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Report on
AVAILABLE RAW MATERIALS FOR A PACIFIC
COAST IRON INDUSTRY

by
Edwin T. Hodge, Consulting Geologist

ALASKA

General statement: - All previous investigations of mineral supplies for an iron industry have, with one exception, been based upon blast furnace reduction and consequently the scope of the inquiries was limited to supplies adjusted to the restricted capabilities of such furances. The exception was a British Columbia investigation that was purposely limited to the use of ores within the province.

For the above reason and because interest in "far away" Alaska has been confined to operators seeking high grade ores the iron deposits have received meager attention. The information available has been obtained as parenthetical and inferential deductions and from reports on other deposits. Nevertheless, it is possible to present a statement, sufficient for the purpose of the report, as follows.

It appears that deposits of iron ore are widespread but so situated as to be a long distance from possible economic transportation.

All the deposits worthy of immediate attention are on the Prince of Wales Island. Magnetite has been found in three districts on Prince of Wales Island: on Kasaan Peninsula, on Hetta Inlet, and near Hunter and Tah Bays.

Kasaan Peninsula is a promontory on the east side of Prince of Wales Island that lies between 132° 5' and 132° 35' W. longitude and 55° 25' and 55° 40' N. latitude. It is about 20 to 40 miles northwest of Ketchikan, and has an area of about 60 square miles. The mines and prospects are at elevations of 200 to 1400 feet. All of them are within 3 miles of navigable tidewater, and most of them are within one mile of the shore.

The Hetta Inlet or Copper Mountain mining district is situated on the West Coast of Prince of Wales Island 35 to 40 miles west of Ketchikan, in about 55° 10' to 55° 17' N. latitude and 132° 30½' to 132° 40' W. longitude.

It is near the head and on the east side of Hetta Inlet which is tributary to Cordova Bay. The mines and prospects are from 1000 to 3000 feet above tide and are one to three miles from navigable tidewater.

Hunter and Tah Bays are on the West Coast of Prince of Wales Island, near its sound end, about 44 miles southwest of Ketchikan. They are about 30 miles SSE. of Hetta Inlet. The prospects are from a quarter to half a mile from tidewater, and are at elevations of only a few hundred feet.

Ores - cupriferous magnetites. - Most of the iron ores of Prince of Wales Island are intimately associated with low grade copper ores. The magnetite-bearing ore bodies of Prince of Wales Island consist of large lenses that are found within the contact-metamorphic zones. The magnetite masses occur as ore shoots within the rocks of the contact zone.

The magnetite lenses are irregular in size, shape, and distribution. The magnetite ores occur in association with copper minerals, chiefly chalcopyrite and its alteration products. Consequently the presence of copper and sulphur is to be expected. Since the copper ores have been, or will be, mined separately, only small amounts of such minerals would be intermingled with the iron ores. None of the copper ores were of high grade.

The ore should be, as far as the associated non-metallic minerals are concerned, self-fluxing.

The following are analyses that are representative as showing the range of composition of the known magnetite ores of Prince of Wales Island:

	Fe	Al_2O_3	CaO	SiO_2	S	P	Mn	TiO_2	Cu
Mount Andrew	60.8	...	...	10.5	0.54	.....	....	....	0.00
Mount Andrew	65.8	...	...	5.4	3.60	.....	....	....	3.36
Mount Andrew	46.2	...	...	32.3	1.41	.....	....	....	0.90
Mount Andrew	42.8	...	0.4	15.2	4.30	.....	....	....	....
Mamie	62.6	...	...	9.3	0.75	.....	0.19	0.05	0.00
Mamie	47.8	7.7	2.7	10.6	6.30	.....	....	....	....
Stevenstown	44.2	...	...	15.3	2.50	0.056	0.00	0.00	0.12
Poor Man's	54.1	...	4.0	8.6	2.51	0.020	0.08	....	....
Poor Man's	65.0	...	0.0	4.9	0.41	0.004	0.04	....	....
Poor Man's	58.2	...	3.0	6.5	1.42	0.020	0.07	....	....
Poor Man's	64.6	...	0.0	6.4	0.48	0.018	0.06	....	....
Morning Star	56.0	...	...	15.5	1.37	0.008	0.42	....	....
Morning Star	59.4	...	...	11.6	0.37	0.006	0.50	....	....

The above analyses were taken of ore bodies left after being explored or mined for copper. It is expected that the oremined for iron will be much lower in both sulphur and copper.

The removal of sulphur in either the blast or the electric furnace offers no problem though it does increase the cost.

Copper question - The presence of copper in the smelted iron is not detrimental according to a large number of authorities whose opinions are quoted at length in Appendix F. In fact, in late years, it has been proven to be beneficial to both cast iron and steel.

Before modern testing methods had been developed, blacksmiths noted red shortness in iron, the cause for which was ascribed to the presence of copper. All writers agree that copper increases the tensile strength.

The hardness tests show the high-copper steel in all tests to be harder than the low-copper. The Charpy shock tests show the high-copper steel in all cases to be superior to the low-copper.

In addition to rendering malleable iron susceptible to improvement by precipitation-hardening treatments, copper has another potentially useful effect as an accelerator of graphitization.

The effect is roughly proportional to the amount of copper added and 1 per cent of copper results in a reduction of graphitization time by about 50 per cent, although this is affected by the rate of heating and other factors.

The addition of 1 to 1.5 per cent of copper increases the yield point of malleableized iron to the extent of about 10,000 pounds per square inch.

References to the use of copper in gray and malleable cast iron are becoming increasingly numerous, thus showing a definite impetus toward utilizing this inexpensive element for the purpose of alloying.

In malleable iron, copper speeds up the graphitization, raises the tensile and particularly the yield strength, increases the hardness, modifies the galvanizing embrittlement effect, promotes corrosion resistance, and makes the iron amenable to precipitation hardening. Since it retards the rate of transformation, copper assists in the heat-treatment of gray or malleable iron by retaining certain structural features, obtained in unalloyed irons only on rapid quenching, at much reduced rates of quenching.

Milling - Concentrating - Because of the long haul and to rid the ores of sulphides, it may be desirable to mill and concentrate them. W. H. Whittier, as a result of experimental tests, states: -

> "Metallurgical experiments indicate that the pyritiferous and gangue-bearing magnetites are very satisfactorily treated by magnetic separation and that wet separation will be best suited to the finer crystallized ores of Prince of Wales Island, Alaska. It is also probable that the copper bearing magnetites will best be treated by a combination of flotation and wet magnetic separation, in which both the copper and iron may be recovered. It might be found most practicable in some cases to employ a combination of magnetic separators and concentrating tables. Roasting or sintering, and nodulizing of fines, particularly concentrates, will probably be advisable."

The cost of this should be less than one dollar.

	Costs of milling and magnetic separation.	Sintering.	Per ton of ore.
Stansfield, B.C. ores 40% to 70%	0.30	1.00	1.80
50% to 65%	-	-	0.63
Disseminated copper ore	-	-	0.40 - 1.00
Calumet and Arizona	-	0.31	-
Mineville, N. Y.	-	-	0.238
1930 U.S. 52.07 to 95.37	-	-	0.437

Costs - The Mount Andrew, Mamie and Stevenstown, Poor Man's, Rush & Brown, and Jumbo properties all have large minable deposits of magnetite ore contained in ore bodies that have been prospected and developed in greater or less degree as low grade copper ores. The amount of such probable ore in each of these properties is of the general order of magnetite of at least several hundred thousand tons and perhaps a few million tons, depending on continuity of ores outside the actual workings. These properties might also perhaps be expected to yield, by special search, on or beneath the surface, a large amount of additional ore in ore bodies that are not now known. Such additional ore might amount to one or more million tons for each property.

It seems evident that there is sufficient ore supply for several years, that can be obtained without much capital expense, close to tide water and of high grade and suited to electric furnace use. During the period of their exhaustion - the other attractive prospective areas could be explored.

Mining of the larger copper-bearing magnetite ore bodies on Prince of Wales Island has included open cut mining, mining from adits that undercut the ore bodies at depth, with "glory holes" extending to the surface, and deep workings.

As iron ore properties, these deposits can be grouped and operated on a larger scale, especially if the ore is milled to separate the gangue minerals and perhaps the sulphur and copper minerals. Assuming 1500 tons of ore mined per day and milled and concentrated to a 1,000 ton product, the cost will be:-

Mining $1\frac{1}{2}$ tons of ore at $1.50	=	$ 2.25
Milling		1.00
Transportation		1.75
Cost per ton 65 per cent ore .		$ 5.00 delivered at Portland.

Mr. L. H. Metzgar, General Superintendent, Alaska Juneau Gold Mining Co., Juneau, Alaska, in a personal communication, dated September 3, 1935, said:-

> "The Alaska Treadwell Gold Mining Company shipped concentrates from Treadwell to the Tacoma smelter. If shipments were to be made in lots of 5000 tons it would be more practical to ship in properly designed and constructed freighters than to ship in barges. The inland waters of southeastern Alaska are open the year round and with due precaution during the stormy periods, shipments could be made the year round."

The Pacific Coast Cement Co. are said to transport limestone from Dall Island. Alaska to Seattle at $0.90 a ton. The deposits are all close to tide water and good harbors.

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In the Northern part of the Territory on the western boundary near Alaska and west of Whitehorse are deposits that may be large but are so removed from possible transportation that they are mentioned only for purposes of complete tabulation.

A deposit of hematite four miles west of Whitehorse could be mined cheaply but would involve rebuilding a railway to Whitehorse and then 112 miles by rail and 1400 miles by water to Portland. The deposits may be large but only about 200,000 tons of ore is in sight.

PRICE OF IRON ORE

The price of iron ore is generally given as at the mine. The average for the years 1906-1933 has been as follows: hematite, $2.60, brown ore $2.41, magnetite, $2.98 and the general average for all ores has been $2.64. The year 1920 was the year of maximum prices. Since 1924 the prices have remained fairly close to the long time average.

The price at the mine includes all capital, operating, interest, depletion and depreciation and profit charges. The prices at the mines of properties held by large corporations are also subject to artificial fixation in the interest of company policy.

The cost of the ore at the furnace includes, in addition, the same lists of cost items for transportation. Thus the unit prices established June 7, 1933, for the four standard grades of Lake Superior ore are the same as those for 1929-32, as follows: Old Range Bessemer, 9.32 cents; Mesabi Bessemer, 9.029 cents; Old Range non-Bessemer, 9.029 cents; and Mesabi non-Bessemer, 8.738 cents. The prices per ton that correspond to these prices are respectively, $4.80, $4.65, $4.65, and $4.50. The base of Bessemer ore, Old Range and Mesabi, for 1925-33 is a metallic-iron content of 51.5 per cent (natural), instead of 55 per cent, as for 1924 and many earlier years. The base of non-Bessemer ore, Old Range and Mesabi, remains as heretofore at 51.6 per cent (natural). In 1934 the costs at the Gogebic range were $2.63, Marquette $2.19, Menominee $2.41 and underground $2.39.

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I R O N

(6) Iron ore supply. -

(a) The iron ores of the deposits recommended by this report are of a higher grade than those used by the Nation as a whole. They average over 60 per cent metallic iron. Hence, on the above basis, there will be needed 960,000 tons of ore, which for a 333-day year is 2,882 tons a day. The figure of 1,000 tons a day requirement is therefore a conservative figure. The cost figures in this report are based upon that quantity.

(b) There are many deposits of iron ore in the western part of the Americas. Many of them are large but undeveloped. Some of these deposits may become available a few years after an iron and steel industry is established. All such deposits have been located, considered, and are described in the report.

(c) Proven deposits within economic transportation range are the following:

(1) Kasaan Peninsula, Alaska, magnetite ore 60 per cent metallic iron, Bessemer, semi-self fluxing, low sulphur and copper, several million tons, 3 months to produce, 1,000 miles water carriage, cost delivered $4.14 to $5.03 a ton.

(2) Louise, Texada and Vancouver islands, magnetite, 60-63 per cent metallic iron, Bessemer, semi-self fluxing, moderate sulphur and copper, several million tons, 3 months to produce 710 to 440 mile water haul, cost delivered $4.50 to $4.15 a ton.

(3) Iron Mountain, Washington County, Idaho, hematite, magnetite, 57 per cent metallic iron, Bessemer, 3 million tons, one year to produce, 420 miles rail haul, cost delivered $4.70 a ton.

(4) Dayton, Nevada, hematite and magnetite, 62 per cent metallic iron, Bessemer, 1,500,000 tons, 3 months to produce, 310 miles rail and 650 miles water carriage, cost delivered $4.75 a ton.

(5) Cave Canyon, San Bernardino County, California, hematite and magnetite, 60 per cent metallic iron, Bessemer, semi-self fluxing, 5-10 million tons, 225 miles rail, 989 miles water carriage, can be put into operation quickly, cost delivered $4.32 a ton.

(6) Ship Mountain, San Bernardino County, California, 65 per cent metallic iron, Bessemer, many million tons, 270 miles rail, 989 miles water carriage, 3 months to produce, cost delivered $5.14 a ton.

(7) El Tepustete, Baja California, Mexico, hematite and magnetite, 65 per cent metallic iron, partially Bessemer, very large, 3 months to produce, 1185 miles water carriage, cost delivered $2.50 a ton.

(8) El Mamey, Colima, Mexico, magnetite and hematite, 56 per cent metallic iron, Bessemer, 24,000,000 tons, 4 months to produce, 2,180 miles water carriage, cost delivered $3.60 a ton.

(9) Las Truchas, Michoacan, Mexico, hematite and magnetite, 63 per cent metallic iron, Bessemer, 50,000,000 tons, 5 months to produce, 2,300 miles water carriage, cost delivered $3.60 a ton.

(10) Marcona, Peru, hematite, 63 per cent metallic iron, Bessemer, 50,000,000 tons, 6 months to produce, 4,850 miles water carriage, cost delivered $4.30 a ton.

(11) Taltal, Chile, magnetite and hematite, 63 per cent metallic iron, Bessemer, 50,000,000 tons, 6 months to produce, 5,284 miles water carriage, cost delivered $4.05 a ton.

(12) Algarrobo, Chile, magnetite, hematite, 65 per cent metallic iron, Bessemer, 50,000,000 tons, 4 months to produce, 5,494 miles water carriage, cost delivered $4.75 a ton.

(13) Chenar Quemado and Dorado magnetite, hematite, 63 per cent metallic iron, Bessemer, both several million tons, 6 months to produce, 5,500 miles water carriage, cost delivered $4.25.

(14) El Tofo, Chile, magnetite, hematite, 64 per cent metallic iron, Bessemer, 100,000,000 tons, 1 month to deliver (operating), 5,569 miles water carriage, cost delivered $4.30.

(7) Reducing Agents.- In the electric furnace carbonaceous materials are not needed as fuels but only as reducing agents. Hence

there is a reduction of two-ninths of the weight and one-third of the volume of the load by using an electric furnace instead of a blast furnace. Also the electric furnace can use a wide variety of substances as long as they have good deoxidizing properties.

QUANTITY OF ORE REQUIRED

The average amount of ore used during a thirteen year period up to 1913 was 1.746 and for 1931 it was 1.700; for 1932 it was 1.542 and for 1933 it was 1.668.

The Pennsylvania average is 1.637, the Ohio is 1.680, the Alabama is 2.457, and at Colorado and Utah 1.856 tons of ore are required.

From the above we learn that the ore used is of a tenor that 1.75 tons of it make up 90 per cent of the pig iron, or 3,920 pounds of ore equals 2,016 pounds of iron, or 1.939 tons of ore equals 1 ton iron. This shows that the average ore used in the United States is a little below 50 per cent metallic iron. The West Coast of North America can obtain ores that will average better than 55 per cent metallic iron.

Pennsylvania and Ohio, dependent upon distant sources, are forced to use only high grade ores, and Maryland under a greater handicap imports ores of only the highest grade.

The average metallic iron content of fifteen localities that are possible sources of iron ore for Bonneville as determined by this study is 64 per cent. If all ore is used, then 1.57 tons of ore would be required to produce one ton of metallic iron. If ore and scrap are used in their usual proportion, 2 to 1, then 1.05 tons of ore will be required.

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(15) Costs - The estimated costs of raw mineral supplies, laid down in Portland, are as follows:

Iron ore, 60 per cent metallic iron, Bessemer grade, a ton	$ 4.50
Coke, 81 per cent fixed carbon, a ton	6.50
Limestone, 90 per cent $CaCO_3$, a ton	2.50
Dolomite, raw, a ton	3.75
Dolomite, calcined, a ton	7.50
Magnesite, raw, a ton	7.00
Magnesite, calcined, a ton	9.00
Silica rock, a ton	6.00
Chromite, 45 per cent Cr_2O_3, a ton	10.00
Manganese, 48-50 per cent Mn, a unit	0.17

If pig iron or hot metal is produced wholly from iron ore, the probable cost of raw materials will be:-

1.66 ton 60 per cent iron ore at $4.50 a ton	$ 7.47
800 lbs. coke, 81 per cent fixed carbon at $6.50 a ton .	2.60
1000 lbs. limestone, 98 per cent $CaCo_3$ at $2.50 a ton .	1.25
Dolomite or magnesite	0.20
Chromite	0.06
Manganese	0.09
Total	$ 11.67