by a geological map of the lake shore, and a sketch map which shows the particular district examined and the position of certain mineral claims staked for iron by Messrs. E. A. and N. C. Butterfield in 1921. Much prominence has been given to this district through reports that rich deposits of iron occurred there.

The geological features shown on the map have been compiled from maps and reports published by the Geological Survey of Canada and from personal observations made by the writers of this report.

This district does not lie within the province of Alberta, but is about 56 miles east of the Alberta-Saskatchewan boundary. However, any minerals produced along the shore of lake Athabaska would have to be brought out of the north through the province of Alberta.

The first chapter in this report deals with the geology and the economic characteristics of the iron-bearing rocks which are too low in iron to be considered iron ores. The most favorable interpretation has been taken of all data obtained in the field, and from laboratory investigations. It was considered advisable to discuss rather fully the commercial possibilities of utilizing iron ores in this part of Canada if such ores were discovered in the future. These possibilities are considered, and data given on the cost of producing pig iron from ores in this district in the second chapter of the report.

This report has been prepared by the undersigned and by Alan E. Cameron, Associate Professor of Mining Engineering at the University of Alberta. Mr. Cameron has been responsible for that part of the report which deals with the commercial possibilities of iron ores that might be found about lake Athabaska.

All of which is respectfully submitted.

Yours truly,

JOHN A. ALLAN.

University of Alberta,

Edmonton, Alberta,

February 7th, 1923.

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An Occurrence of Iron on Lake Athabaska

BY

JOHN A. ALLAN AND ALAN E. CAMERON

CHAPTER I.

GEOLOGY

OBJECTS OF THE INVESTIGATION

The occurrence of iron-bearing rocks has been reported from time to time along the north shore of lake Athabaska, since the earliest geological surveys of that district were made by J. B. Tyrrell in 1893. In 1921 renewed interest arose from reports and specimens brought by Messrs. E. A. and N. C. Butterfield. As an iron deposit with economic possibilities would tend to build up a basic mining industry which would have a direct effect on the industrial development throughout western Canada, and as this district is accessible only by way of the western end of lake Athabaska, Athabaska river, and the Alberta and Great Waterways Railway, the government of the province of Alberta considered it advisable that an investigation should be made of this occurrence, although the particular area does not lie within its province. The necessary field work was carried out by the writers between the 24th of July and the 11th of August, 1922.

LOCATION OF THE DEPOSITS AND MEANS OF ACCESS

The deposits about to be described lie on the north shore of lake Athabaska, 112 miles northeast of Chipewyan, about 20 miles east of Crackingstone point, 56 miles east of the Alberta-Saskatchewan boundary, and four miles west of Moose island. The principal deposits occur on the lake shore, and about a small bay, named by the discoverers "Fishhook bay." The locality is just slightly north of the main route of travel between Chipewyan and Fond du Lac. The district is most accessible by way of the Alberta and Great Waterways Railway from Edmonton to Waterways (300 miles); Athabaska river from Waterways to Chipewyan (236 miles); and thence east along the north shore of lake Athabaska, about 112 to 120 miles via the course followed by boats on the lake travel. The total distance from Edmonton by this route is about 650 miles.

An alternative route is by way of the Edmonton, Dunvegan and British Columbia Railway from Edmonton to Peace River, a distance of 312 miles; Peace river to Chipewyan, a distance of 490 miles, including a portage of four miles at Vermilion Chutes; and Chipewyan to Fishhook bay, a distance of 120 miles. This makes a total distance by this route of about 920 miles.

Previous Investigations

In 1893, J. B. Tyrrell* noted the presence of iron in pre-Cambrian rocks exposed on the north shore of lake Athabaska at several points between Chipewyan and the east end of the lake. Camsell†, in 1914, in his report on the Tazin and Taltson rivers, notes the presence of early pre-Cambrian rocks carrying iron, and mentions their occurrence in the vicinity of the mouth of Charlot river. In 1914, Alcock‡ made a geological reconnaissance of the north shore of lake Athabaska, and in 1916** examined areas of iron-bearing rocks exposed in the vicinity of Black bay and Beaverlodge bay, about Crackingstone point, and closely adjacent to the district described in this report.

General Physiographic Features

The country adjacent to the north shore of lake Athabaska, throughout its entire length of 175 miles, is represented by low relief. The hills are well-rounded by glaciation, and rise in places abruptly to a maximum elevation of about 700 feet above the lake, or 1400 feet above sea-level, within a distance of 6 miles from the lake shore. The shore line is indented by numerous bays and coves, some of which penetrate the upland, with irregular outline, for a distance of several miles. On the whole, the north shore may be regarded as rugged, and, especially to the south-west of Crackingstone point, shelter for boats is hard to find. Eastward from Crackingstone point the numerous islands afford ample shelter for the deepest draft boats, the lake shores dropping abruptly into several fathoms of water within a few feet of the shore. (Plates I. and II.)

At many points the bays follow the trend of the rock structure and frequently represent softer bands of rock which have been eroded by glacial action. (Maps 3 and 4.)

The well-rounded ridges along the shore line have a general north-south trend, but the persistence of any ridge is not great, the general appearance being in the nature of rounded, irregularly

*Tyrrell, J. B.: Report on country between Athabaska lake and Churchill river, N. W. T.; Geol. Surv., Can., New Series, Vol. VIII. Pt. "D", 1895, p. 54.

†Camsell, C.: An exploration of the Tazin and Taltson rivers, N. W. T.; Geol. Surv., Can., Memoir 84, Geol. Series, No. 69, 1916.

‡Alcock, F. J.: Geology of north shore of Lake Athabaska, Alberta and Saskatchewan; Geol. Surv., Can., Sum. Report, 1914, p. 60.

**Alcock, F. J.: Beaverlodge lake area, Athabaska lake, Sask.; Geol. Surv., Can., Summary Report, 1916, p. 152.

placed knobs. The rock surfaces are in all cases heavily striated, and frequently polished by the action of the ice. The general direction of the glacial striae is about south, 60 degrees west, magnetic. Vegetation is scant throughout the region, being confined to the lower lands about the bays and inlets, where it largely consists of spruce, jack pine, poplar and willow.

GENERAL GEOLOGY

The geological succession of the rocks on the north shore of lake Athabasca has been tabulated by Alcock* as follows:—

QUATERNARY	Recent	River deposits, lake beaches
	Pleistocene	Glacial deposits
	Unconformity	
PRE-CAMBRIAN	Athabaska series	Sandstone, arkose, conglomerate, trap flows, sills, and dykes.
	Unconformity	
	Granites and gneisses	
	Intrusive contact	
	Tazin series	Iron formation, quartzite, slate, dolomite, schists.
	Unconformity	
	Gneissic complex	

In discussing the gneissic complex and the granites and gneisses, Alcock states that, "it was not found possible to differentiate the granites and gneisses of the region, although they clearly belong to at least two different periods of intrusion. The greater part of them are younger than the rocks of the Tazin series, as is shown by their intrusive contact with the latter at most places. The existence of an older complex is shown, however, by several lines of evidence; granites are found at various places cutting foliated gneisses; at two different localities Tazin quartzite was found dipping off from a surface of gneiss; a few pebbles of gneiss were, in one locality, found in Tazin sediments; the fact that the dominant sediment of the Tazin series is quartzite implies the existence of an older acidic terrane. Though most of the gneisses are clearly igneous. The fact that some of them are graphitic and others garnetiferous, is suggestive of a sedimentary origin for at least part of the older complex."

These general considerations, which were applied principally to the rock around Beaverlodge bay, can be taken to describe the

*Alcock, F. J.; Geol. Surv., Can., Summary Report, 1916, p. 153.

conditions in the district further east about Fishhook and Moose bays, shown in Map 3. The larger areas of granite and gneiss shown on the sketch map probably, in part at least, represent the older gneissic complex; but in the small area on the west side of the Besmer mineral claim the granite is younger than the Tazin series, as fragments of dolomite and ferruginous quartzite were found enclosed in the granite.

Tazin Series.—The name *Tazin series* was introduced by Charles Camsell for a group of rocks seen by him in his exploration journey in 1914 from Athabaska to Great Slave lake by way of the Tazin and Taltson rivers. Rocks of this series occur on the north shore of lake Athabaska in three areas: on the mainland north of Burntwood island and west of Big point; from near Grey Willow point to Charlot river; and from the east side of Crackingstone point to near the mouth of Old Man river. This last area includes the exposures about Beaverlodge, Fishhook and Moose bays.

The rocks belonging to the Tazin series in the vicinity of Fishhook bay consist of greenish and dark grey quartzites (frequently ferruginous), white and iron-stained dolomites, ferruginous slates, and greenish chlorite and amphibolite schists. At a few points around Moose bay and, particularly, about Fishhook bay, certain beds of quartzite and dolomite are highly stained with iron and represent local concentrations of iron ore. These concentrations have the form of bands and lenses which conform to the general strike of the rocks. To a similar iron-bearing series in Beaverlodge bay area, Alcock has assigned the name, "Iron formation," and this name will be used in describing these rocks about Fishhook bay. It is important to note, however, that the iron formation is distinctly banded within itself, consisting of white and ferruginous quartzites and dolomites interbanded with thin layers of hard, blue hematite. A red color is the predominant weathering color of the formation, and this is characteristic of the white quartzites and dolomites as well as of the ferruginous beds. The distribution of the iron formation as exposed about Fishhook bay is indicated in the sketch map 4. The actual width of the iron formation nowhere exceeds 50 feet.

Athabaska Series.—The Athabaska series, composed of thick-bedded sandstones, arkoses and conglomerates, does not outcrop in the region adjacent to Fishhook and Moose bays. This series occurs abundantly along the south shore of the lake throughout the whole length of the shore line. It is also reported by Alcock to occur in the Beaverlodge lake area north of Beaverlodge bay, where it has a thickness of approximately 8,800 feet.

Pleistocene and Recent Deposits.—Pleistocene glaciation has been largely responsible for the present topography about Athabaska lake. The more resistant rocks have been rounded and polished and stand up as irregularly shaped knobs. The softer, more highly metamorphosed, rocks have been eroded to lower levels. The direction of the ice movement, as shown by glacial striae, was south, 55 degrees west. The bays and island groups, particularly along the north shore, conform to this general direction. Where the iron formation outcrops it shows a very highly polished surface, having in places where iron is abundant, a distinct metallic lustre. Such islands as Beartooth, Burntwood and Big islands consist of glacial debris left by the retreating ice sheet, and appear to mark remnants of a terminal moraine formed, possibly, during a period of halt in the general retreat of the ice from the region. According to Dowling's report on the south shore of the lake* the hills lying about 8 to 12 miles south of the lake are composed in large part of morainal material and boulder clay made up largely of debris from the underlying Athabaska sandstone.

The south shore of Athabaska lake from Old Fort bay east almost to the narrows is characterized by a wide, sandy plain, marked today by extensive stretches of sand dunes. These plains were produced from the glacial moraines and from the Athabaska sandstone when the lake stood at a higher level than at present. Offshore, sand and gravel bars are numerous, and form shoal water conditions extending in places for several miles from the shore. These features are particularly characteristic of the shore line from Old Fort bay east to Barrier point, and form a serious hindrance to navigation along this portion of the shore. The mouth of Williams river is considered the only possible harbor on the south shore for small craft between Athabaska river and the narrows. This would appear to be the natural terminus for a projected railway to Athabaska lake, but the off-shore conditions are such that it would require extensive dredging operations to make a harbor that could be reached by craft of any considerable size.

On the north shore of Athabaska lake a similar low, sandy shore, with numerous sand dunes, extends from Big point to Lobstick island.

The west end of the lake consists of a broad, alluvial plain, extending several miles south of the 28th base line, a distance of about twenty-five miles in a straight line. This plain is the delta of Athabaska river. Alluviation of the lake is still in progress, so that the many river channels change their position frequently. In stages of low water it is only with great difficulty that navigable channels can be found that will allow the passage of the numerous types of shallow-draft boats now in operation on the river.

That the lake formerly occupied a larger basin and stood at a higher level is evidenced by the numerous gravel and shingle beaches that occur at various points about the lake shore. In the vicinity of Fishhook bay as many as fifteen distinct lake terraces were observed (Plate VII.). The early history of this and other northern lakes has been fully discussed by one of the writers of this paper†.

*Dowling, D. B.: Geol. Surv., Can., Summary Report, 1895, pp. 68D to 71D.

†Cameron, A. E.: Post-glacial Lakes in the Mackenzie River Basin, etc."; Jour. Geol., Vol. 30, No. 5, 1922, pp. 337-353.

STRUCTURAL GEOLOGY

The rocks of the Tazin series, as exposed about Moose and Fishhook bays, are highly folded and metamorphosed. The strike of the rocks is not constant, but varies from about north, 50 degrees east, to north, 30 degrees west. In most cases the trend of the bays tend to conform to the strike of the rocks, as is well shown in the sketch map 4. Attention might be drawn in particular to the outline of Fishhook bay and the deep bay lying about one mile east of the eastern side of the Besmer mineral claim.

There is no regularity to the dip of the rocks. About Fishhook bay the predominant dip is westerly, at angles from 30 to 50 degrees. On the Besmer claim the two bands of iron formation shown on the sketch map are dipping about 35 degrees to the northwest. No attempt was made to work out the structure in detail except in those localities where the iron formation occurs. but it seems likely, as stated by Alcock, that, "the areas where these rocks are exposed today are mere synclinal remnants of a once widespread series." The structure of the gneisses is equally as complex as that of the Tazin series, but the granites are not affected to the same extent. The peninsula shown on the west side of the Besmer mineral claim consists chiefly of a pink granite, enclosing small and large, irregular blocks of dolomite, quartzite, quartz schists, and iron formation. These granites are therefore of a more recent age.

ECONOMIC GEOLOGY

In the vicinity of Fishhook bay, shown on Plate I., five mineral claims were staked for iron by Messrs. E. A. and N. C. Butterfield during the summer of 1921. An examination of the area in which these claims were staked formed the principal portion of the field work. The shores of Fishhook bay were examined in detail, and every exposure of iron-bearing rock was sampled. At several points traverses for some distance from the shore line were made, completely covering the area blocked out by the claims. The outcrops of the iron-bearing rocks, outlined on the sketch map 4, represent the only exposures encountered during the examination.

Iron Formation.—As previously noted, the iron-bearing rocks of the Tazin series represent bands and lenses of quartzite and dolomite in which local concentration has caused an enrichment in iron. The iron formation is characterized by an intricate, irregular interbedding of quartzites, quartz schists and dolomites, occurring as narrow bands or lenses with more massive-bedded, less ferruginous quartzites and dolomites. All of these rocks weather to a dominant red color. The more highly ferruginous rocks, however, are limited in thickness from a mere fraction of an inch to a maximum of not over 50 feet. The lateral extent of these ferruginous bands is also limited. For example, at one point on Fishhook bay a lense of rock, apparently highly ferruginous, varied in thickness from 14 inches at the widest point to one-half inch within a dis-

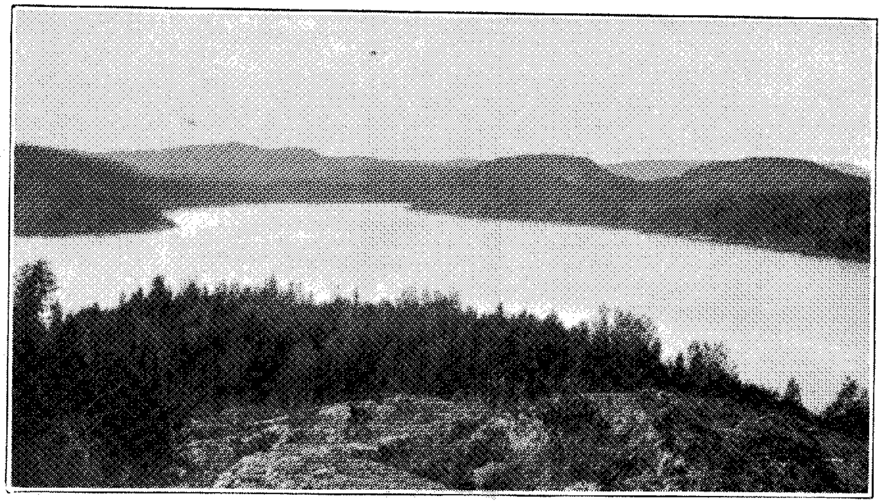

PLATE III.—Looking into Fishhook Bay from a quartzite knob in the centre of the Valley Mineral Claim. Doris and Dock Mineral Claims lie on the left.

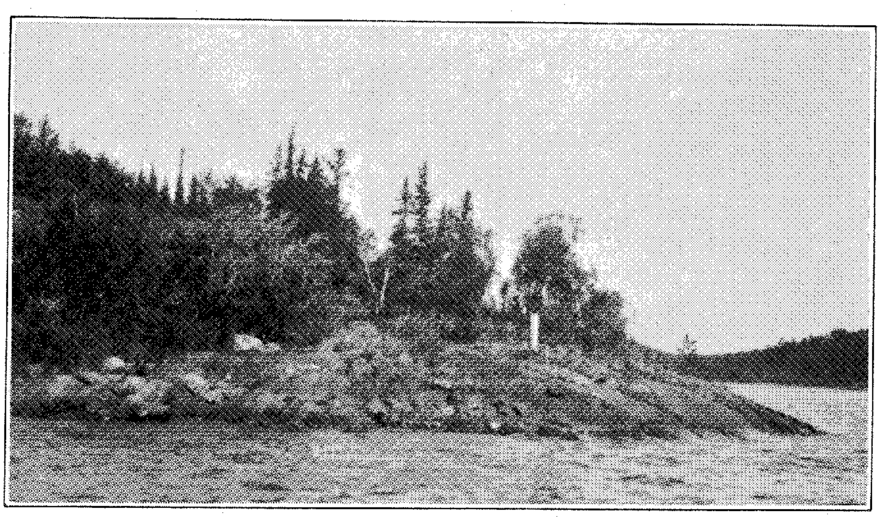

PLATE IV.—No. 1 post. Jay Mineral Claim, characteristic exposure of Schists.

tance of fifteen feet. This particular band, which appeared to carry a high iron content in the hand specimen, proved on analysis (No. 8) to carry only 12.11 per cent. metallic iron.

In the field there can be recognized three types of rocks rich in iron: coarsely crystallized red dolomites; massive red quartzite; and a thin-bedded, flaggy, bluish quartzite representing the slaty type. Of these, the last mentioned usually has the highest iron content.

Surface waters running over and passing through the iron-bearing rocks deposit an encrustation or coating of iron oxide on all materials with which they subsequently come in contact. For example, the wash of waves along the lake shore, and the water draining small lakes lying within the Jay mineral claim, have given a red stain to glacial boulders of granite, gneiss, quartzite and other rocks scattered along the lake shore on the south side of the Jay mineral claim. (Plate IV.). Similar conditions are shown on rounded and angular fragments forming the beach gravels, derived from the neighboring rocks along the shores of the bays about the Besmer mineral claim (Plate V.). The bottom of the shallow bay just east of the Besmer claim shows a series of seventeen lake beaches (Plate VII.), all of which are iron-stained, although few of these pebbles have been derived from the iron formation.

Along the east side of the Dock mineral claim, and north of Fishhook bay, there lies a broad valley-like depression (Plate III.). It is swampy in character, and apparently is frequently flooded during high stages of water in lake Athabaska. The fine sediments along the floor of this depression are highly stained with iron, and some bog iron ore is in process of formation, but only in very small quantities.

Analyses.—The following table gives analyses of samples and specimens collected from various outcrops about Fishhook bay. The samples represent the average of chips taken across the width of iron-rich bands. The specimens represent individual fragments from the richest looking bands. The analyses were made by J. A. Kelso, Director, Industrial Laboratories, University of Alberta.

TABLE I.—ANALYSES

	1	2	3	4	5	6
Silica	1.28	0.51	14.82	0.96	0.52	55.80
Iron Oxide.......	6.04	10.02	11.40	4.90	9.80	43.40
Alumina	0.38	0.10	0.28	0.00	0.09	0.15
Lime	28.56	26.41	23.02	29.21	27.01	0.00
Magnesia	20.06	19.38	15.02	19.12	17.00	0.00
Ignition Loss ...	43.80	43.40	35.01	45.20	45.31	0.50
Phosphorus	....	0.027	....	....	....	0.018
Sulphur	....	0.049	....	....	....	0.052
Equivalent in metallic iron...	4.22	7.01	7.98	3.43	6.86	30.38

	7	8	9	10	11	12
Silica	59.10	60.40	49.82	44.24	55.76	50.80
Iron Oxide	22.90	17.30	48.61	54.60	42.08	44.90
Alumina	0.30	0.08	0.07	0.19	0.60	3.10
Lime	4.40	8.51	0.00	0.00	0.00	0.00
Megnesia	3.94	4.80	0.00	0.00	0.12	0.00
Ignition Loss	8.60	8.40	1.01	0.90	0.90	0.90
Phosphorus	....	0.049	0.016	0.014	0.021	0.031
Sulphur	....	0.060	0.060	0.050	0.041	0.021
Equivalent in metallic iron ..	16.03	12.11	34.02	38.22	29.45	31.43

1. Sample across exposure of red dolomite, 20 feet wide, south-east corner of Jay mineral claim.
2. Specimen, same locality as No. 1.
3. Sample across exposure of red dolomite, 40 feet wide, north-east corner of Jay mineral claim. (Plate VIII.)
4. Sample across exposure of red dolomite, 30 feet wide, west side of peninsula north of Valley mineral claim. (Plates I. and IX.)
5. Specimen from same locality as No. 4.
6. Specimen of thin-bedded, flaggy, bluish iron-slate from north-east corner of peninsula north of Valley mineral claim. (Plate X.)
7. Sample across exposure of red quartzite, 25 feet wide, on east side of peninsula north of Valley mineral claim. (Plate VI.)
8. Specimen of red quartzite from same locality as No. 7.
9. Sample across exposure of interbedded red quartzite and blue iron-slate, 35 feet wide, on the western exposures on Besmer mineral claim.
10. Specimen of red quartzite from same locality as No. 9.
11. Specimen of thin-bedded, flaggy, blue iron-slate from Besmer claim.
12. Sample across exposure of blue iron-slate, 30 feet wide, about one mile and a quarter east of Besmer mineral claim.

The table shows that none of the samples analysed are iron ores. The first five analyses represent carbonate rocks, which are described as red dolomites, or dolomite marble. Analyses 7 and 8 show the highest silica content, and the microscopic examination shows that other silicates, in addition to quartz, are present. The other five analyses represent ferruginous quartzites.

Microscopic Examination.—It is not possible to determine the mineralogical composition of these iron-bearing rocks from the hand specimen, as iron oxide is abundant and stains the entire rock. Thin sections from some of the richer looking iron-bearing rocks were therefore prepared for microscopical examination. Such an examination shows what iron minerals are present, and their relation to other minerals in the rocks. Photomicrographs were taken of four of these sections (Plates VIII. to XI.), and these show the relative amounts of iron minerals present. The microscopic study bears out the evidence shown by the analyses: that there are no iron ores of commercial value in the district examined about Fish-hook bay.

Plate VIII. is a photomicrograph of a representative part of the thin section of a red dolomite marble from the north-east corner of the Jay mineral claim. The analysis of a representative sample

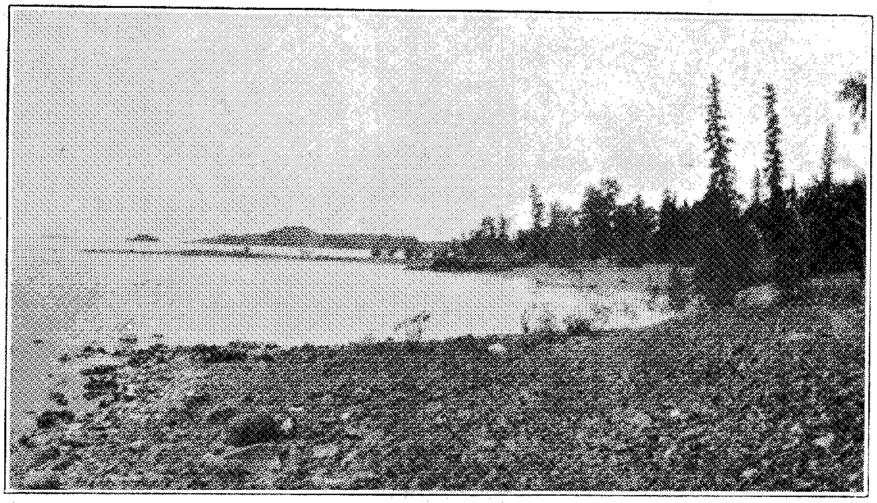

PLATE V.—Red Shingle Beach on south side Besmer Mineral Claim. Sample No. 9 was taken from iron formation to right of picture.

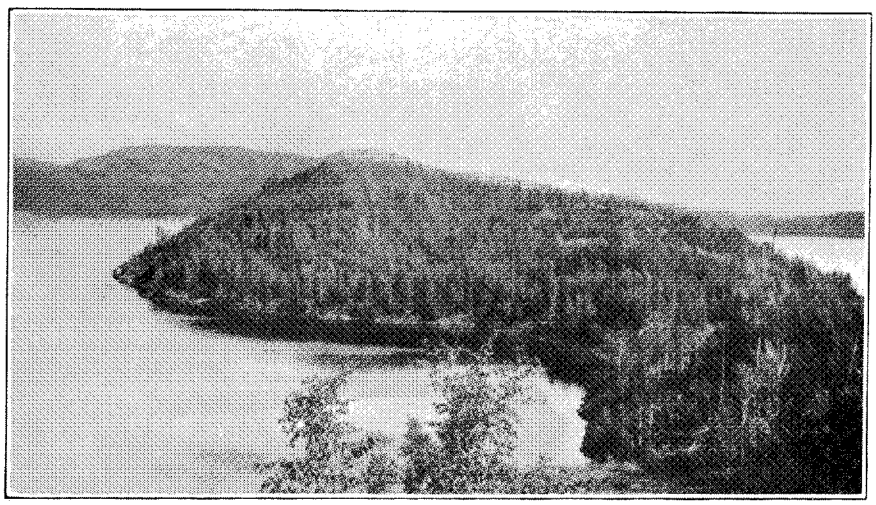

PLATE VI—Looking southeast from end of peninsula on east side of Fishhook Bay. Sample No. 7 was taken from point on the left of the picture.

taken across 40 feet of this rock is shown as analysis No. 3, Table I. The rock consists essentially of angular grains of dolomite, and a small amount of accessory green chlorite. There are irregular segregations and clusters of granular hematite, which make up 10 per cent. of the whole rock. Red iron oxide from the hematite is more widely distributed between the grains of dolomite.

Plate IX. is a photomicrograph of a deep red dolomite from the west side of the peninsula just north of the Valley mineral claim. The analysis of a representative sample taken across 30 feet of the mineralized band is shown as analysis No. 4, Table I. From an examination of the hand specimen, this rock might be called an iron ore, but the photomicrograph shows that the iron is in the form of the red iron oxide, which has been brought in by solutions and deposited around the grains of dolomite and along the cleavage planes of this mineral.

Plate X. is a photomicrograph of a dark bluish hematite schist from the north-east corner of the peninsula north of the Valley mineral claim. Analysis No. 6 was made from a specimen representative of the whole width of the band, and contains 30.38 per cent. metallic iron. The silica content is high, being 55.80 per cent. in the analysis. The photomicrograph shows that most of the silica is in the form of quartz. Hematite occurs in shreddy masses that appear to replace an older mineral. There is some magnetite, and the hematite grains are partly altered on the margins to red iron oxide.

Plate XI. is a photomicrograph of a thin section made from the specimen that gave analysis No. 11 in Table I., with 29.45 per cent. metallic iron and 55.76 per cent. silica. The specimen comes from the south side of the Besmer mineral claim, within one hundred yards of the shore line shown in Plate VI. The rock is massive, bluish in color, and has the appearance of being almost pure hematite. It weathers as a flaggy iron-slate and the bands of this grade are only a few inches thick. In the photomicrograph, the speckled mineral is granular hematite, the black is magnetite, and the white mineral is quartz. The quartz represents over half of the whole rock.

Other specimens examined included a red jasper rock from the same locality as that represented in Plate XI., but from a different bed. Analysis No. 10, Table I., was made from this specimen, and shows 38.22 per cent. metallic iron. This is the highest iron content obtained from the samples analysed, but there is no quantity of material of this grade. Fourteen inches was the thickest band of uniformly rich iron rock at this locality. Microscopically the rock consists of quartz and hematite, with a small amount of magnetite in a banded structure. The radiating, needle-like habit of the hematite suggests that it is an alteration product from tremolite. The hematite is associated with a finely crystalline quartz, which is secondary, so it would appear that the hematite is not a primary mineral, but that it has been brought into the rock by solutions during the period of alteration.

Another specimen from the same locality, but taken from a thin-bedded, bluish, ferruginous quartzite at the point where the channel sample gave analysis No. 9, Table I., with 34.02 per cent. metallic iron, was also microscopically examined. The thin section from this specimen showed that 80 per cent. of the rock consisted of clear quartz, and ferruginous muscovite, and that less than 20 per cent. was made up of shreddy and granular hematite and red iron stain. It is important to note that the metallic iron content in this specimen was less than 15 per cent., but when a representative sample was taken across the whole iron formation, here about 50 feet thick, the metallic iron content was twice as high. It is clear that the iron content varies greatly in adjacent beds, and that a uniform grade of iron rock cannot be expected.

A specimen obtained from the small point shown in Plate VI., occurring on the east side of the peninsula north of the Valley mineral claim, was classed in the field as a red jaspelite. Analysis No. 8, Table I., made from a part of the same specimen, shows only 12.11 per cent. of metallic iron. The microscopic examination explains the low iron content by showing over 80 per cent. of the rock consists of quartz, jasper, mica and sericite; the remainder being largely shreddy hematite and an abundant red stain of iron oxide.

A banded and brecciated dolomite, associated with the dolomites shown in Plate IX., on microscopical examination, was found to consist of crushed dolomite, with the fragments cemented together with dolomite, tremolite, epidote, hematite and limonite. The iron is distinctly secondary, and has been introduced later than the crushing.

Thin sections from a number of other iron-bearing rocks from the district were examined, but were not found to differ materially from those already discussed.

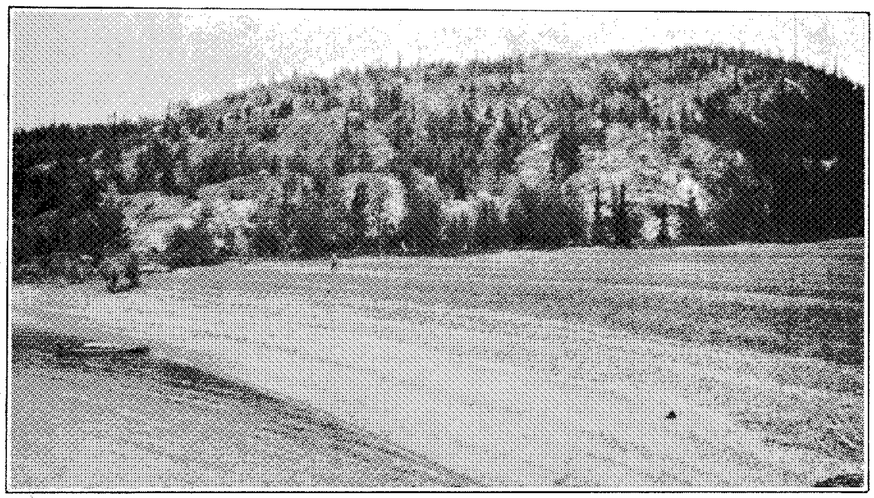

PLATE VII.—Beach terraces just east of Besmer Mineral Claim.

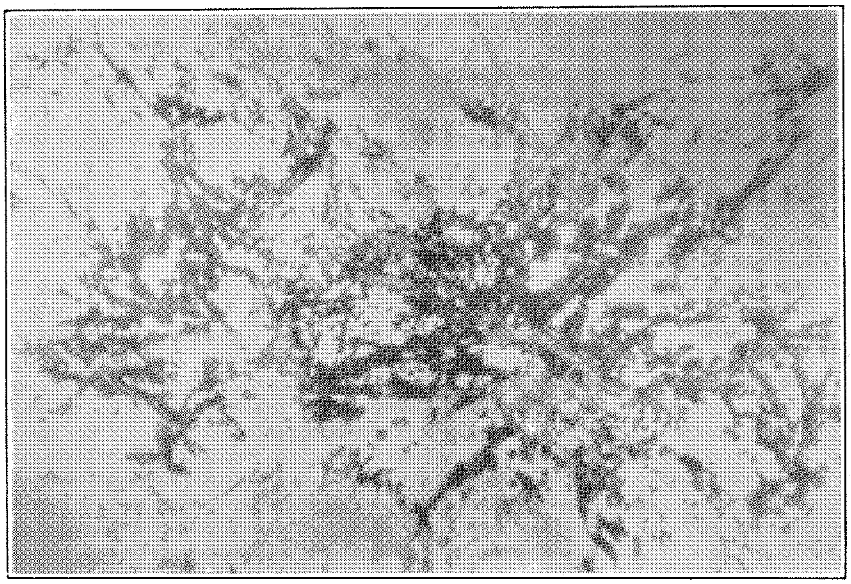

PLATE VIII.—Photomicrograph of Red Dolomite from the northeast corner of Jay Mineral Claim. Shows a small quantity of granular Hematite between the grains of Dolomite.
Magnified 75 diameters.

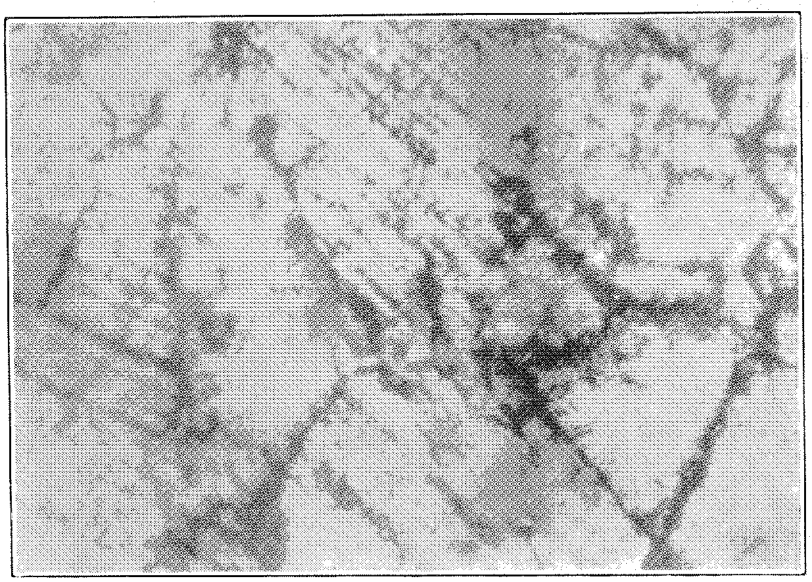

PLATE IX.—Photomicrograph of dark Red Dolomite Marble from the west side of the peninsula north of the Valley Mineral Claim. Shows red iron oxide at the crystal boundaries and along the cleavage planes in the Dolomite.
Magnified 75 diameters.

CHAPTER II.

COMMERCIAL POSSIBILITIES OF IRON ORE FROM LAKE ATHABASKA

TRANSPORTATION

In any consideration of the possible commercial development of iron ores from the district adjacent to lake Athabaska the problem of transportation is of first importance.

The areas in which iron ore may occur about lake Athabaska lie on the north shore of the lake, approximately in latitude 59°10′N. The nearest railhead to these deposits at present is the end-of-steel of the Alberta & Great Waterways Railway at Waterways, Alberta, in latitude 56°40′N. Transportation between these two points at present is limited to the water route down Athabaska river, 236 miles, and then north-east across the lake, another 110 to 120 miles.

Athabaska river opens for navigation about the first of May and ice is running in the river usually by the fifteenth of October. The season for navigation, therefore, is limited to approximately five and one-half months each year. The river is navigable for river steamers not exceeding three feet in draft between Waterways and lake Athabaska during the greater part of this time. Limestone ledges obstruct navigation during stages of low water for a distance of about ten to twelve miles below Fort McMurray, but from there north shifting sandbars form the only serious hindrance to traffic on the river during the navigation season.

Lake Athabaska is open for navigation between the mouth of Athabaska river and the outlet of the lake at Chipewyan early in May, but the eastern portion of the lake, including the shores adjacent to the possible iron fields, is not clear of ice much before the first of June, and it is doubtful if permanent navigation could be established before the fifteenth of June. The season for possible ore transport is thus limited to a little over four months.

The movement of ore in bulk by steamer or barge up the river would necessitate continuous dredging operations along the river channel, and particularly within the delta of the river. Beside these facts, it must be noted that the traffic would be all a one-way traffic, and that upstream. River transportation, particularly upstream transportation, is not an economical means of transportation, and can only be carried on by the charging of high freight tariffs. Package freight on Athabaska river now moves at a cost of 1½ cents per pound between Waterways and Fond du Lac; and under the most favorable conditions it is doubtful if ore could be brought upstream at less than $10.00 per ton. In Western Canada, at least, it has been clearly shown that river transportation cannot compete with rail transportation. River transportation on the Thompson, Fraser and other rivers was firmly established at one time, but with the advent of a parallel railway line traffic on these rivers rapidly dwindled until now it has virtually ceased.

The high cost of river transportation, together with the short navigation season, undoubtedly prohibits the movement of ores by water from the possible iron fields south to a smelter and market. If iron ores of high grade are found within the region, before any commercial development of the deposits could be contemplated it would be necessary to extend the Alberta & Great Waterways Railway north to lake Athabaska, a distance of approximately 200 miles. The country through which this railway would be projected is practically unsurveyed, and the difficulties to be encountered and overcome virtually unknown. It is known to be a rolling country, well wooded, and drained by many streams flowing in deep valleys. The cost of railway construction under these conditions would be high. Several engineers have quoted $40,000 a mile as a minimum estimate for such construction, and on this basis there would be required an expenditure of some $8,000,000 before any extensive production of ore from possible iron fields could be undertaken.

Inasmuch as this railway would be projected through an unsettled and undeveloped country, its traffic would be practically limited to the hauling of ore. The total freight entering the north country through Waterways at present does not exceed 2,000 tons per annum. Certain other industries, such as lumber, pulp, fisheries, etc., would in time undoubtedly increase the traffic on the railway, but it is safe to assume that at least half of the traffic would at all times have to come from the iron fields.

With the railway connected to lake Athabaska as outlined above, there still remains a water haul of about forty miles across the lake, together with the necessary dockage, and trans-shipment facilities. As navigation on the lake is limited to not over five months in the year, extensive storage yards would be required on each side of the lake, together with the necessary facilities for unloading and re-loading.

COST OF TRANSPORTATION

Tables II. and III. (see next page) give the freight rates charged by the Canadian Pacific and the Canadian National Railways on coal and pig iron for hauls throughout Western Canada. From them the graph, Figure I., has been prepared, showing both the rate per ton mile and total rate per ton of 2,000 lbs. for distances of from 100 to 1,000 miles.

No freight rates have been established relative to the handling of ores throughout the prairie provinces. Undoubtedly the shipment of iron ore by train load lots is elsewhere handled very cheaply. For example, ores from the Minnesota iron ranges to Duluth, distances of 50 to 70 miles, are charged as low as one-half cent per ton mile. In this case, however, very large tonnages are being hauled short distances, and it appears reasonable to assume that iron ores from lake Athabaska could not be hauled throughout western Canada at rates much cheaper than the present rates for coal. In all calculations in the following pages relative to the cost of transportation, ore, fuel and flux, the cost of transporting coal from Western coal fields to eastern points has been taken as a basis.

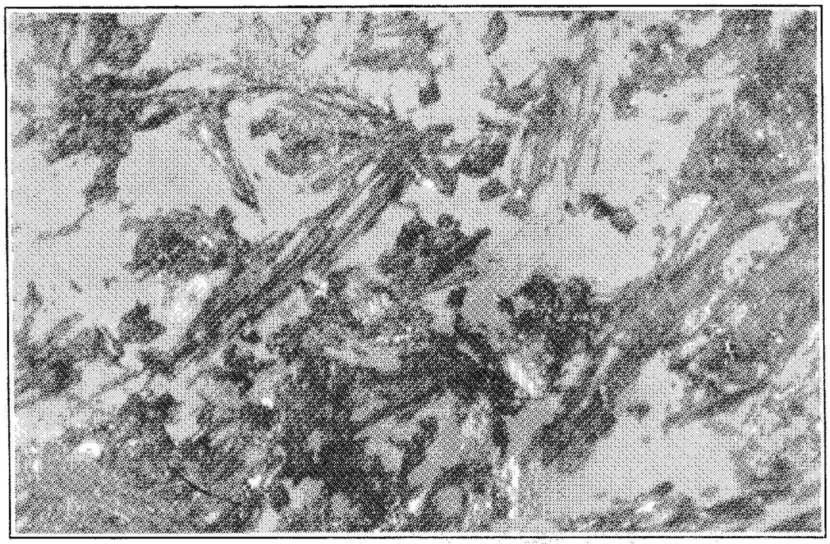

PLATE X.—Photomicrograph of dark bluish Hematite Schist from northeast corner of peninsula north of Valley Mineral Claim. Shows shreddy masses of iron oxide replacing an older mineral, Magnetite (black), Hematite (speckled), and altered to red iron oxide on margins. Magnified 75 diameters.

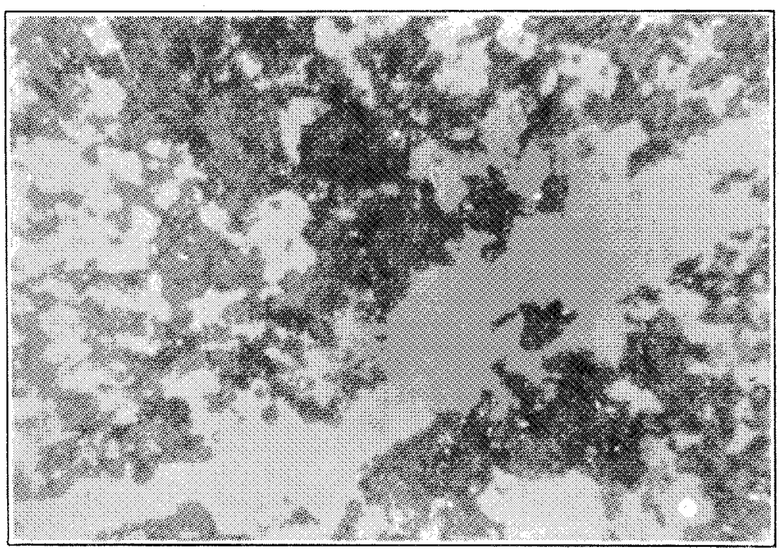

PLATE XI.—Photomicrograph of massive bluish, flaggy iron slate from south side of Besmer Mineral Claim. Shows granular Hematite (speckled), Magnetite (black), and Quartz (white). Magnified 100 diameters.

TABLE II.—WESTERN FREIGHT RATES—COAL—JAN. 1ST, 1923

Shipping Point	Coal Field	Railway	Destination: Winnipeg	Brandon	Portage	Souris	Prince Albert	Saska-toon	Regina	Moose Jaw
Fernie	Crow's Nest Pass	C. P.	5.30	4.80	5.10	4.80	4.90	4.40	3.90	3.70
Blairmore	" " "	" "	5.10	4.70	4.90	4.60	4.50	4.20	3.70	3.40
Canmore	Canmore-Banff	" "	5.30	4.80	5.10	4.80	4.20	3.90	3.90	3.80
Lethbridge	Lethbridge	" "	4.70	4.20	4.50	4.20	4.40	4.00	3.10	3.00
Taber	Taber-Bow Is'd	" "	4.70	4.10	4.40	4.10	4.40	3.90	3.00	2.90
Edmonton	Edmonton-Clover Bar	" "	4.70	4.70	4.70	4.80	3.10	2.90	3.70	3.60
Nordegg	Brazeau	C. N.	5.20	5.20	5.20	5.30	4.10	3.90	4.40	4.30
Coalspur	Yellowhead Pass	" "	5.20	5.20	5.20	5.60	4.10	3.90	4.70	4.60
Drumheller	Drumheller	" "	4.70	4.60	4.70	4.60	3.20	3.80	3.60	3.40
Evansburg	Pembina	" "	5.00	5.00	5.00	5.10	3.40	3.10	4.00	4.10
Cardiff	Namao	" "	4.80	4.80	4.80	5.00	3.20	3.00	3.80	3.90

TABLE III.—WESTERN FREIGHT RATES—PIG IRON—JAN. 1ST, 1923

Shipping Point	Origin	Railway	Winnipeg	Brandon	Portage	Edmon-ton-	Battle-ford	Saska-toon	Regina	Moose Jaw
Ft. William.....	Sault or U.S.A.	C. N.	3.80	5.10	4.30	10.40	8.30	8.60	7.30	7.80

Water transportation across the lake from the possible iron deposits to a railhead on the south shore, a distance of 40 miles, could probably be accomplished by proper scows or barges. The cost of such transportation is difficult to estimate. Stansfield* gives an estimate made by W. M. Brewer, of one dollar a ton for transportation of iron by barge from Texada island to Vancouver, a distance of about 75 miles. The cost of water transportation across lake Athabaska would probably be of the same order, and will be assumed at $0.50 per ton.

REQUIREMENTS FOR SMELTING

For the production of pig iron in a blast furnace and its conversion into steel, two materials other than the ore are required: fuel, in the form of coke; and flux, in the form of limestone.

Coke.—Coals capable of being converted into a good grade of commercial coke occur at a number of points in Alberta. All these deposits, however, lie well on the western edge of the province, and would mean a considerable rail haul to the ore. The nearest coking coals to lake Athabaska are probably those occurring in the Peace River Block of B. C., a distance of over 540 miles in a straight line from the ore deposits. The nearest railhead at present (Grande Prairie) is over 157 miles from these deposits, and the possibility of coke being supplied from this coal in the near future at least, is slight. Coking coals occur in the Mountain Park and Jasper districts, west of Edmonton, and these seem to be the points best suited to supply the coke required, although no coke ovens have been established up to the present. The nearest coke ovens at present producing coke are those of the Crow's Nest Pass Coal and Coke Company at Fernie in the Crow's Nest Pass. Coke is available at the ovens at the rate of $12.00 per ton, f.o.b. cars.

Flux.—Devonian limestones outcrop at a number of places along the valley of Athabaska river between McMurray and McKay. Chemical analyses from which an estimate of their fluxing value could be obtained are not available, but it seems reasonable to assume that beds of limestone could be located which would be suitable for fluxing material.

The low grade carbonate ores from the north shore of lake Athabaska, analyses of which are given in the table on page 17, could also be made to serve as fluxing material.

The cost of producing this material is problematical. Limestone for fluxing material is quoted on the markets at from $1.00 to $1.50 per ton f.o.b. quarry, and on this basis an estimate of $1.25 per ton for the production of the flux would appear reasonable. West of Edmonton, on the Canadian National Railway, limestones for cement manufacture are quarried near Entrance and Marlboro, and would probably serve as suitable material for flux. This material is available at a cost of about $1.00 per ton, f.o.b. cars.

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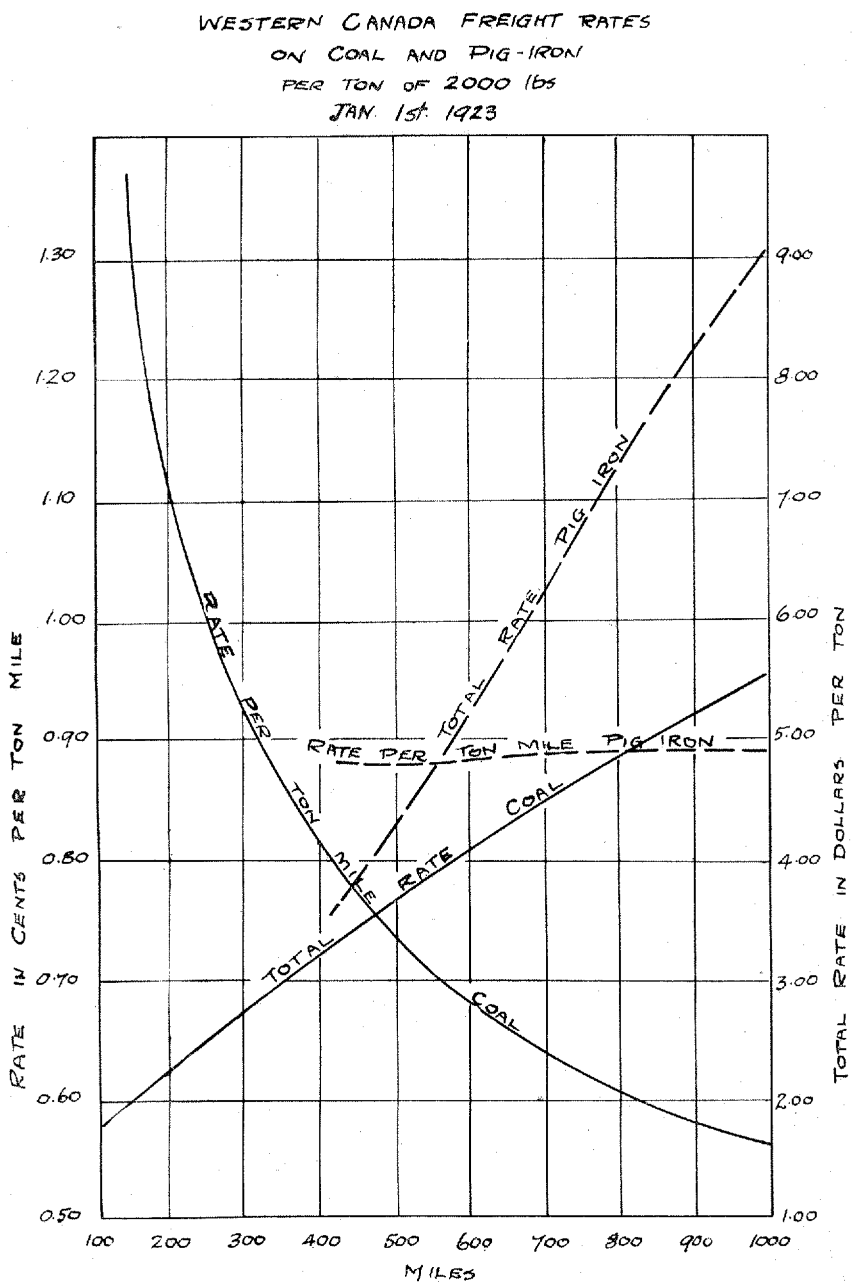
*Stansfield, A.: The commercial feasibility of smelting iron ores in B. C.; B. C. Bureau of Mines, Bull. 2, 1919, p. L26.



WESTERN CANADA FREIGHT RATES
ON COAL AND PIG-IRON
PER TON OF 2000 lbs
JAN. 1st. 1923
RATE IN CENTS PER TON MILE
TOTAL RATE IN DOLLARS PER TON
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
100
200
300
400
500
600
700
800
900
1000
MILES
TOTAL RATE PIG IRON
RATE PER TON MILE PIG IRON
TOTAL RATE COAL
RATE PER TON MILE
COAL

FIGURE I

SMELTER LOCATION

As a possible smelter location, four localities suggest themselves:—

(1) At the iron ore deposits; (3) Waterways;
(2) South shore of Athabaska lake; (4) Edmonton.

With regard to the possible location at the ore deposits, it is sufficient to refer to what has already been noted, namely, that for about seven months each year lake Athabaska is closed to navigation, and hence a smelter so situated would be out of contact with its market for that length of time and obviously could not exist.

An idea of the relative value of the other three possibilities can be obtained by considering the cost of transportation of ore, fuel and flux to the smelter and transportation of the product (pig iron) to the market, say at Edmonton.

For the purpose of these calculations we can assume that for the production of one ton of pig iron from ore approximately one ton of coke and one-half ton of flux are required. Assuming the ore to carry 60 per cent. of iron, Tables IV., V. and VI. show the comparative transportation costs for these points.

These figures show the lake Athabaska location has an advantage of $1.54 per ton over the Waterways location, and of $1.10 over the Edmonton location. There are, however, certain physical disadvantages which must be considered. A smelter so situated would be 500 miles from the nearest large centre of civilization (Edmonton) and thus also from its labor market. It would be subjected to rigorous climatic conditions during the winter months, and the winter period would be long. Such conditions would not be conducive to a satisfied labor, and of necessity high wages would have to be offered.

Located at Edmonton, the smelter would be within a civilized area, winter conditions are not exceptionally severe, and labor troubles would not be greater than usual. Moreover, the city would act as a local market for various by-products from the smelting operations, and thus aid in reducing the cost of production. These factors would seem to more than compensate for the slight disadvantage due to transportation costs, and a location at Edmonton appears to be a logical one.

TABLE IV.—LOCATION—SOUTH SHORE, ATHABASKA LAKE

Material	Origin	Transport	Distance miles	Rate per ton $	Quantity tons	Estimated Transport Costs, $
Ore	Athabaska L.	Water	40	0.50	1.67	.84
Flux	" "	Water	40	0.50	0.50	.25
Coke	Jasper	Rail	700	4.50	1.00	4.50
Pig Iron..	Athabaska L.	Rail	500	4.20	1.00	4.20
					Transportation Costs	$ 9.79

TABLE V.—LOCATION—WATERWAYS, ALBERTA

Material	Origin	Transport	Distance miles	Rate per ton $	Quantity tons	Estimated Transport Costs, $
Ore	Athabaska L.	Water	40	0.50	1.67	4.70
		Rail	200	2.30		
Flux	Athabaska R.	Water	10	0.25	0.50	.13
Coke	Jasper	Rail	500	3.70	1.00	3.70
Pig Iron..	Waterways	Rail	300	2.80?	1.00	2.80
					Transportation Costs	$11.33

TABLE VI.—LOCATION—EDMONTON, ALBERTA

Material	Origin	Transport	Distance miles	Rate per ton $	Quantity tons	Estimated Transport Costs, $
Ore	Athabaska L.	Water	40	0.50?	1.67	7.64
		Rail	500	3.70		
Flux	Entrance	Rail	175	2.10	0.50	1.05
Coke	Jasper	Rail	200	2.20	1.00	2.20
					Transportation Costs	$10.89

MINING OPERATIONS AND COSTS

What method of mining could be adopted in the field, it is impossible to approximate at present. With ore bodies similar to those examined and discussed in the earlier pages of this report, large scale open-cut work would appear to be out of the question. It is doubtful, in fact, if any extensive open-cut operations could be economically carried on under the existing climatic conditions, especially of the winter months. Stansfield (*loc.cit.*, page L25) quotes estimates by Brewer of about $2.25 per ton for the costs of mining iron ores on Texada and Ridonda islands. In view of the long freight haul on equipment and supplies to a mining camp on the north shore of Athabaska lake, a charge of $3.00 per ton would appear to be an extremely favorable estimate for mining costs.

SMELTING OPERATIONS AND COSTS

As previously noted, for the production of pig iron from ores in a blast furnace, two other materials, fuel and flux, are essential.

The average consumption of coke in twenty-six blast furnaces in the United States, compiled from a table by Howland, quoted by Bacon and Hamor*, shows 1,896 lbs. of coke used per ton of pig

*Bacon & Hamor: American fuels, vol. I., 1922, p. 119.

iron produced. Assuming that the ton referred to is the usual long ton (2,240 lbs.) this means a consumption of approximately 0.85 tons of coke per ton of pig iron produced.

Richards† in his calculations assumes that 0.288 parts of available carbon are required for smelting one part of slag produced, and 0.66 parts of carbon per part of pig iron produced. Under the ordinary conditions of smelting, this would be equivalent to approximately 0.9 tons of coke per ton of pig iron produced.

The amount of flux used varies considerably, depending on the impurities in the ore and other materials charged to the furnace. Richards (*loc.cit.*, pp. 252-257) gives calculations showing requirements of from 2.0 to 3.7 lbs. of limestone per pound of silica in the ore, depending upon the other bases present and the ratio of silica to base required in the slag. On the basis of 2.5 lbs. of limestone per pound of silica in the ore, and assuming the ore to carry 10 per cent. of silica, there would thus be required 875 lbs. of flux per short ton (2,000 lbs.) of pig iron produced, or approximately 0.55 tons of flux per ton of pig iron.

An estimate of the cost of one short ton (2,000 lbs.) of ore at a smelter situated at Edmonton is shown in Table VII. below:—

TABLE VII.—ESTIMATE OF COST OF ORE AT SMELTER SITUATED AT EDMONTON, PER TON OF 2,000 POUNDS

Estimated cost of mining	$3.00
" " " water transportation	0.50
" " " unloading and reloading	0.25
" " " rail haul to Edmonton	3.70
Royalty to owner	0.50
Estimated total cost, per ton	$7.95

With a smelter situated at Edmonton, the logical position for a coking plant would be at Edmonton also. A rough estimate of a by-product coke plant capable of producing 400 tons of coke a day may be placed at $2,000,000. Assuming a 75 per cent. recovery of coke from the coal charged, and that the coal costs $3.00 per ton at the mine, an estimate of the cost of coke is shown in Table VIII., below:—

TABLE VIII.—ESTIMATED COST OF COKE PER TON OF 2,000 POUNDS FROM A BY-PRODUCT COKING PLANT SITUATED AT EDMONTON

Interest and Depreciation on plant at 20%	$ 3.30
Cost of Coal, 1.33 tons at $3.00 per ton	3.95
Freight on Coal, 1.33 tons at $2.30 per ton	3.05
Operating Charges	2.00
Estimated Cost of Coke	$12.30

Limestone for fluxing purposes, brought from Marlboro, 150 miles west of Edmonton, would cost about $3.00 per ton, made up as follows:—

†Richards, J. W.: Metallurgical calculations, 1918, pp. 262-267.

Cost of Limestone	$1.00
Freight, 150 miles	2.00
Estimated Cost of Limestone at Edmonton	$3.00

The cost of smelting operations, including interest on capital, depreciation on plant, labor and management, etc., is difficult to estimate. Richards (*loc.cit.*, pp. 266-267) assumes operating charges of $1.00 per ton of slag produced, and $3.00 per ton of pig iron produced. Stansfield (*loc.cit.*, p. L74) quotes an estimate by the B. L. Thane Company for the cost of producing pig-iron in a blast-furnace near Puget Sound which includes the following items:—

Labor	$1.50
Materials	1.50
Capital Charge	3.40

From these, an average operating charge of $3.50 per ton of pig iron produced, and a charge of $3.00 per ton to cover capital, etc., would appear reasonable.

The cost of producing one long ton (2,240 lbs.) of pig iron from Athabaska ores, assuming a 60 per cent. ore, is shown in Table IX., below:—

TABLE IX.—ESTIMATED COST OF PRODUCING ONE LONG TON OF PIG IRON FROM ORES FROM LAKE ATHABASKA AT A SMELTER SITUATED AT EDMONTON

Ore, 3,740 lbs. at $7.95 per ton	$14.87
Fuel, 1,900 lbs. at $12.30 per ton	11.70
Flux, 987 lbs. at $3.00 per ton	1.48
Operating charges	3.50
Capital charges	3.00
Estimated cost of pig iron	$34.55

For comparative purposes, Table X. has been compiled, showing the cost of smelting some of the richer ores, as shown in the analyses in Table I.

TABLE X.—COST OF PRODUCING PIG IRON FROM LAKE ATHABASKA ORES AT A SMELTER SITUATED AT EDMONTON

	Sample 6		Sample 9		Sample 10		Sample 12	
	Wt. lbs.	Cost $	Wt. lbs.	Cost $	Wt. lbs.	Cost $	Wt. lbs.	Cost $
Ore	7380	29.30	6600	26.10	5860	23.15	7150	28.40
Fuel	3270	20.10	3250	20.00	2890	17.80	3395	20.90
Flux	3020	4.50	4280	6.42	3380	5.07	4400	6.60
Operating Charges		4.80		4.75		4.25		4.95
Capital Charges		3.00		3.00		3.00		3.00
Total Costs		$61.70		$60.27		$53.27		$63.85

The increase in operating charges is due to increased amount of slag produced per ton of pig iron.

Pig iron at Edmonton, brought in from eastern smelting plants is at present worth $44.60 per long ton (2,240 lbs.).

MARKET CONDITIONS

The average daily output of the twenty-six blast furnaces quoted by Bacon & Hamor (*loc.cit.*, p. 119) is 484 tons (2,240 lbs.?). The smallest furnace produces 272 tons per day, and the largest, 608 tons. With an average daily output of 450 tons for a moderate-sized furnace, and 300 working days a year, the annual output from such a furnace amounts to 135,000 tons (2,240 lbs.).

The present price of pig iron at the head of the lakes (Fort William) is about $33.00 per long ton, or slightly less than the estimated cost of production of pig iron from Athabaska ores at Edmonton. Thus, even under the extremely favorable conditions assumed for the estimate, it is evident from the tables on page 23 that eastern pig iron would be able to successfully compete with Athabaska pig iron at points east of Saskatoon.

The nearest sea port to Edmonton is Prince Rupert, B.C., 950 miles west of Edmonton. Assuming prairie rates on coal to hold for traffic across the mountains, the cost of landing pig iron from Edmonton for water shipment amounts to $39.95 per long ton (2,240 lbs.). The present price of pig iron in British Columbia (Vancouver) is considerably in excess of this figure, but is scarcely likely to remain so for long. Stansfield (*loc.cit.*, p. L17) says it is not safe to count on a price of more than $35.00 per long ton during the next few years. Obviously pig iron from Athabaska ores could not compete in the British Columbia market.

To ascertain what is the annual consumption of pig iron within the province of Alberta, a circular letter was sent out to the more important foundries within the province, asking for information on the annual output of castings from each foundry, and the ratio of pig iron to scrap metal used in the castings. From the replies received, it would appear that about 5,000 tons of castings are produced annually within the province, of which considerably less than 30 per cent. is made from pig iron. The present consumption of pig iron for foundry purposes is considerably less than 2,000 tons per annum.

It must be remembered, however, as stated by Stansfield (*loc.cit.*, p. L21), "that the amount of pig iron used in foundries for iron castings is far less than the amount which is converted into steel. . . . The amount of steel produced from one ton of pig iron depends somewhat upon the process employed. The Bessemer process yields something less than one ton of steel per ton of pig iron, while the open-hearth process, using a mixture of pig iron and scrap steel, may produce two tons of steel per ton of pig iron."

Presumably the cost of making steel from Athabaska pig iron would be at least the same as that of steel made elsewhere, and thus the market conditions for steels would be limited, due to transportation charges, to the same extent as for pig iron.

The consumption of steel within the province of Alberta is practically impossible to estimate. Stansfield gives the following table by John McLeish of Ottawa, showing the imports of iron and steel goods from foreign countries through the ports of British Columbia and Alberta during the twelve months ending March 31st, 1915, (*loc.cit.*, p. L21):—

TABLE XI.—IMPORTS OF IRON AND STEEL GOODS FROM FOREIGN COUNTRIES THROUGH PORTS IN BRITISH COLUMBIA AND ALBERTA DURING TWELVE MONTHS ENDING MARCH 31ST, 1915

Product	Quantity Short Tons	Value
Pig-iron	2,341.0	$ 27,838
Ingots, billets, and forgings	67.7	4,564
Scrap	262.0	2,700
Cast-iron pipe	1,411.5	41,319
Steel rails and connections	14,993.5	379,134
Angles, bars, plates, etc.	15,394.5	552,939
Tin-plate	8,217.5	621,051
Wire rods, wire, and wire nails	5,404.4	378,076
Nails, rivets, and nuts	402.0	22,712
Chain	205.4	19,385
Car-wheels, anchors, and other manufactures	282.5	17,058
	48,982.0	$2,066,776
Other iron and steel products and manufactures, valued at		4,391,955
Total value		$6,458,731

This table, however, does not include steels of domestic (Canadian) origin, a considerable amount of which is used in the province as railway steel, building construction, small shapes, etc.

Undoubtedly a large amount of railway steel is used in construction and maintenance throughout the province, and this would represent the largest part of the steel consumption of the province. The average life of a steel rail is, perhaps, ten years, but replacement is largely either re-rolled material or second hand material from other lines, and the actual new steel used per year would not exceed that required for more than 200 miles of railway. Assuming 90-lb. steel, this would be equivalent to approximately 30,000 long tons (2,240 lbs.) per annum.

From the foregoing approximate figures, it becomes very apparent that the total consumption of pig iron, both as foundry iron and in the form of steel, within the possible market for such material contributary to Edmonton, would not in the near future warrant the erection and operation of a smelting plant and rolling mill, even under the very favorable assumption of an operating railway connection to the possible iron ore fields and an abundant supply of a good grade of ore.

ELECTRIC SMELTING

The problem of the commercial feasibility of electric smelting of iron ores has been very completely dealt with in the report by Professor Alfred Stansfield frequently referred to in the early pages of this report. He has shown that electric smelting of iron ores in B. C. can not be a commercial possibility even under the comparatively favorable transportation conditions there existing unless the cost of electric power is considerably less than 0.5c. per kilowatt-hour. The cheapest rate at present offered for electric power produced by the Electric Light and Power Department of the City of Edmonton is 2 cents per k.w.h., and the rate could not be reduced much below one cent per k.w.h. even for large consumers.

The only feasible source of hydro-electric power adjacent to possible iron ore deposits at Athabaska lake would be the development of the Grand Rapids on Athabaska river, about 100 miles upstream from McMurray. A report by John S. Fielding, made in 1910, for the Commissioner of the City of Edmonton, on the power possibilities of this site, states that power to the amount of 10,000 h.p. could be developed at a cost of about $30.00 per h.p. per year. This is equivalent to a charge of a little over 0.5c per k.w.h. When it is considered that these figures would probably have to be at least doubled for present day conditions, it becomes obvious that electric power is not available for smelting operations at a price which would at all come within the requirements for commercial operations.

CHAPTER III.

SUMMARY AND CONCLUSIONS

On the north shore of lake Athabaska there are certain areas in which the pre-Cambrian carries iron in small quantities. One of these areas is discussed in this report. This area is in the vicinity of Fishhook and Moose bays on the north shore of lake Athabaska, 20 miles east of Crackingstone point, 56 miles east of the Alberta-Saskatchewan boundary, 112 miles from Chipewyan, and 350 miles from Waterways, the closest railway terminus. Five mineral claims were staked in 1921 for iron by E. A. and N. C. Butterfield, and it was reported that large bodies of commercial iron had been discovered. The occurrence of a commercial deposit of iron ore in this part of Canada, and the fact that any minerals or other resources from lake Athabaska would have to be brought out through Alberta to market are the principal reasons for the authorization of a field survey made by the writers in the summer of 1922.

The conclusions given below were reached after examining the problem in the most favorable way. In order to point out the difficulties to those who contemplate or who endeavor to develop any iron deposit in the north, the second chapter in this report deals with the problems relative to the commercial development of an iron ore deposit after the existence of a sufficiently large deposit of iron ore of commercial grade has been defined by careful field investigations.

Chapter I. deals with the geological examination of the reported iron ore deposits. The conclusions arrived at in this investigation may be briefly summarized as follows:

Field investigations showed that there is no iron ore deposit in the vicinity of Fishhook and Moose bays. Bands of quartzite, dolomite, slate and schist have been enriched by the impregnation of iron-bearing solutions. Iron oxide is abundant in these bands and adjacent rock, producing a deep red color on weathered surfaces. This red color suggests that the quantity of iron in the rock is much greater than it really is. The iron-bearing bands are most irregular in thickness and in lateral extent. The thickest band exposed about Fishhook bay does not exceed fifty feet, and this thickness is made up of interbedded quartzites, quartz-schists, slates, (more or less ferruginous), and thin beds of bluish hematite. The thickest bed of hematite noticed measured only fourteen inches. The bands of dolomite marble impregnated with iron are also irregular, and grade into whitish marbles or are interbedded with slates.

Samples for analysis were taken in the field across portions of the most enriched bands that would have to be mined, if developed, and picked hand specimens were selected from the richest beds at a number of points. The percentage of metallic iron in the average samples ranged from 4.22 to 34.02 per cent., and in the specimens, from 6.86 to 38.22 per cent. With the exception of the carbonate rocks, the other analyses show that the rocks are highly siliceous quartz-rich rocks low in iron content. The term iron ore cannot be applied to any of these rocks, according to the generally accepted definition of ore.

In order that the character of the iron and its relation to the other minerals in the rock might be accurately determined, thin sections of various iron-rich rock were prepared and examined microscopically. The results from the microscopic examination are even more discouraging than those from the analyses. Photographs were taken of some of these rock sections, magnified 75 to 100 diameters in order to show clearly to the reader the relatively small amount of iron present in these ore-like rocks. Much of the red color is due to iron oxide. In every section examined the iron minerals are of secondary origin, having been brought, in solution, into the primary rock, which, in the case of the siliceous rock, was a sandstone. The quantity of iron is so small and so disseminated throughout the rock that no processes of concentration can be suggested.

It is with regret that the writers have to report that *there is no commercial deposit of iron ore exposed around Fishhook bay, and, furthermore, that the surface exposures do not indicate that enrichment can be expected at depth which would produce an economic deposit of iron.*

Chapter II. includes a discussion of the commercial possibilities of producing iron from ores from the lake Athabaska district, *assuming that large deposits of high grade ore are discovered in the future.* This part of the report shows clearly that the development of such ores could not be a commercial success within the near future. The chief reasons given for this may be summarized as follows:—

First.—The long distances separating these possible ores from the necessary fuel and other materials incur high transportation charges, which so increase the cost of these raw materials that iron could not be produced at a cost of much less than $35.00 per long ton. Even under the extremely favorable conditions assumed, including an operating extension of the Alberta and Great Waterways Railway to lake Athabaska, cheap mining costs, low freight rates, and a high grade of ore, of the estimated cost of $34.55 per long ton of pig-iron, over $11.00, or practically one-third, is due to transportation charges.

Second.—The possible market for pig iron and steel products produced from lake Athabaska ores is limited, again due to the cost of transportation, to an area but little, if any, greater than the province of Alberta, and the consumption of these materials within that area is not in itself sufficient to keep one medium-sized blast furnace in operation.

These factors prohibit for the present the commercial development of any iron ore deposits which might be found about lake Athabaska.

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LIST OF PUBLICATIONS

ANNUAL REPORTS OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

Report No. 3 (for the calendar year 1920); pp. 36.

Report No. 5 (1921); pp. 86.—Reviews the work done during 1921 under the auspices of the Research Council. This includes:—the sampling, screening, storage and carbonization of Alberta coals, and their use in boilers; tests on household furnaces; geological reconnaissance in Alberta; the Athabaska district bituminous sand and its commercial development; road materials; forest products; salt at Fort McMurray; analyses of coal samples taken by the Mines Branch of the province during the year.

ANNUAL REPORTS ON THE MINERAL RESOURCES OF ALBERTA

By Dr. J. A. Allan, Professor of Geology, University of Alberta.

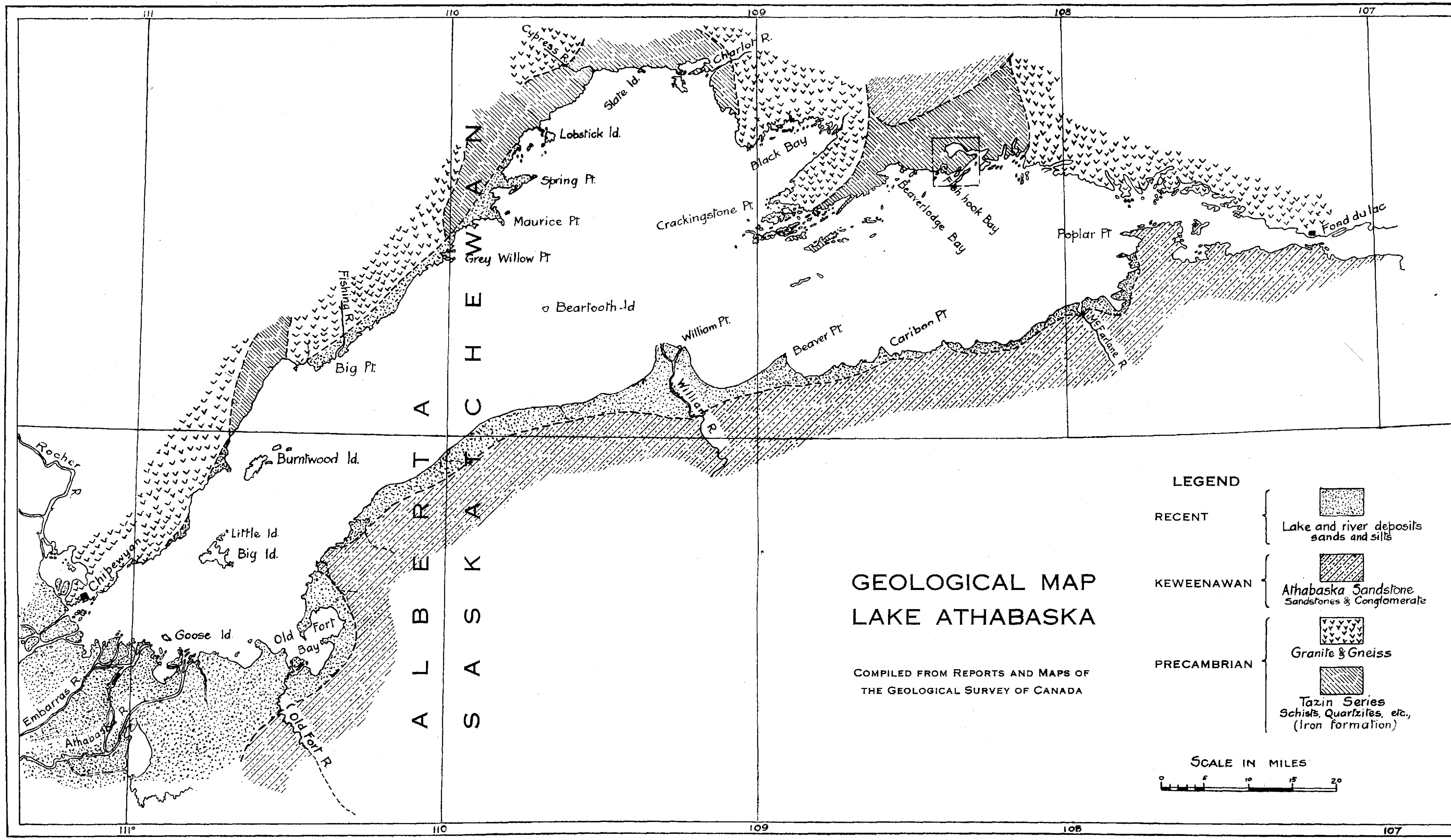
Report No. 1 (1919); pp. 104.—A summary of information collected with regard to the mineral resources of Alberta.

Report No. 2 (1920); pp. 138+14.—Supplements the information contained in Report No. 1.

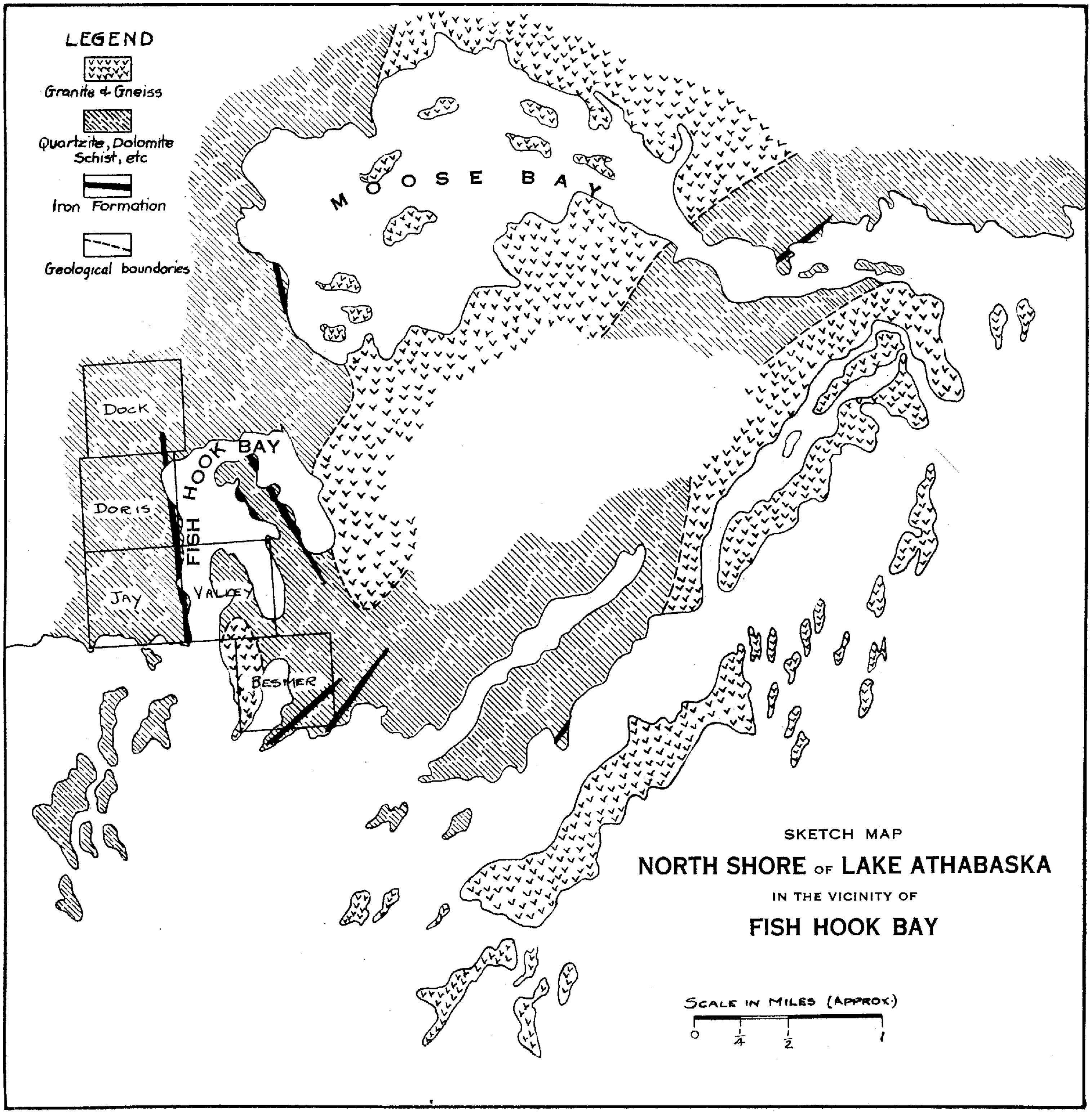
Report No. 4 (1921), GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA; pp. 72, and 6-colour map (Serial No. 1). Price $1.00.

Report No. 6 (1922, Pt. I.), GEOLOGY OF THE SAUNDERS CREEK AND NORDEGG COAL BASINS, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. ?, and 2-colour map (Serial No. 2.). A preliminary report on the stratigraphy of the coal measures mined along the Brazeau Branch of the Canadian National Railways.

Report No. 7 (1922, Pt. II.), AN OCCURRENCE OF IRON ON THE NORTH SHORE OF LAKE ATHABASKA, by J. A. Allan and A. E. Cameron; pp. 40, two maps (Serial Nos. 3 & 4).—Chapter I. deals with the association of iron minerals in pre-Cambrian rocks in the vicinity of Fishhook Bay. Chapter II. deals with the problems of transportation, smelting and markets.



To accompany Fourth Annual Report on the Mineral Resources of Alberta, Part II, 1922, by J. A. Allan and A. E. Cameron. Map No. 3.



To accompany Fourth Annual Report on the Mineral Resources of Alberta, Part II, 1922, by J. A. Allan and A. E. Cameron. Map No. 4.