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THE SNAKE RIVER IRON DEPOSIT

Notes on a Talk to the
YUKON NORTHERN RESOURCE CONFERENCE
April 7, 1972
by
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The Snake River iron deposit is near the northern edge of the Mackenzie Mountains on the Yukon-Northwest Territories boundary (Fig. 1). The iron formation occurs within the Rapitan formation, a wedge of clastic Proterozic rocks which is separated by unconformities from carbonate rocks above and below (Fig. 2). The Snake River exposures of iron formation extend over an area some 30 miles east-west by 10 miles north-south (Fig. 3). Rocks thought to be correlative are intermittently exposed in a broad arc extending from the Tatonduk River at the Alaskan border to Redstone River in the southern Yukon. At Snake River the Rapitan formation consists of an upper shale unit and a lower shaly conglomerate unit. Near the base of the conglomerate unit there is a thick jasper-hematite iron formation. This iron formation is depositionally bounded by lap-out to the east and west, is truncated by both ancient and recent erosion to the north and extends an unknown distance downdip to the south (Fig. 4). The deposit occurs on the gently south dipping limb of the Mackenzie Mountain anticlinorium which is traversed by smaller northwesterly trending folds and associated faults in the Snake River area (Fig. 5).

Crest Exploration has systematically sampled the iron formation at half mile intervals by channel sampling of exposures and by diamond drilling (Fig. 6) thereby demonstrating that the iron-bearing unit is thick and extensive, particularly in the Iron Creek area (Fig. 7). The iron formation consists of a number of remarkably persistent and consistent members (Figs. 8 and 9). Analyses show that the hematite horizons normally have 40 to 45% iron, 20 to 30% silica and a phosphorus content which progressively diminishes from 0.70 to 0.80% in the upper units to 0.20 to 0.25% in the lower units (Fig. 10). None of the lesser components are present in commercially significant amounts (Fig. 11). The composition of the Snake River iron formation has not been altered significantly by post-depositional processes. Unfortunately it was not enriched by post-depositional leaching and removal of silica as many iron deposits were.

The "ore" layers in the iron formation consist primarily of red chert and fine grained "blue" specular hematite which were apparently deposited simultaneously as gelatinous precipitates with hematite dominant in some layers and jasper in others. Compaction, soft rock deformation ("flow") and diagenetic "replacement" phenomenon are abundant. The "waste" layers within the iron unit are usually a peculiar shaly conglomerate characterized by widely dispersed pebbles and cobbles in an unsorted fine grained matrix. Laterally the pebble content often diminishes and a conglomerate bed becomes a hematitic shale bed. Some of the shaly conglomerate was deposited within erosional channels in the iron formation. Some of the clasts in the conglomerate are rolled up masses of what was apparently "soft" iron formation and others are boulders or pebbles of indurated iron formation but there are also lenses and interbeds of iron formation which were deposited within conglomerate units during periods of quiesence. Apparently the chemical process which deposited the chert-hematite iron formation and the clastic process which deposited the shaly conglomerates went on simultaneously. There are also occasional units of normal, well sorted sandstones and conglomerates within the iron formation. The shaly "tilloid" conglomerates could be explained either as glacial tills or as mud flows. Without being conclusive the observed evidence does indicate that the mud flow hypothesis is preferable.

The iron formation in the Iron Creek area would be particularly amenable to open pit mining. With arbitrary strip ratios of 2 waste (internal and external) to 1 ore there are several billion tons of material which could be mined at strip ratios of 1/3 to 1 (Fig. 12). Since the biggest of modern iron ore mines could operate on a billion tons for 50 years the exact amount of potential ore is only of academic interest. Depending upon the degree of selectivity which can be exercised in rejecting the internal waste during mining the grade will vary (Fig. 13).

A significant problem with the Snake River iron material is its high phosphorus content. The ore is also very fine grained so that the usual gravity concentration techniques cannot provide a product with an acceptable phosphorus content. It is thought that this engineering problem can be overcome with an appropriate flow sheet and/or by selectively open pit mining the basal low phosphorus units.

The principal advantages of the Snake River iron deposits are its tremendous reserves and the potential for low cost mining (Fig. 14). However, the world is well endowed with iron reserves (Fig. 15). The logical market for Snake River iron ore is Japan (Fig. 16) as the west coast U.S.A. and Canadian markets are too small to support the size of operation that Crest would require. Much of the recent Japanese market expansion has been supplied from Australia (Fig. 17). Although these producers do have a potential for extensive expansion it is unlikely that they will be permitted to supply more than 40 to 50% of the total Japanese market.

Tremendous investments are required for major iron ore producers (Fig. 18) but most of the investment is in infrastructure rather than in the mine itself (Fig. 19). This would be particularly true of a Crest project if the railway alternate were selected as it would be twice the length of the longest Australian iron ore railway. Ordinarily the capital charges and the transportation costs are the big items of expense in an iron ore operation (Fig. 20). Where extensive beneficiation is needed, and it will be mandatory at Snake River, the treatment cost is substantial although this is offset by higher prices for the resultant premium product.

Since Japan must import most of its raw materials a very concerted effort has been made to reduce the cost of iron and steel production (Fig. 21). Of major importance was a drastic decrease in iron prices when the Australian producers were coming into production which is still in effect despite subsequent inflation (Fig. 22). Much attention has been devoted to reducing the capital cost of expansion by increasing the productivity of existent blast furnaces. Sizing the ore fed to the furnace is effective and combining this with an increase in the iron content of the feed by using pellets is even more effective (Fig. 23). The next logical step is to use pellets which have been "direct reduced," that is, converted without melting either partially or wholly from hematite (Fe_2O_3) to metallic iron (Fe). This type of furnace feed has only been used on an experimental basis so the advantages shown for reduced pellets (Fig. 23) are based on calculations rather than on experience. Direct reduced material is marketable now as a scrap substitute and as feed for electric furnaces (Fig. 24). Because these are both relatively low volume uses it is unlikely that large volume operations, in the 10 million t.p.a. range, can be justified until reduced material is acceptable as an additive for blast furnace feed.

For an operation at Snake River direct reduction is an attractive possibility since it permits a raw material (iron) and low cost energy (natural gas) to be combined into a single product. Transportation costs are substantially reduced since the iron moves as an element instead of an oxide and the energy doesn't move at all after its work at the direct reduction plant is done. For the Japanese who must import both coke and iron it would appear that this would be an attractive possibility. Hammersley is building a 2 million t.p.a. plant at Dampier to produce "H iron" from Australian coal and iron. As a pioneer operation this plant is expected to be influential in establishing the acceptability and the price of direct reduced products in Japan. The future economics of the venture should be favorably altered by the large new offshore gas discoveries at Rankin, only 85 miles away. Once again developments in Australia may materially affect the fate of the Snake River iron deposit.

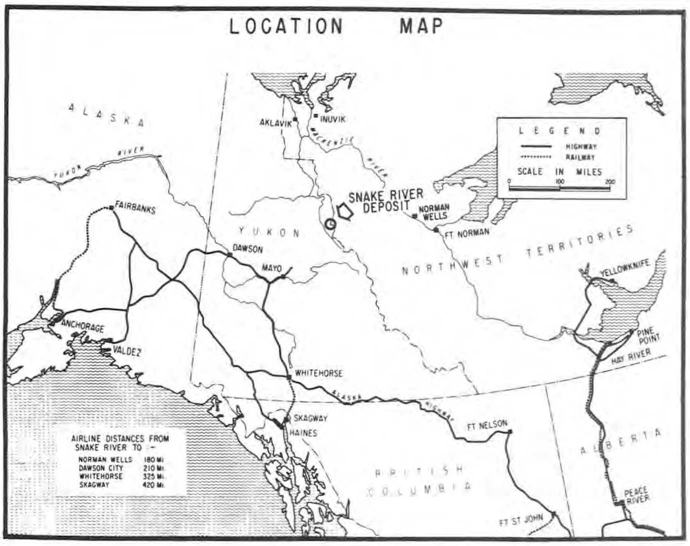


Fig.1

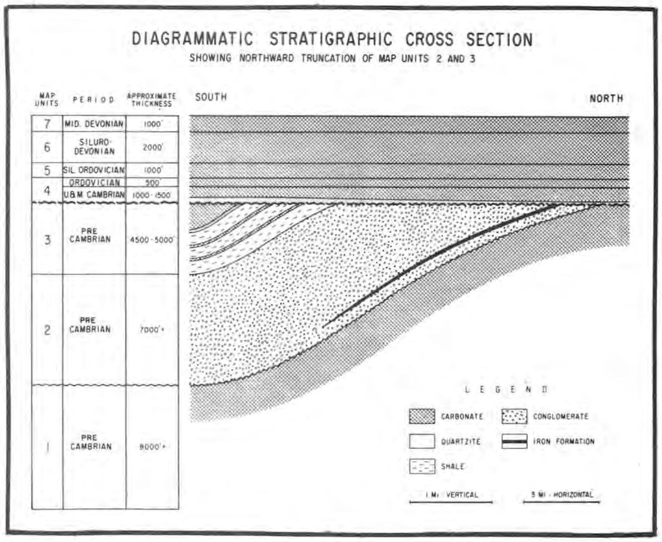


Fig.2

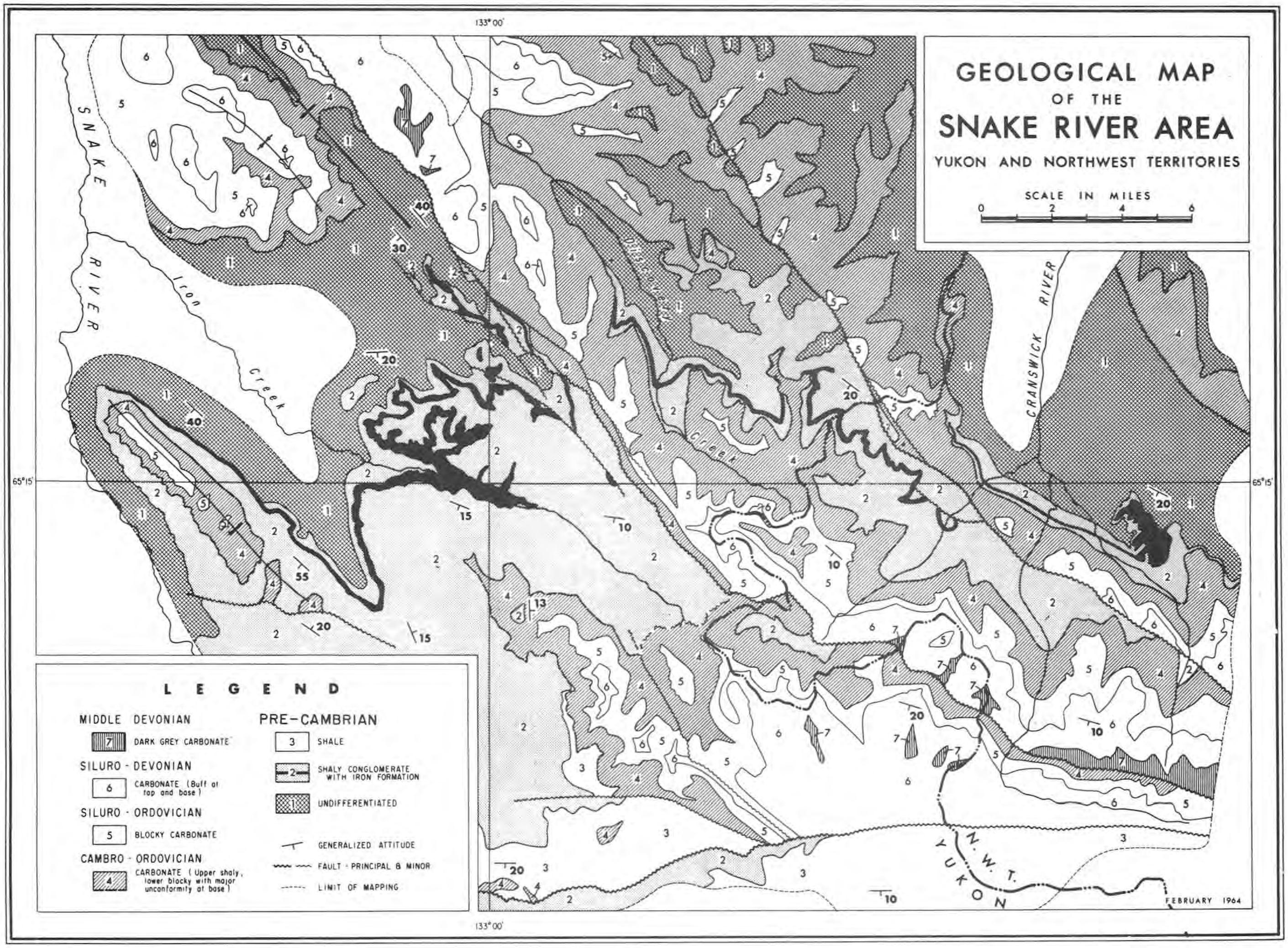


Fig.3

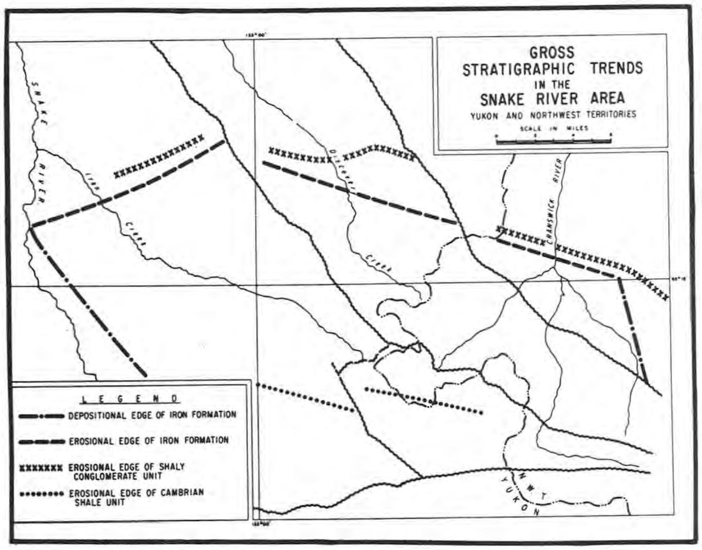


Fig. 4

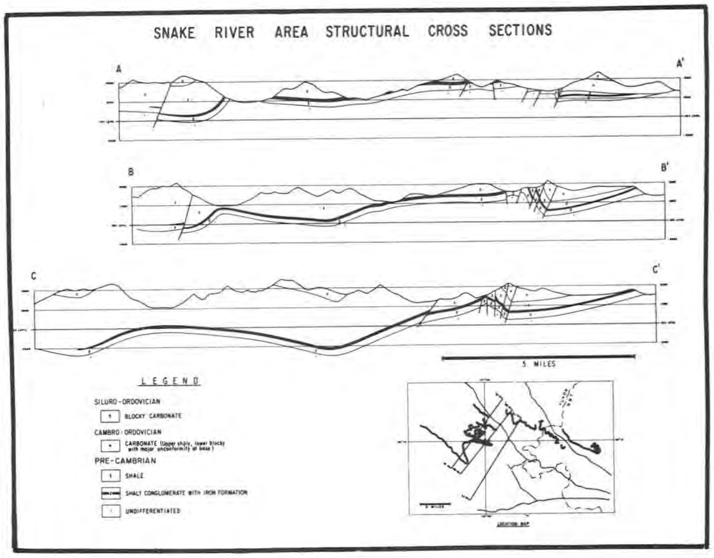


Fig.5

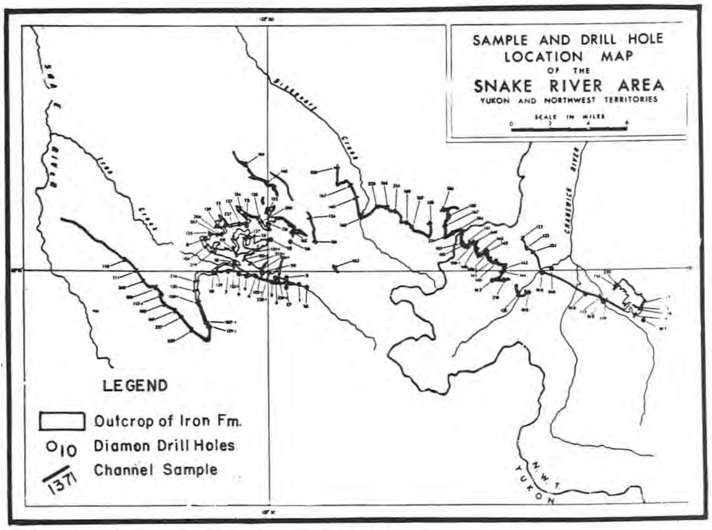


Fig. 6

OBLIQUE VIEW LOOKING EAST TOWARD THE HEADWATERS OF IRON CREEK. THE UPPER AND LOWER CONTACTS OF THE IRON FORMATION ARE OUTLINED. SCALE IS SHOWN BY THE NUMBERS SPACED AT ONE MILE INTERVALS ALONG IRON CREEK. LOCAL RELIEF IN THE AREA IS ABOUT 3000 FEET.

Fig.7

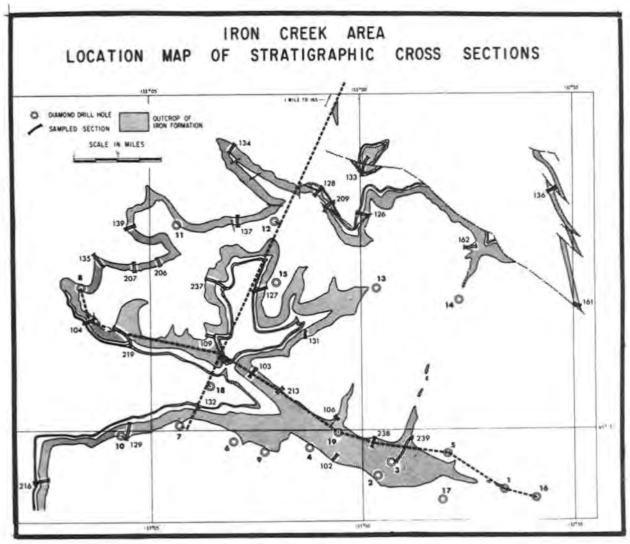


Fig. 8

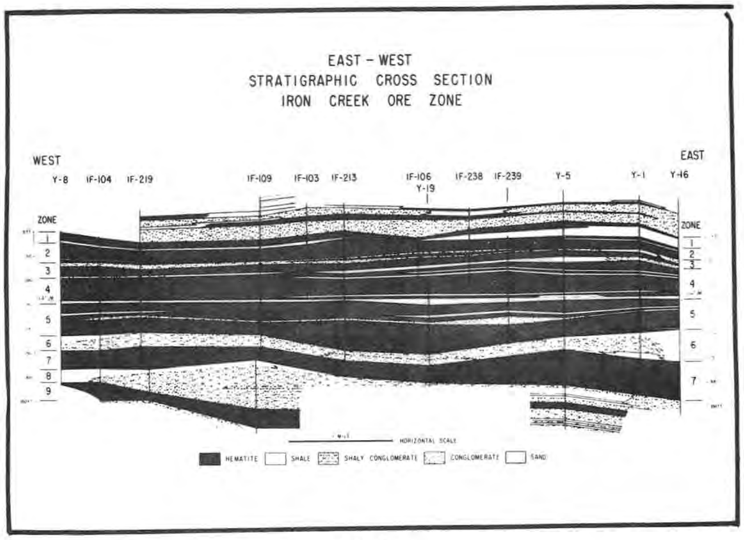


Fig.9

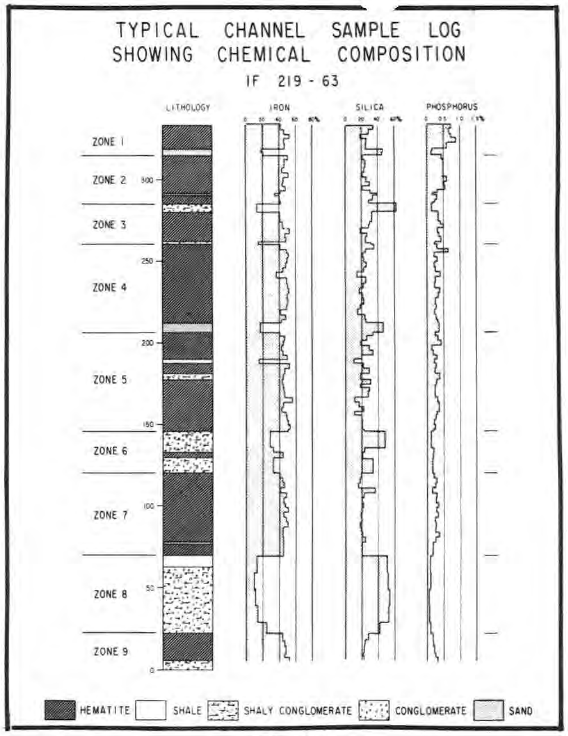


Fig.10

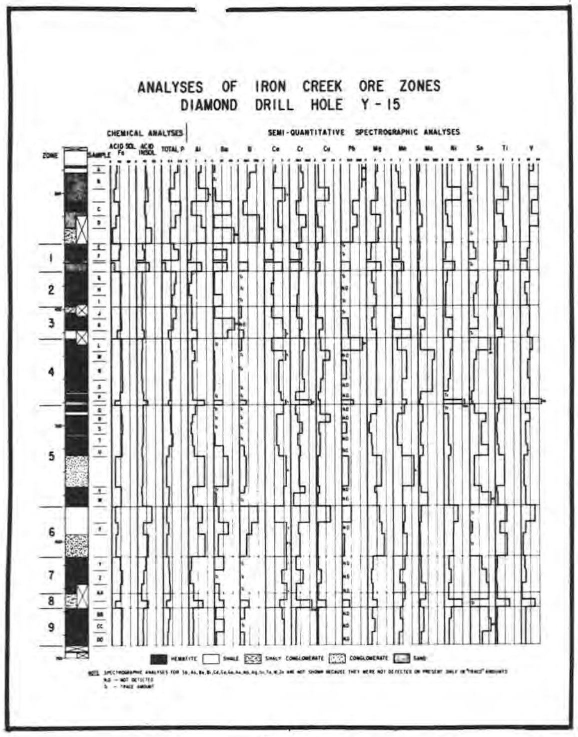


Fig.11

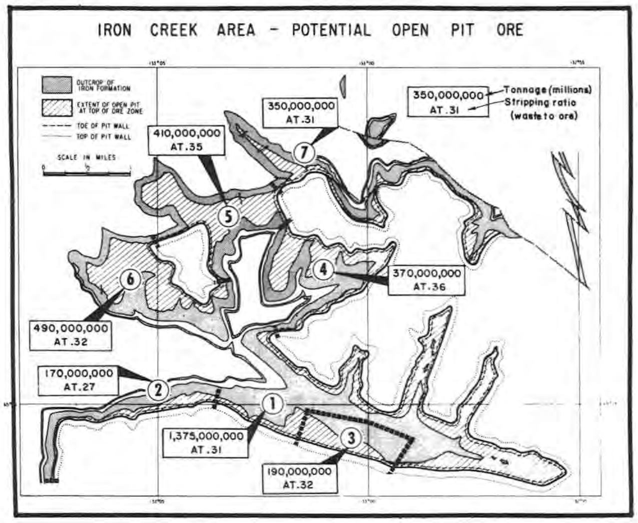
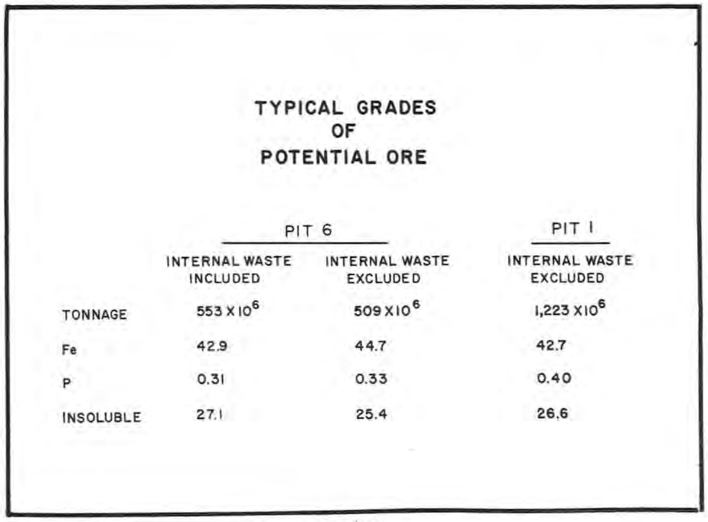


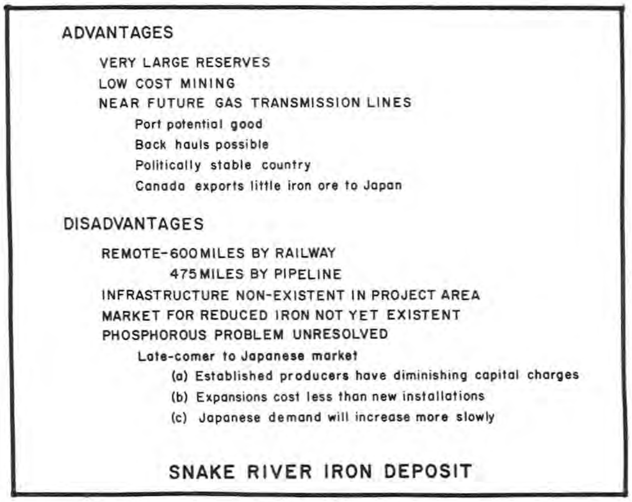
Fig.12



TYPICAL GRADES OF POTENTIAL ORE

	PIT 6		PIT 1
	INTERNAL WASTE INCLUDED	INTERNAL WASTE EXCLUDED	INTERNAL WASTE EXCLUDED
TONNAGE	553 X 10^6	509 X 10^6	1,223 X 10^6
Fe	42.9	44.7	42.7
P	0.31	0.33	0.40
INSOLUBLE	27.1	25.4	26.6

Fig.13



ADVANTAGES

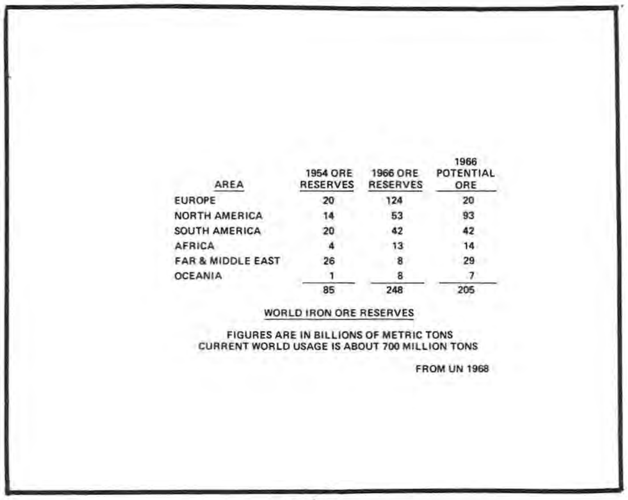
- VERY LARGE RESERVES
- LOW COST MINING
- NEAR FUTURE GAS TRANSMISSION LINES
  - Port potential good
  - Back hauls possible
  - Politically stable country
  - Canada exports little iron ore to Japan

DISADVANTAGES

- REMOTE-600 MILES BY RAILWAY
  475 MILES BY PIPELINE
- INFRASTRUCTURE NON-EXISTENT IN PROJECT AREA
- MARKET FOR REDUCED IRON NOT YET EXISTENT
- PHOSPHOROUS PROBLEM UNRESOLVED
  - Late-comer to Japanese market
    - (a) Established producers have diminishing capital charges
    - (b) Expansions cost less than new installations
    - (c) Japanese demand will increase more slowly

SNAKE RIVER IRON DEPOSIT

Fig.14



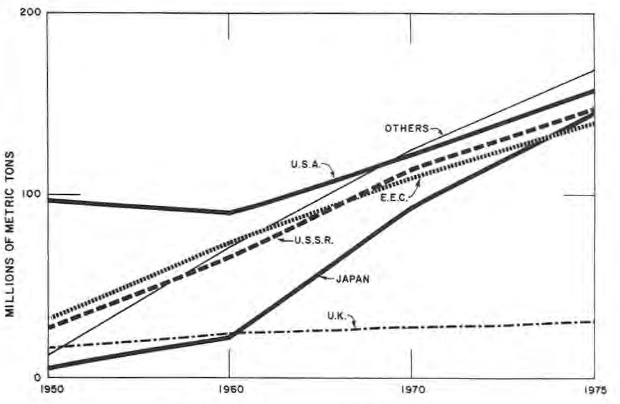
AREA	1954 ORE RESERVES	1966 ORE RESERVES	1966 POTENTIAL ORE
EUROPE	20	124	20
NORTH AMERICA	14	53	93
SOUTH AMERICA	20	42	42
AFRICA	4	13	14
FAR & MIDDLE EAST	26	8	29
OCEANIA	1	8	7
	85	248	205

WORLD IRON ORE RESERVES

FIGURES ARE IN BILLIONS OF METRIC TONS
CURRENT WORLD USAGE IS ABOUT 700 MILLION TONS

FROM UN 1968

Fig.15



WORLD STEEL PRODUCTION

After Coghill

Fig.16

SOURCE	1965	1970
AUSTRALIA	0.5	35
AFRICAN COUNTRIES	3	11
BRAZIL	2	6
INDIA & GOA	20	16
CHILE	18	9
PERU	12	8
MALAYSIA	18	4
OTHER	26.5	11
	100%	100%

SOURCE OF JAPANESE IMPORTS OF IRON ORE

1970 VOLUME – 102 MILLION METRIC TONS
1970 AVERAGE PRICE – $11.84 (U.S. c.i.f.)

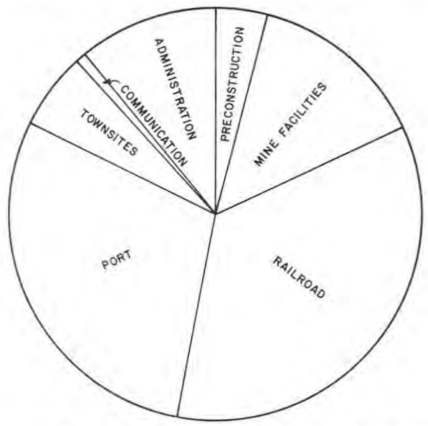
AFTER COGHILL

Fig.17

	MOUNT GOLDSWORTHY	HAMMERSLEY	MOUNT NEWMAN	SAVAGE RIVER
START PROJECT	1961	1962	1964	1963
START PRODUCTION	1966	1966	1969	1968
PRODUCTION RATE (MILLIONS)	6.5	17 (1970)	13 (1970)	2.25
RESERVES (MILLIONS)	110	5,000	1,000	800
INVESTMENT (MILLIONS)	60 (1966)	300 (1969)	210	67 (1968)
RAILWAY DISTANCE	70	182	265	53 (PIPE)
CONSTRUCTION TIME (YEARS)	1-1/4	1-3/4	2	2

MAJOR AUSTRALIAN IRON ORE PRODUCERS

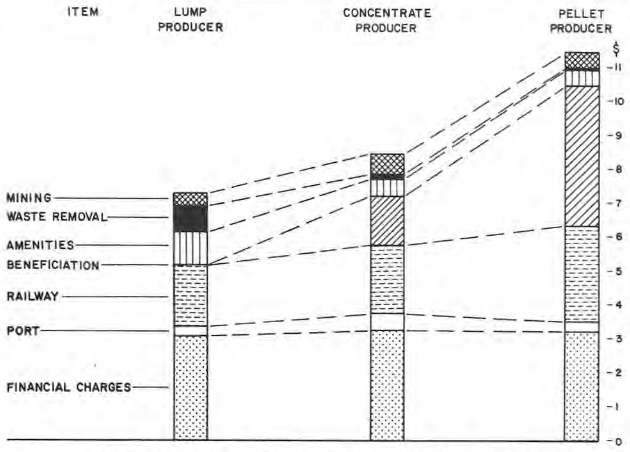
Fig.18



DISTRIBUTION OF CAPITAL COST–MT. NEWMAN

(Total cost $207 million)

Fig.19



TYPICAL IRON ORE F.O.B. PRODUCER COSTS

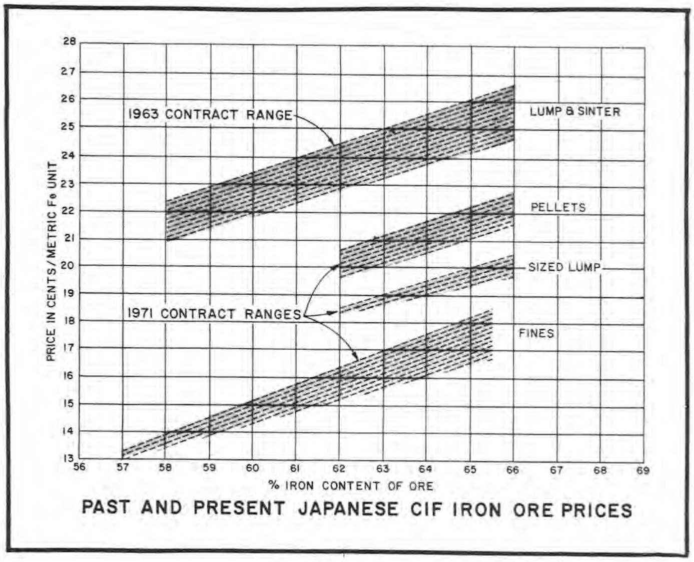
From UN 1968

Fig.20

RAW MATERIALS:	IRON ORE	– LOWER PRICE IMPROVED GRADE SCREEN TO SIZE SINTER & PELLET
	COAL	– WASH & SIZE BLEND
TRANSPORTATION:	LAND	– UNIT TRAINS
	SEA	– INCREASE SHIP SIZE BACK HAUL
FURNACE OPERATION:	INCREASE FURNACE SIZE FUEL INJECTION CONTROL FURNACE ATMOSPHERE TOP PRESSURE HIGHER TEMPERATURE OXYGENATE	

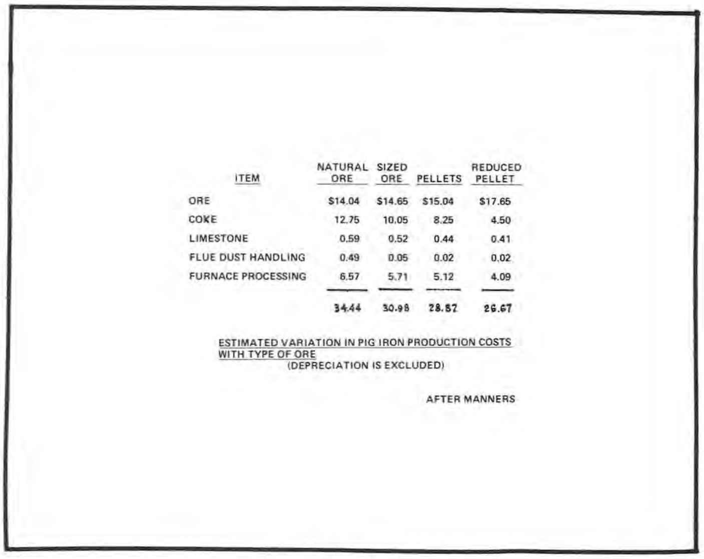
MAJOR COST REDUCTION FACTORS IN JAPANESE PIG IRON PRODUCTION

Fig.21



PAST AND PRESENT JAPANESE CIF IRON ORE PRICES

Fig.22

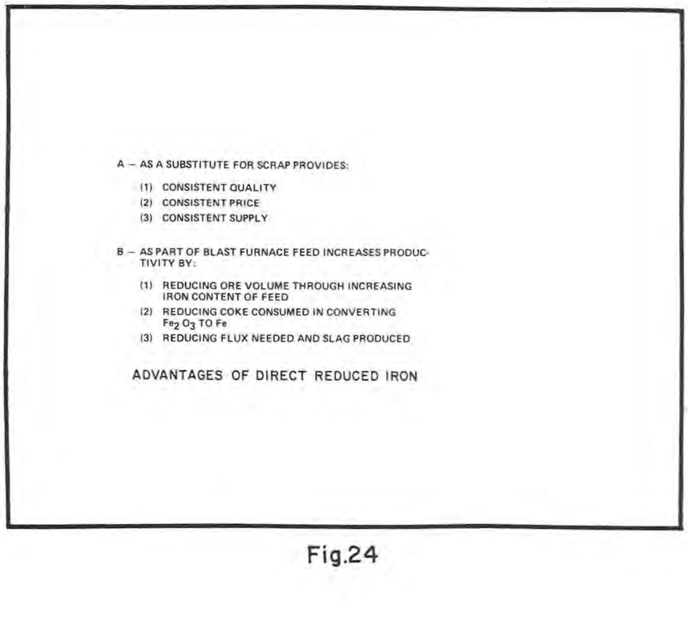


ITEM	NATURAL ORE	SIZED ORE	PELLETS	REDUCED PELLET
ORE	$14.04	$14.65	$15.04	$17.65
COKE	12.75	10.05	8.25	4.50
LIMESTONE	0.59	0.52	0.44	0.41
FLUE DUST HANDLING	0.49	0.05	0.02	0.02
FURNACE PROCESSING	6.57	5.71	5.12	4.09
	34.44	30.98	28.87	26.67

ESTIMATED VARIATION IN PIG IRON PRODUCTION COSTS WITH TYPE OF ORE
(DEPRECIATION IS EXCLUDED)

AFTER MANNERS

Fig.23



A – AS A SUBSTITUTE FOR SCRAP PROVIDES:

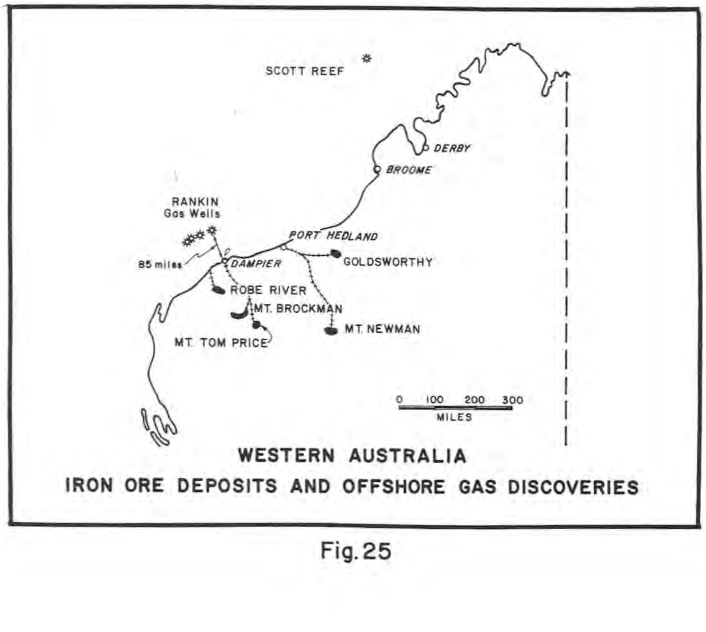
(1) CONSISTENT QUALITY
(2) CONSISTENT PRICE
(3) CONSISTENT SUPPLY

B – AS PART OF BLAST FURNACE FEED INCREASES PRODUCTIVITY BY:

(1) REDUCING ORE VOLUME THROUGH INCREASING IRON CONTENT OF FEED
(2) REDUCING COKE CONSUMED IN CONVERTING Fe_2O_3 TO Fe
(3) REDUCING FLUX NEEDED AND SLAG PRODUCED

ADVANTAGES OF DIRECT REDUCED IRON

Fig.24



WESTERN AUSTRALIA
IRON ORE DEPOSITS AND OFFSHORE GAS DISCOVERIES

Fig. 25