UNCOVERING THE POTENTIAL OF ULTRA-LOW COST STEEL MAKING USING TITANO-MAGNETITE ORES IN BLAST FURNACE-BASED MILLS

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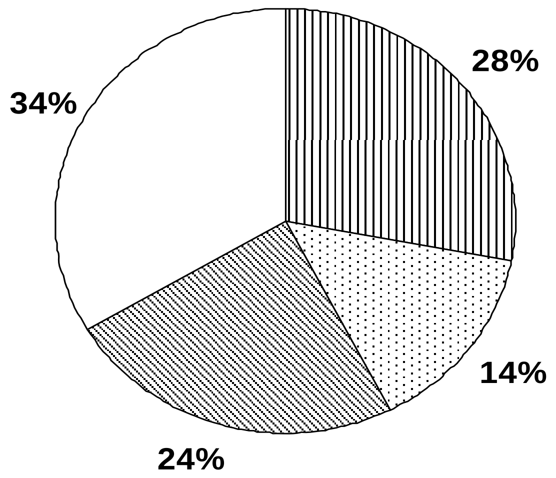
Contents

- The supply of conventional high quality, low cost iron ore is coming to an end…
- …but an untapped very large, low cost iron ore source in New Zealand, albeit atypical.
- TiFe ore is an acceptable feed for a blast furnace/sinter plant and valuable by-products (vanadium and titanium) can be recovered.
- Steel mills can reap major economic benefits by switching partially or totally to TiFe ores.

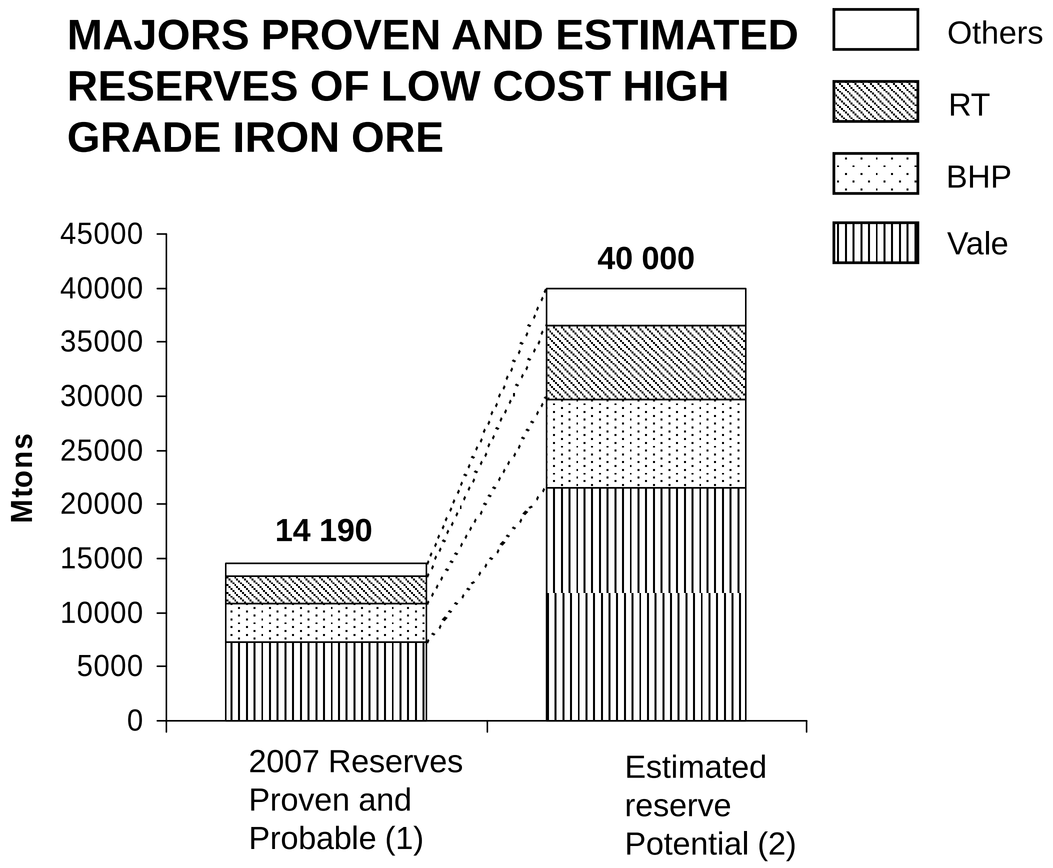
The seaborne iron ore market is dominated by the 'majors' (Vale, RT and BHP) who also control 90% of the known reserves of low cost high grade iron ore , which could represent an ultimate potential of up to 40 Btons.

MAJORS SHARE OF SEABORNE IRON ORE MARKET, YEAR 2007

Total 862 Mtons



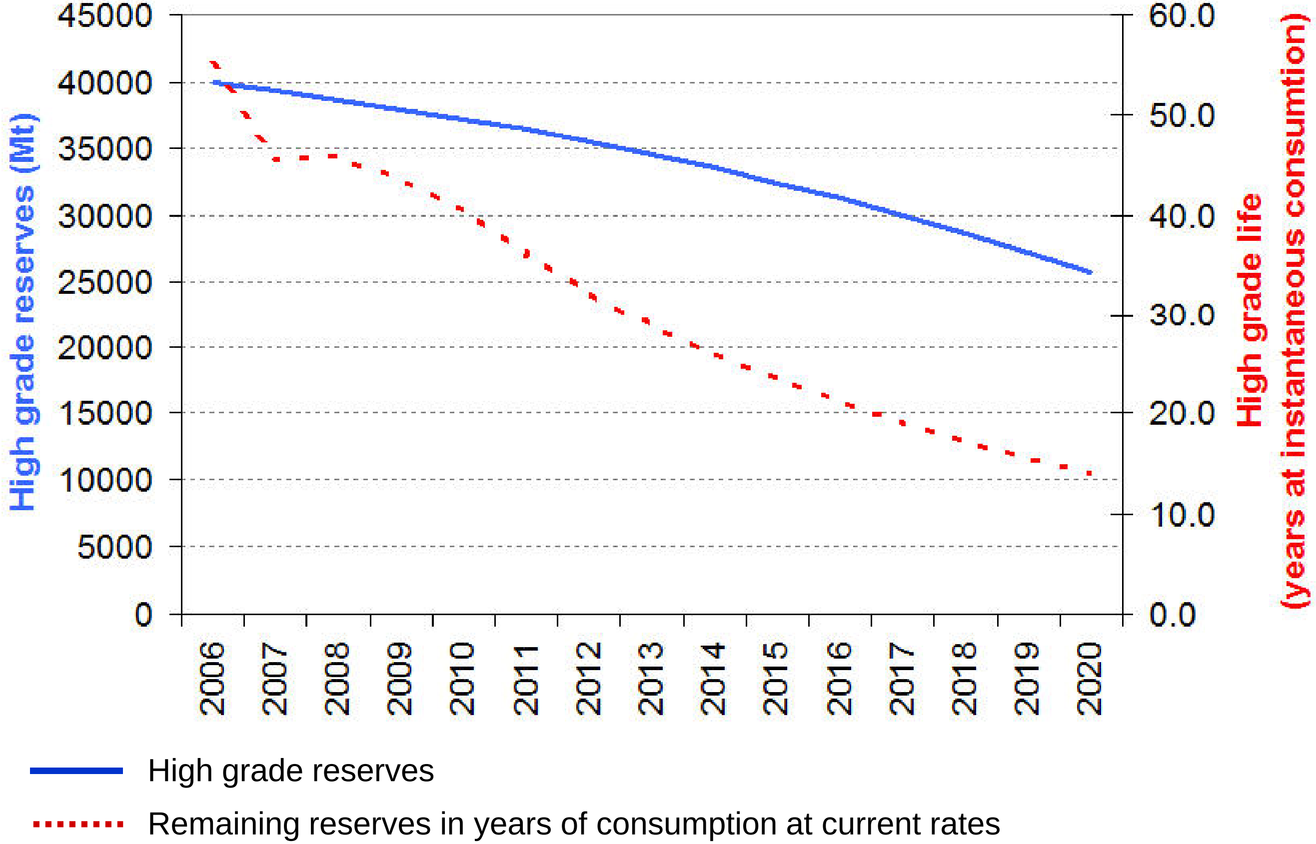
MAJORS PROVEN AND ESTIMATED RESERVES OF LOW COST HIGH GRADE IRON ORE



(1) Source GTIS, Clarksons, yearly reports. These are JORC compliant.
(2) TTR estimates discoveries at historical rates and successful drilling. Actually a very optimistic estimate

However, in the absence of major new discoveries, these high grade reserves could be completely depleted by 2030, leading to structural high prices for iron ore.

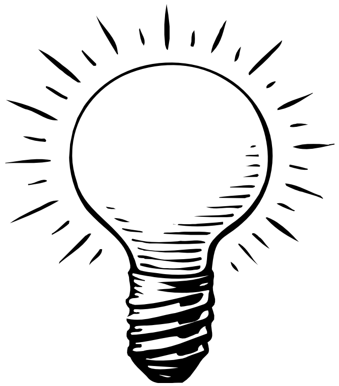
HIGH GRADE IRON ORE RESOURCE DEPLETION PROJECTIONS



Source : TTR analysis

- India's untapped resources of iron are not in excess of 10 Btons , representing less than 3 years of consumption of the seaborne iron ore market in 2020.
- The world needs a new low cost source of iron ore to maintain the growth of steel consumption in developing nations.

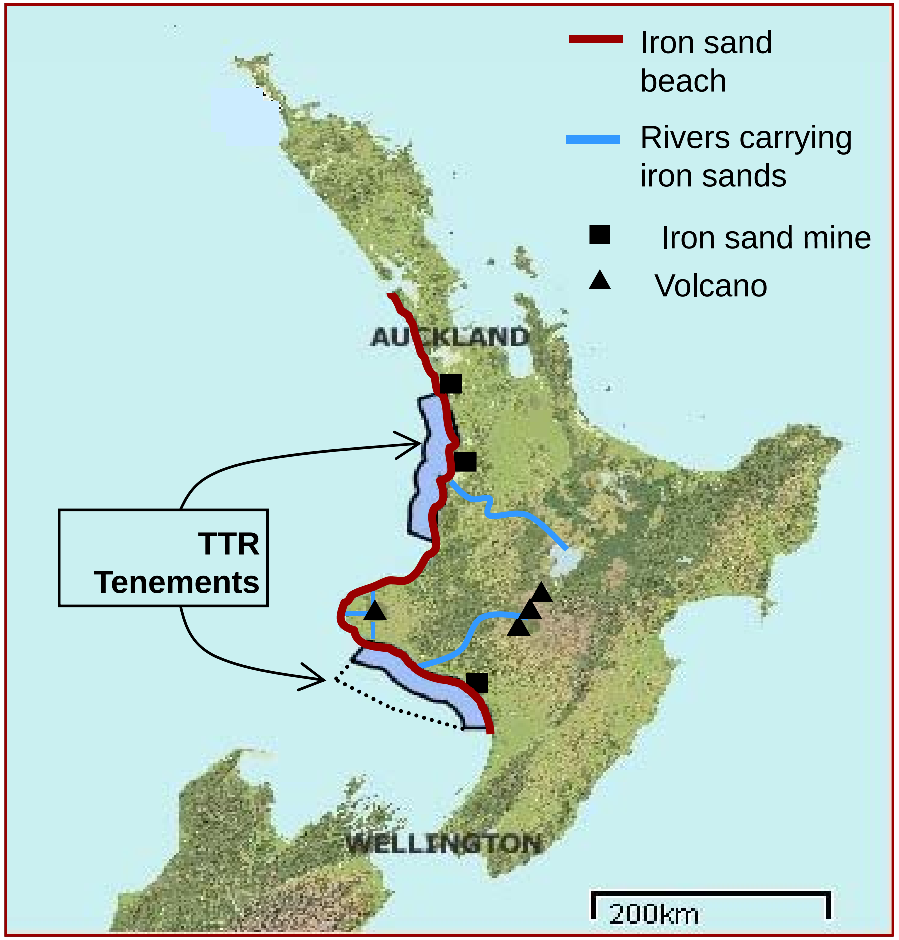
But what if there was an infinite, low cost iron ore resource available?



IRON SANDS IN NEW ZEALAND

There are massive reserves of untapped LOW COST iron ore in New Zealand in the form of iron sands

- The NZ black sand on shore deposits are the most extensive and the most concentrated in Fe in the world. Typical iron content is 20-25% Fe in weight for the beach sands over 480 km in length
- Generated titanomagnetite is transported and milled by rivers, washed out to sea, and deposited as dunes.
- TTR holds highly prospective tenements adjacent to the iron sands beaches and the main iron sand rivers.



* TTR has also lodged an application for an exclusive mineral prospecting over an additional area of 2300km2 , represented by the dotted line.

TTR OFF SHORE IRON ORE PROJECT SYNOPSIS

- **MASSIVE RESOURCE POTENTIAL AND LOW COST EXPLORATION**
  - TTR is targeting an initial minimum JORC compliant resource equivalent to **1 billion tonnes @ 60% Fe within 2 years**
  - TTR is targeting a three year JORC compliant resource equivalent in excess of **9 billion tonnes @ 60% Fe**.
- **ULTRA LOW COST MINING OPERATIONS AND VERY LOW CAPEX**
  - Estimated mine OPEX lower than best BHP/RT Pilbara DSO mines
  - Estimated mine CAPEX 7-10 times lower than RT/ BHP expansions
- **HIGHLY CONTESTED EMERGING IRON ORE PROVINCE**
  - Rio Tinto , FMG and Sinosteel are aggressively pursuing the potential of iron sands deposits in this region since 2007
- **ATYPICAL LOW COST IRON ORE FEED WITH VALUABLE BY PRODUCTS**
  - Typical Chinese mill can blend 20%-40% of iron sands in the sinter feed
  - Benefits for hot metal costs are achieved with 15% discount to benchmark
  - Very significant additional benefits if vanadium is recovered by steel mill
  - Overwhelming economics for blast furnaces dedicated to iron sands

TTR IS CURRENTLY LOOKING FOR STRATEGIC PARTNERS / INVESTORS FOR THE NEXT PHASE OF PROJECT DEVELOPMENT.

EXPLORATION POTENTIAL IN THE SOUTHERN TENEMENT

ESTIMATE OF THE SIZE OF THE RESOURCE FOR PART OF THE SOUTHERN TENEMENT

Assumptions for the active areas[1]

- Total high conc. areas = 2100 km2
- Sand depth is 20 meters.[2]
- Average concentration of iron sand[1] in sediment is 10.6%

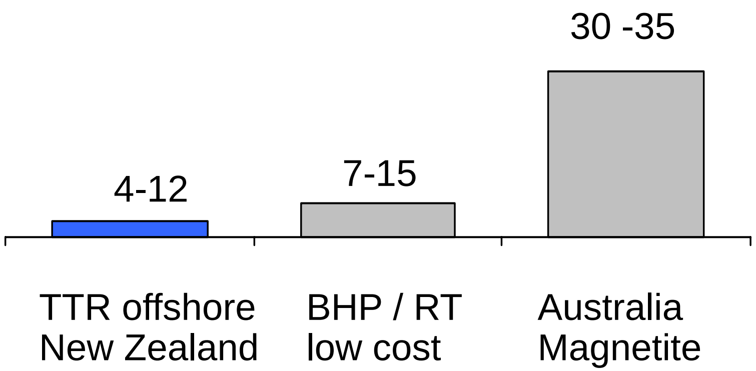
9 BT of iron sand concentrate @ 60% Fe

10%-42% iron sands	Economic grades
8%-10% iron sands	Economic grades
6%-8% iron sands	Economic grades
2%-6% iron sands	

(1) Pure iron sands contain 60% Fe in weight
(2) Data collected by oil and gas operators indicates 90-150m deep columns of iron sands

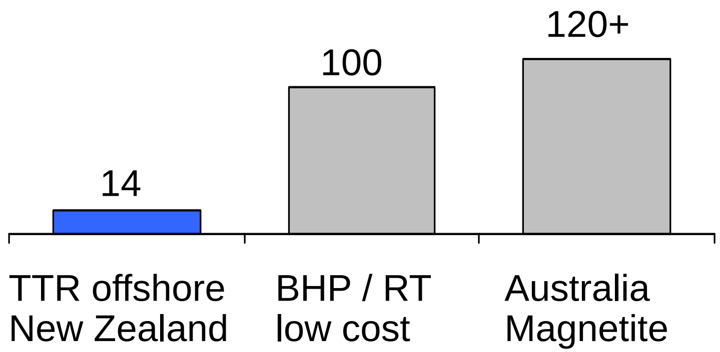
TTR has the potential to become a super low cost iron ore producer, due to the structural advantages of dredging over drill and blast.

OPERATING COSTS
2006 – FOB - USD/ t (FOB)



- ➢ Dredging costs much cheaper than drill & blast
- ➢ No crushing required for the iron sands
- ➢ Floating mine enables selective mining and longer lower cost operation

CAPITAL COSTS
2006 – USD/ tonne of capacity of DSO



- ➢ No deep sea port or rail required. Iron sands are slurried to Capesize vessel and dewatered at sea. The main capital cost for mining is the port, typically requiring 45-60 USD/tonne of capital investment.
- ➢ No tailings dam required. Sediment is returned to seabed with minimal environmental impact

IRON SANDS PROSPECTING TENEMENTS IN NZ

Rio Tinto / IONZ
- JV (60%/40%) – Operator Rio Tinto Exploration
- Initial license granted **21/02/2005** for 1270 km2 off shore
- Rio Tinto involvement in license extension **21/02/2007**
- Application for an extension of area lodged **01/02/2008**
- Application for an exploration license lodged **13/02/2009**

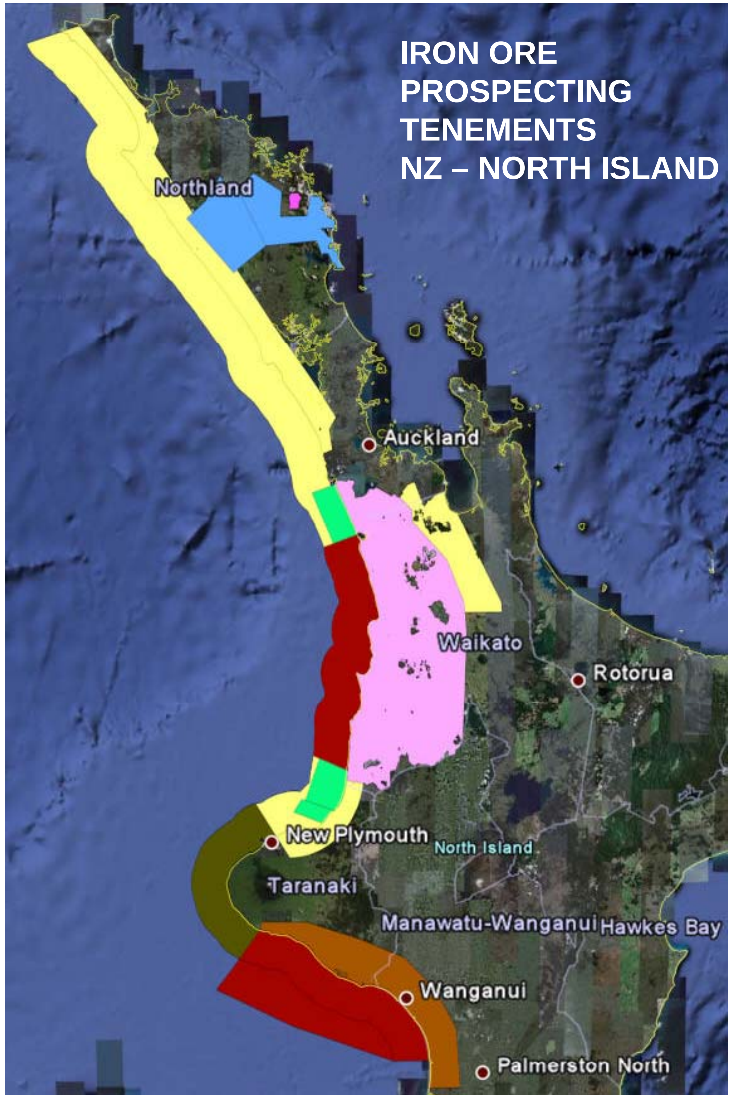
Sinosteel Australia
- License granted **19/10/2007** for 9401 km2 on shore

Trans-Tasman Resources
- Initial license granted **14/03/2008** for 6319 km2 off shore
- Application for an extension of 2300 km2 lodged **22/04/2008**

Sericho Developments
- . Application lodged **30/10/2007** for 3249 km2

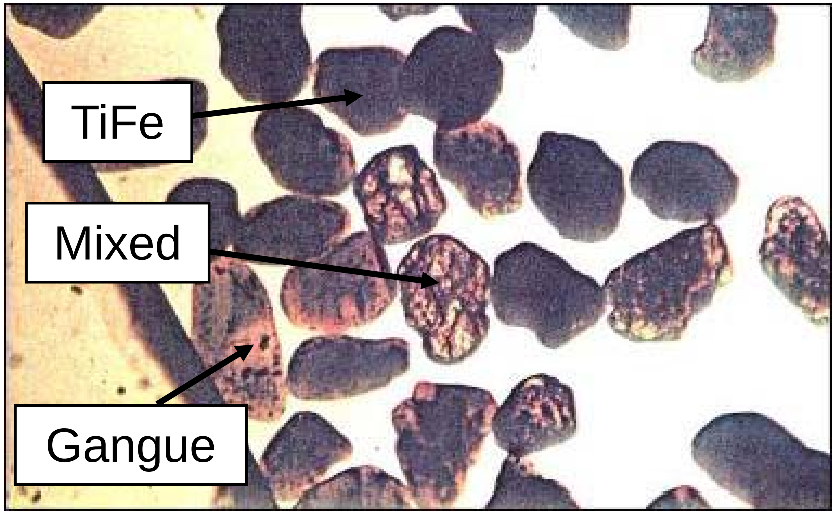
FMG
•Two applications granted **03/04/2009** for 650 km2 off shore and 874 km2 on shore (enclosing Rio Tinto tenements)
•Two additional applications lodged **30/06/2007** for 8204 km2 off shore and 3000 km2 on shore (Northland)

Ironsands Offshore Mining Limited
•Application lodged **06/04/2007** for 2361 km2 offshore



Source : Crown Minerals

Mineralogy of iron sands and possible product grades



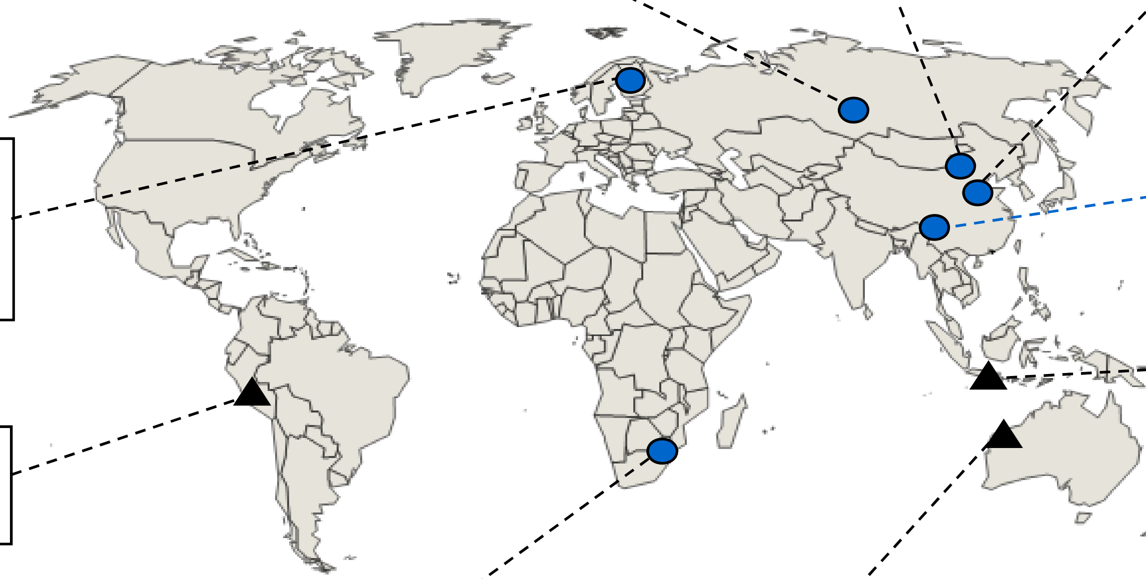
- Optical microscope structure
  - opaques, mixed, clear
- Academic work performed on NZ iron sands
- Some possible product grades with lower Fe recovery.

	Fe	SiO_2	Al_2O_3	TiO_2	V_2O_5	P	LOI
River mouth sediment iron sands	57.19	3.58	3.63	7.68	0.54	0.17	-2.94
TTR TiFe concentrate for blending	60.96	0.1	2.03	7.84	0.55	0.02	-2.95
TTR TiFe concentrate for TiFe mills	59.96	0.1	3.65	7.71	0.54	0.02	-3.00

We have a low cost, large tonnage product entering the market. Can we economically make steel with it?

CURRENT DEDICATED TiFe STEEL MILLS
(with vanadium recovery)

● TiFe dedicated mill
▲ New TiFe project/mine



Nizhniy Tagil - Russia
Technology: Blast Furnace

Rockcheck Steel Group - China
Technology: Blast Furnace

Chengde Iron and Steel - China
Technology: Blast Furnace

Panzhihua Iron and Steel - China
Technology: Blast Furnace
Main producer of vanadium and titanium in China

SSAB Luleå – Sweden
Technology: Blast Furnace
CSP = 2.1 Mt p.a.

Cardero
Pampa el Toro
Sands ~2-8% Fe.

Indomines
Jogjakarta deposit – Sand, ~11% Fe.
DRI plant planned

Highveld Steel and Vanadium – RSA
Technology: Rotary Kiln + Electric smelter

Aurox
Balla Balla deposit – hard rock, ~40% Fe.

New Zealand Steel
New Zealand
Technology: Rotary Kiln + Electric smelter

* These steel mills use TiFe ores as main part of their feed.
Source: SBB

TiFe in the sinter plant

- Sintering – granulation poor in low quantities. Higher quantities will assist granulation.[1)]
- Productivity generally decreases, sinter strength decreases.
- Mostly solved by increasing fuel rate and sinter basicity.
- Blend granulation in low quantities solved with finely divided burnt lime addition.

1) Bristow & Loo – Sintering properties of iron ore mixes containing Titanium, ISIJ Vol 32 no7 (1992)

Impact of higher TiFe burden in the blast furnace

	Typical conventional b.f.	DedicatedTi Fe b.f.
$[Si]_{hm}$	0.5	0.2
CaO/SiO_2	1.15	1.15
$(Al_2O_3)_s$	15.0	12.0
Slag Volume (kg/thm)	300	470
Fuel rate (kg/thm)	500	550

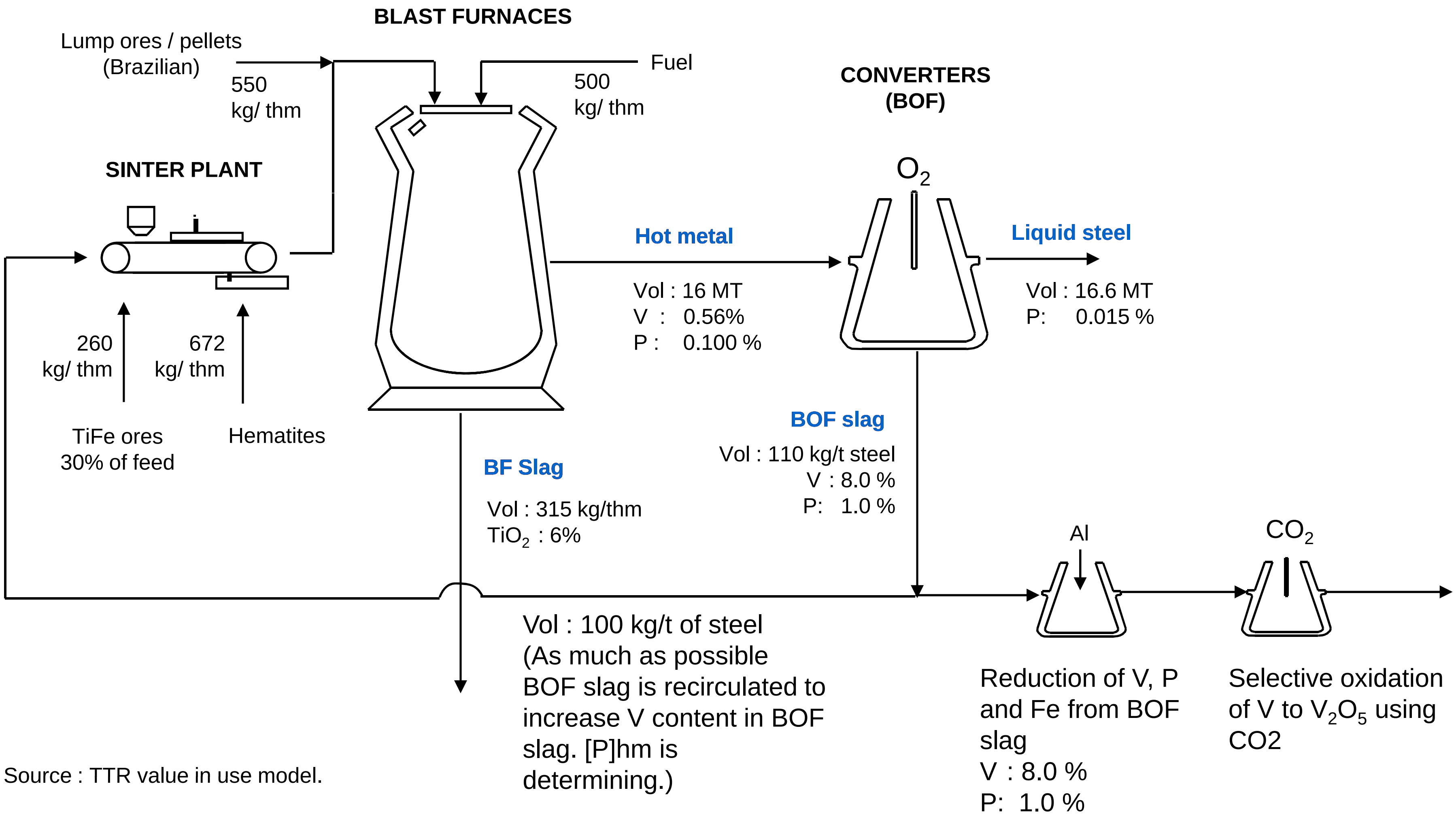
- Higher slag volume, and higher fuel rate.
- Positive impact on slag fluidity at <20%[1)], or add slag modifier at TiO_2 > 20% in slag.
- Low Si operation required to ensure TiO_2 goes to slag, and not to $[Ti]_{hm}$.
- VIU benefit to steelmaker at 15% discount to fines reference price.
- Extra b.f. offgas used for downstream vanadium production from vanadium-rich slag.
- Titania recovery from slag economical in dedicated bf.[2)]

1) Saito et.al. - Viscosity of blast furnace type slags, Metallurgical and Materials transactions, Oct 2003.

2) Calculated from Haigang et.al. – A Fundamental investigation on recovery of Titanium from Titanium-Bearing blast furnace slag, 2007 TMS Annual Meeting and Exhibition

SIMULATION 1 - TiFe ORE USE FOR A TYPICAL CHINESE COASTAL MILL
Vanadium recovery from BOF slag with BOF slag recirculation

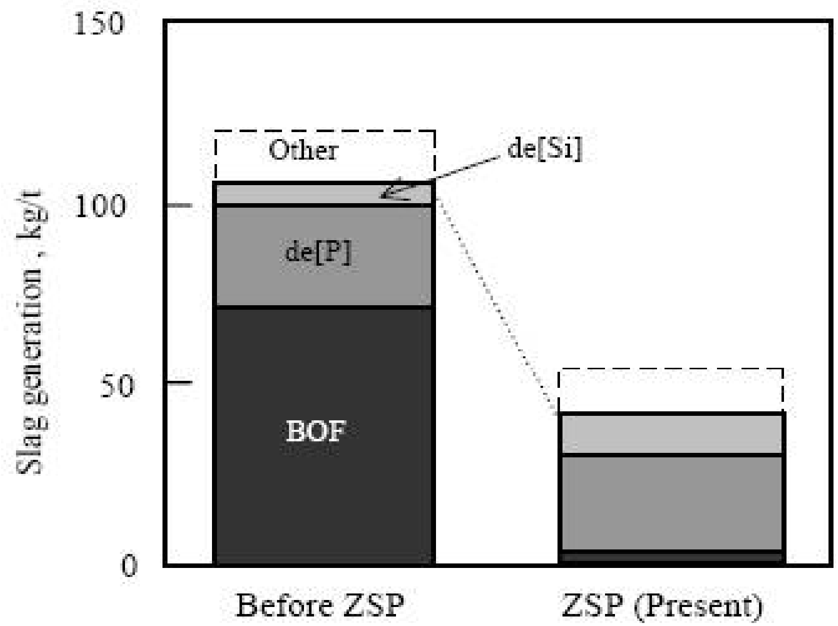
SIMPLIFIED FLOW CHART



Source : TTR value in use model.

Hot metal Pre-treatment and vanadium recovery from TiFe ores

- Made famous by Japanese plants, Posco, CSC, increasing number of Chinese plants. – to remove phosphorus
- No dependence on purchased scrap
- Targeted pre-treatment slag compositions results in saleable by-products
- Highly positive impact on steel making flux consumption and cost.
- **Can also recover vanadium with a slight process modification**.

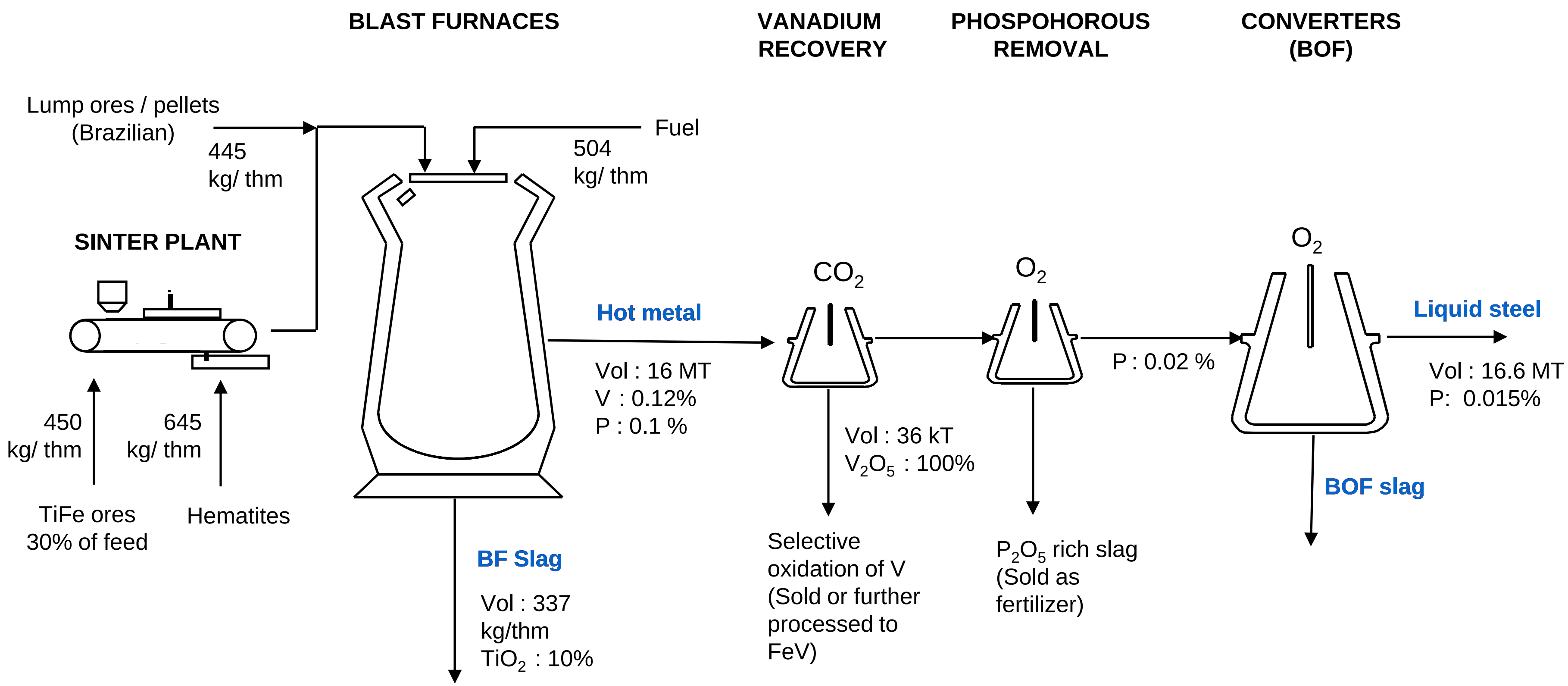


JFE Fukuyama slag reduction with hot metal pre-treatment[1)]

1) Tanabe and Nakada – Steelmaking technologies contributing to Steel Industries, NKK Technical Review no 88 (2003)

SIMULATION 2 - TiFe ORE USE FOR A TYPICAL CHINESE COASTAL MILL
Vanadium recovery in hot metal with dephosphorisation

SIMPLIFIED FLOW CHART

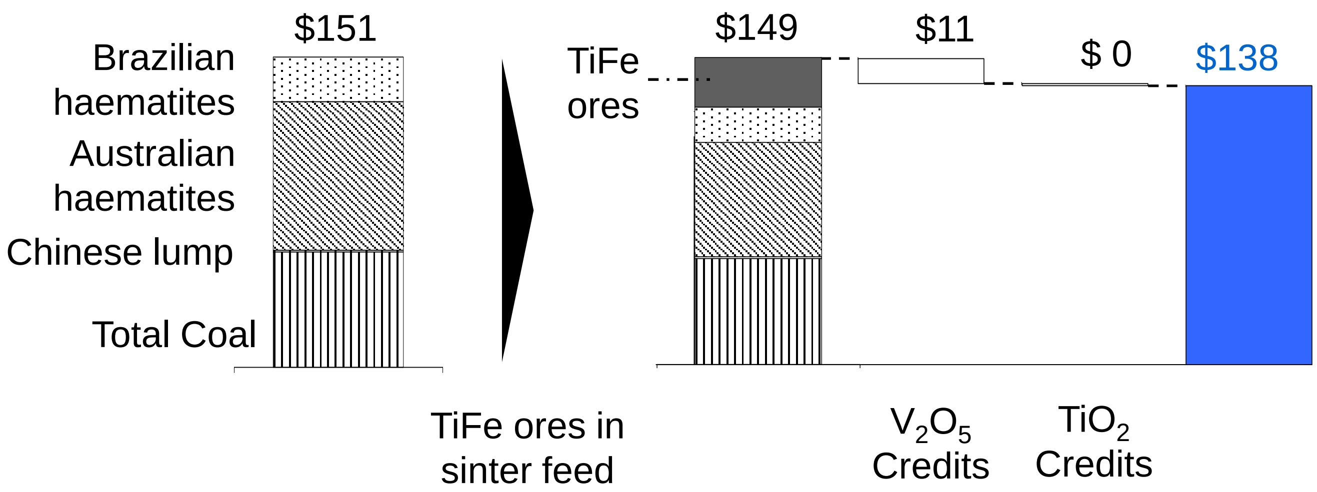


Source : TTR value in use model.

SUMMARY OF ECONOMICS OF USING TiFe ORES

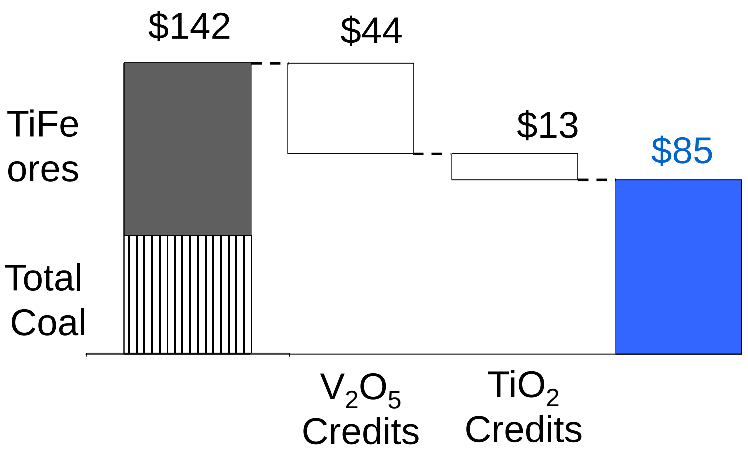
Raw materials basket, 2015, USD/ tonne of hot metal

EXISTING (1) COASTAL CHINESE MILL - BLEND



- TiFe ores sold at 15% discount to benchmark
- Simple vanadium recovery yields significant benefits

TIFe DEDICATED CHINESE MILL



Coastal Chinese dedicated TiFe mill would have very strong cost advantage over traditional mills.

(1) Mill equipped with de-phosphorisation and unlimited access to Brazilian and Australian ores.

Conclusion

- The supply of conventional high quality, low cost iron ore is coming to an end, potentially leading to structurally higher steel making costs.
- But there is an untapped very large, low cost iron ore source in New Zealand, albeit atypical.
- Steel mills can reap major economic benefits by switching partially or totally to TiFe ores.
- Early adopters of low cost TiFe ores will benefit from significant cost advantage compared to peers.

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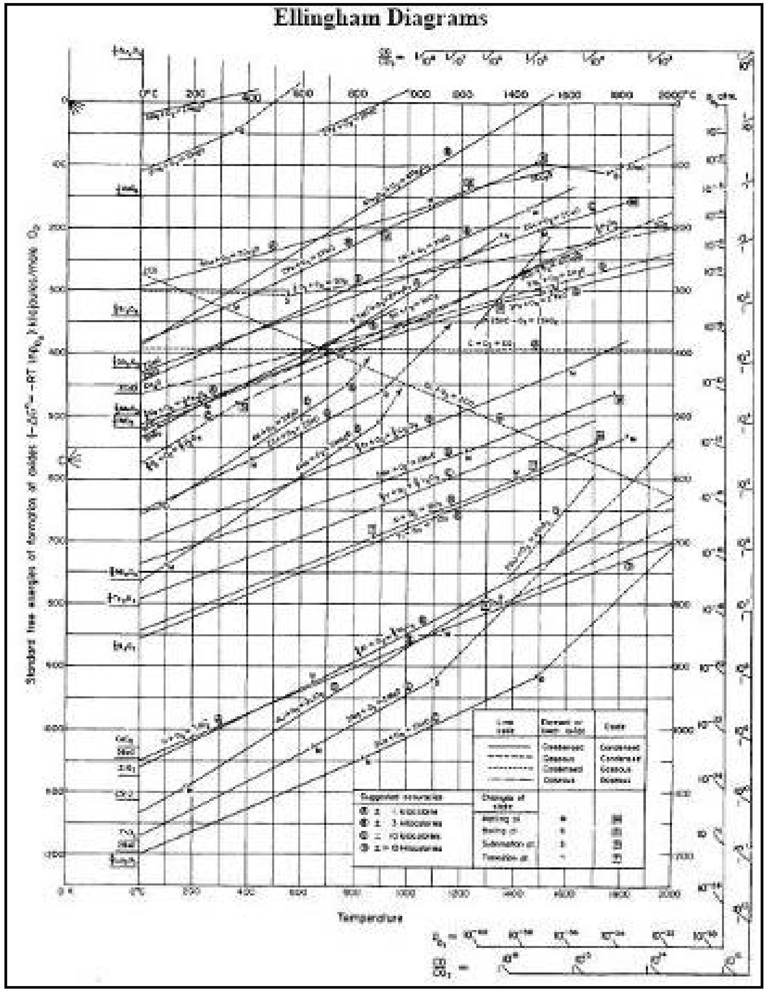
Long term (2015) assumptions used by TTR

Long term iron ore fines price	65 USc/Fe unit
Lump premium	20 USc/Fe unit
Pellet premium	17 USD/t
Hard Coking coal (USD/t)	100 USD/t
Freight Pilbara-Qingdao	10.65 USD/wt
Freight Brazil-Qingdao	34.50 USD/wt
Freight NZ-Qingdao	15.85 USD/wt
Slab FOB Brazil	430 USD/t
World steel production 2015	1.8 Bt
2020	2.2 Bt
Seaborne iron ore market 2015	1.4 Bt
2020	1.8 Bt
V_2O_5 slag sales price	5000 USD/t
TiO_2 intermediate precipitate	250 USD/t

Vanadium oxides can be recovered by selective oxidation either in the hot metal or in the BOF slag as illustrated by the Ellingham diagram



The Ellingham diagram graphically presents Gibbs free energy for equilibrium reactions between species and their oxides as a function of temperature and partial oxygen pressure.

For treatment of hot metal, either in a BOF or with hot metal pre-treatment, oxidation will occur in the following sequence:

1. Silicon
2. Vanadium
3. Phosphorus
4. Carbon

INITIAL OFF SHORES SAMPLES IN SOUTHERN TENEMENT

- 160 surface and core samples collected by academic institutions and TTR indicate the existence of large areas with concentrations of iron sands* in the sediment of 15%-40%.
- A core sample down to **18 meters** deep revealed a continuous column of unconsolidated iron sands with an average concentration of 11.5%. Reported iron sand column was 90m.
- The straight average for the concentration of iron sands is **8.3%,** with large areas **15%-40%.** The economic cut off grade (including CAPEX) is estimated at 6%.

MAPPING OF IRON SAND* CONCENTRATIONS

10%-42% iron sands
8%-10% iron sands
6%-8% iron sands
2%-6% iron sands

Economic grades

* Pure iron sands contain 60% Fe in weight
** Samples were stored and provided by NIWA, Wellington
Additional more recent samples were collected by TTR