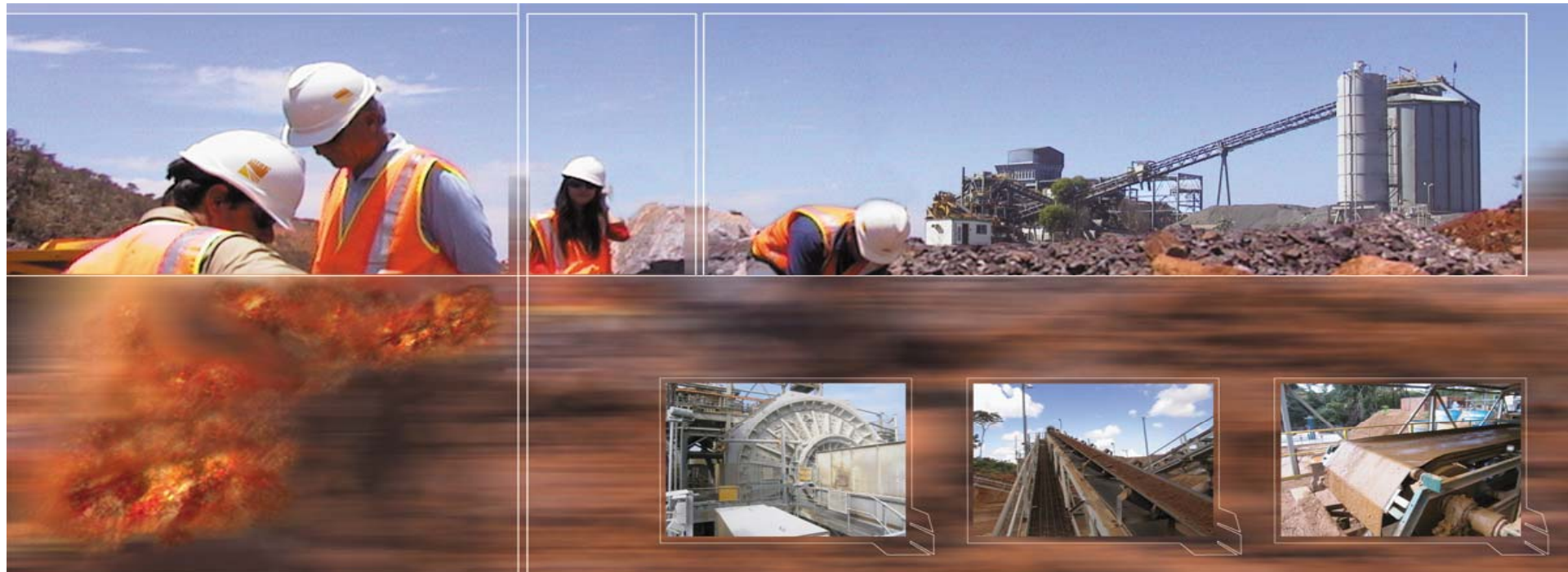


Scandinavian Resources

Metallurgical Summary





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> ACKNOWLEDGEMENTS

This document is a dynamic record of the knowledge and experience of personnel at Mineral Engineering Technical Services. As such it has been built upon over the years and is a collaborative effort by all those involved. We are thankful for the material supplied by and referenced from various equipment manufacturers, vendors, industry research and project partners.





Introduction - Kiruna

- > A well known iron ore province in northern Sweden
- > The location of the worlds largest underground iron ore mine
- > Orebodies usually comprise of magnetite, martite, hematite and apatite
- > Many orebodies exhibit a high iron grade (in excess of 60% Fe)
- > Typically, Kiruna iron ore contains higher levels of phosphorus which requires processing to remove.



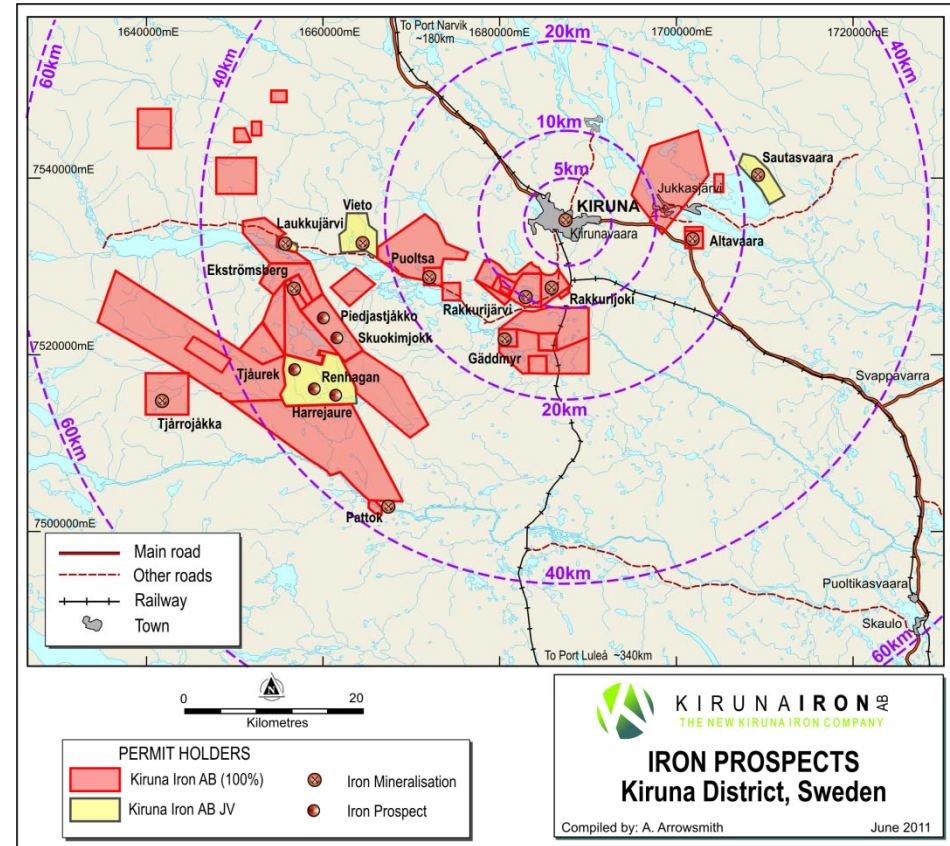
AusIMM
AUSTRALASIAN INSTITUTE OF MINING & METALLURGY

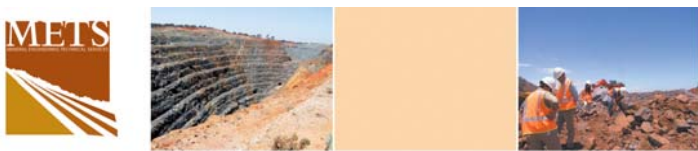




Introduction - Kiruna

- > The Kiruna Project lies to the south west of Luossavaara-Kiirunavaara Altiebolag (LKAB) mine and Kiruna
- > The boreholes tested include Vieto, Laukkujärvi, Ekströmsberg, Puoltsa, Gäddmyr, Rakkurijärvi, Rakkurijoki and Sautasvaara





Metallurgical Testwork

- > Two phases of metallurgical studies have been performed and a third is currently underway (Davis Tube Recovery tests)

- > Phase 1: Mineral Engineering Technical Services (METs)
 - Puoltsa (1 hole), Gäddmyr (1 hole), Vieto (1 hole), Laukkujärvi (2 holes) and Ekströmsberg (1 hole)
 - Head grades
 - Magnetic Separation by Davis Tube Recovery (DTR)

- > Phase 2: JK Tech
 - Sautasvaara (2 holes)
 - Comminution (crushing and grinding)
 - Davis Tube Recovery

- > Phase 3: METs
 - Rakkurijärvi (5 holes), Rakkurijoki (5 holes)
 - Currently underway

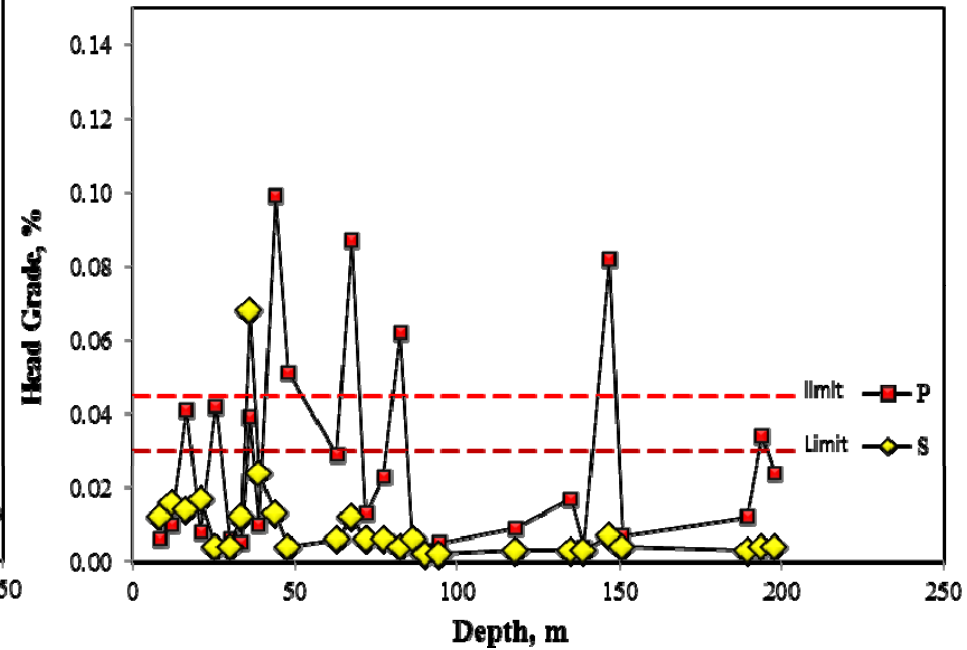
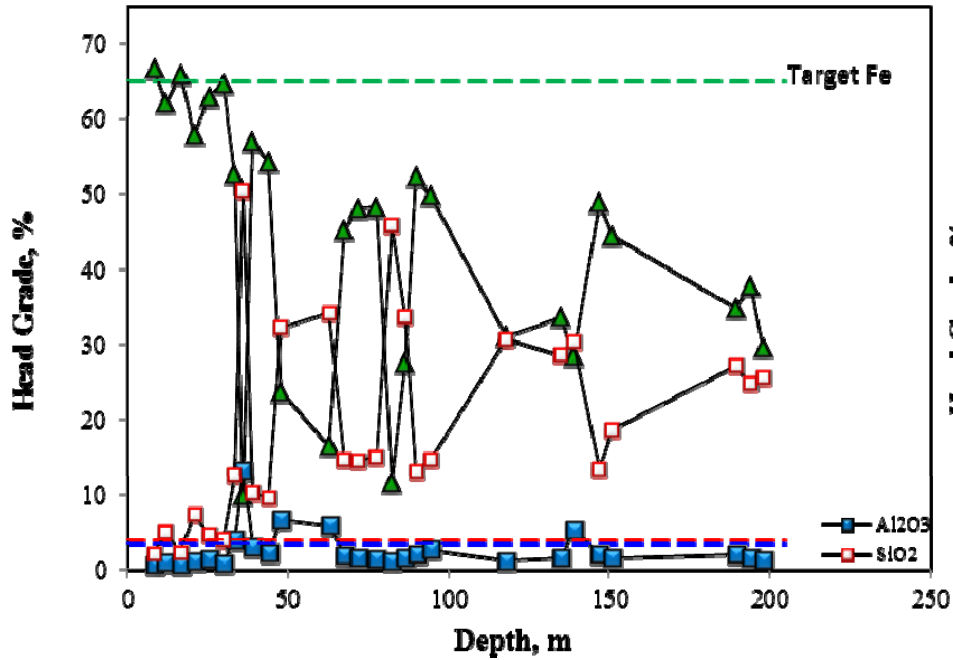


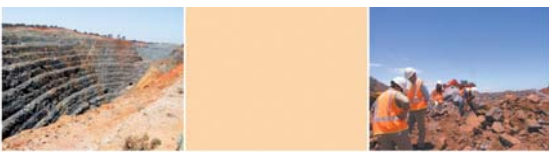


Phase 1 - METS

> Puoltsa borehole - Assay

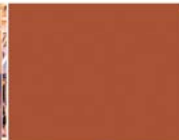
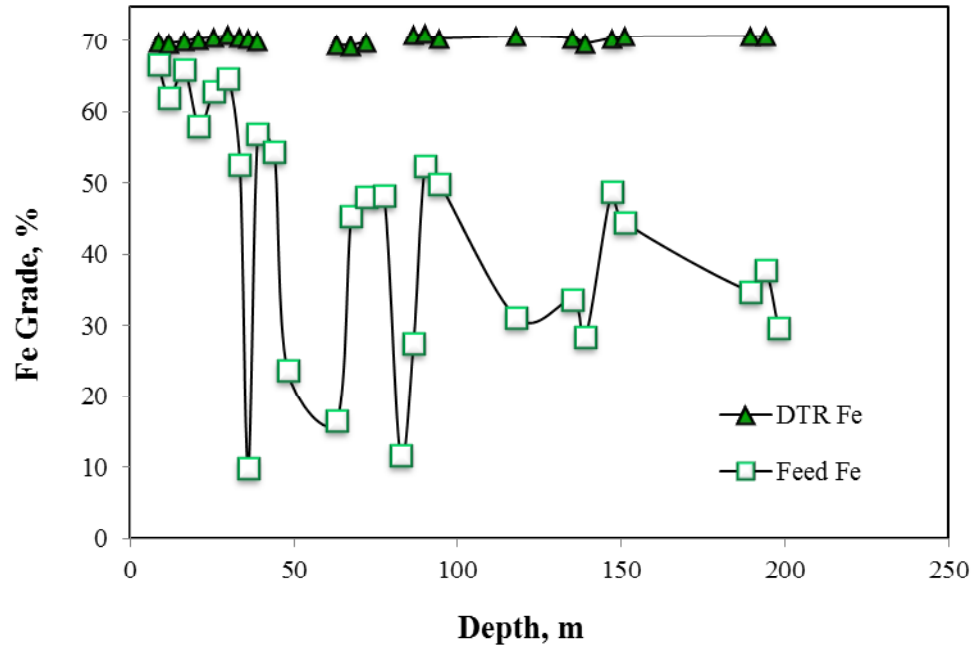
- Head assay returned iron grade up to 66% Fe (average of 48% Fe)

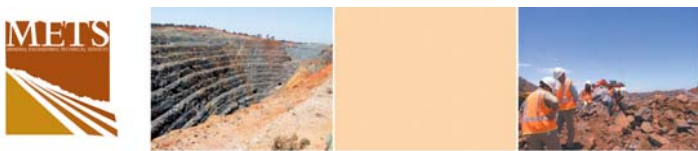




Phase 1 - METS

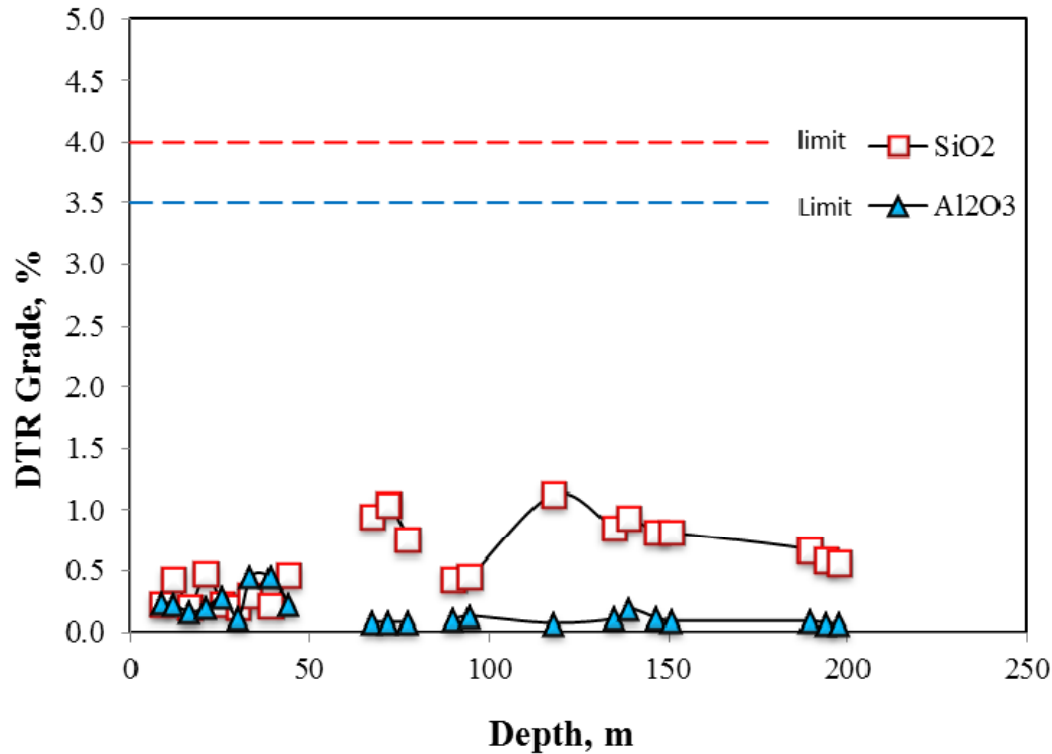
- > Puoltsa borehole - Davis Tube Recovery
 - Head assay returned iron grade up to 66% Fe (average of 48% Fe)
 - Iron recoveries over 90% were achieved in the magnetic products
 - Majority of the iron was contained in magnetite.
 - DTR concentrate averaged 70.3% Fe





Phase 1 - METS

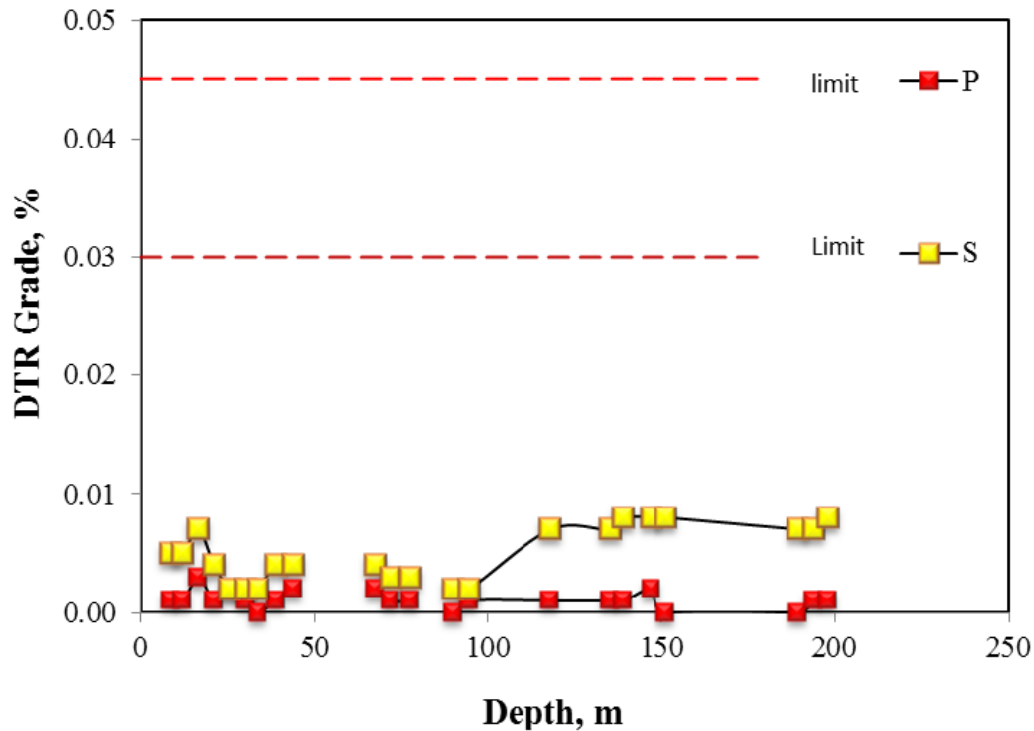
- > Puoltsa borehole
 - Low alumina and silica levels. Within iron ore specification limit





Phase 1 - METS

- > Puoltsa borehole
 - Low levels of phosphorus and sulphur

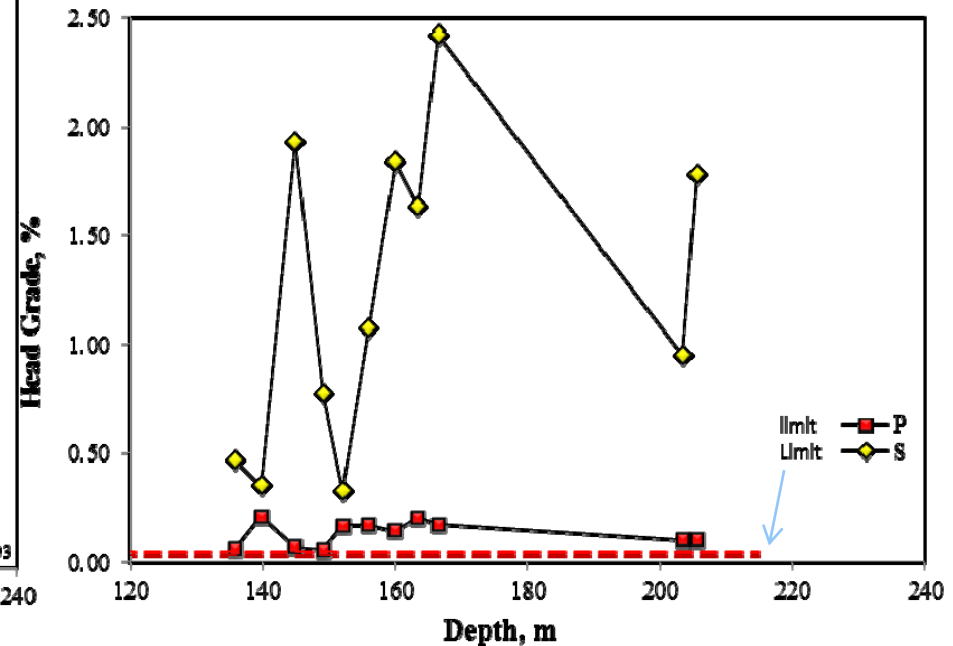
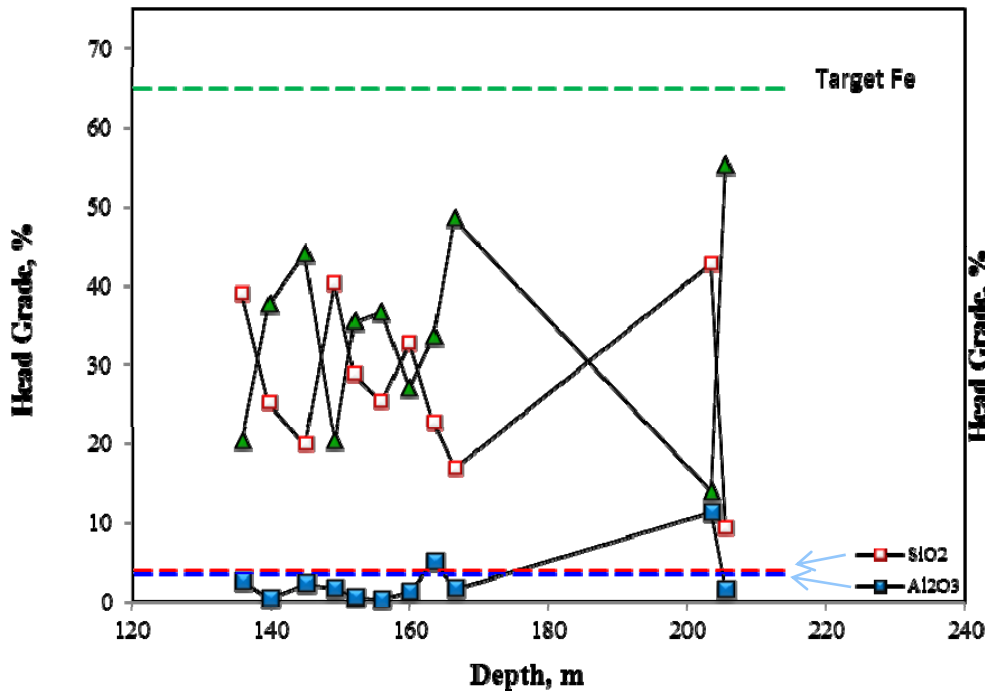


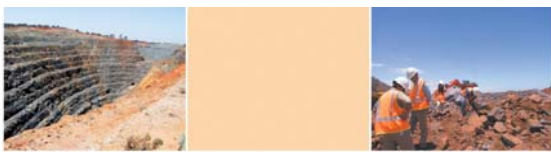


Phase 1 - METS

> Vieto Borehole – Head Assay

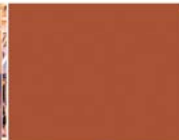
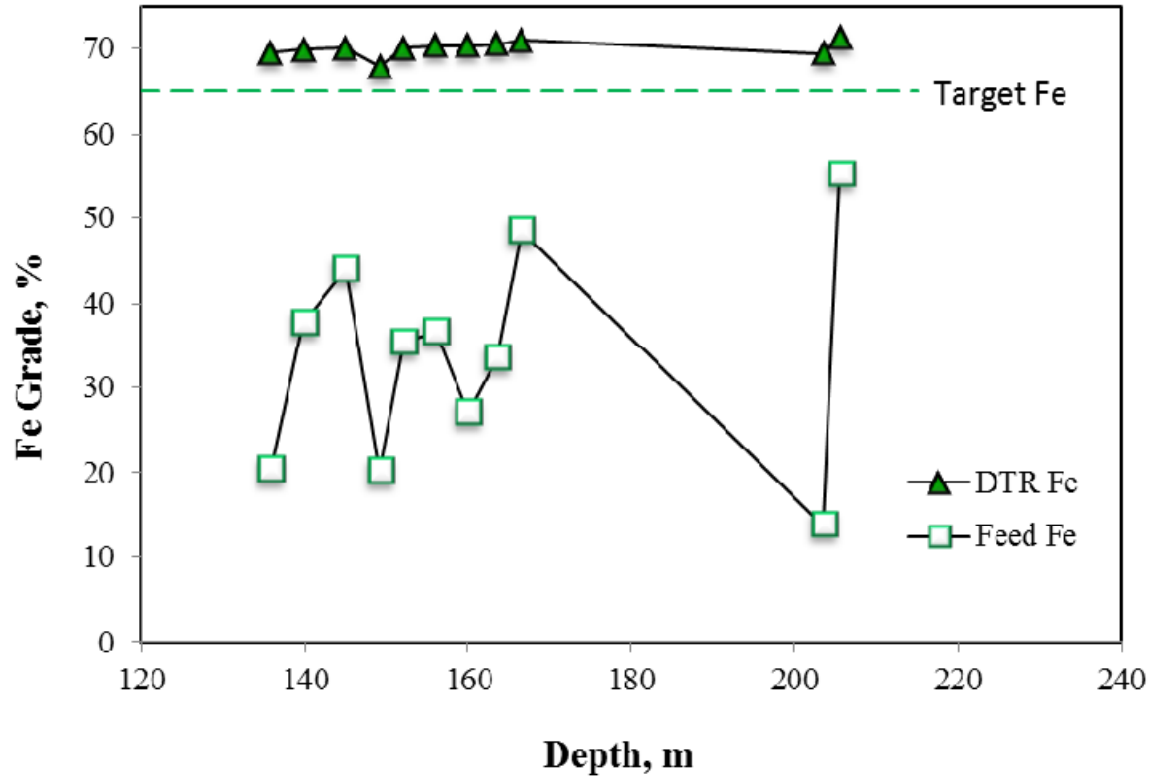
- Iron grades ranged from 10 – 58% Fe.
- Good correlation between iron grade and magnetic susceptibility (the majority of the iron is present in magnetite)

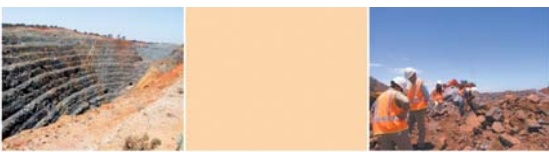




Phase 1 - METS

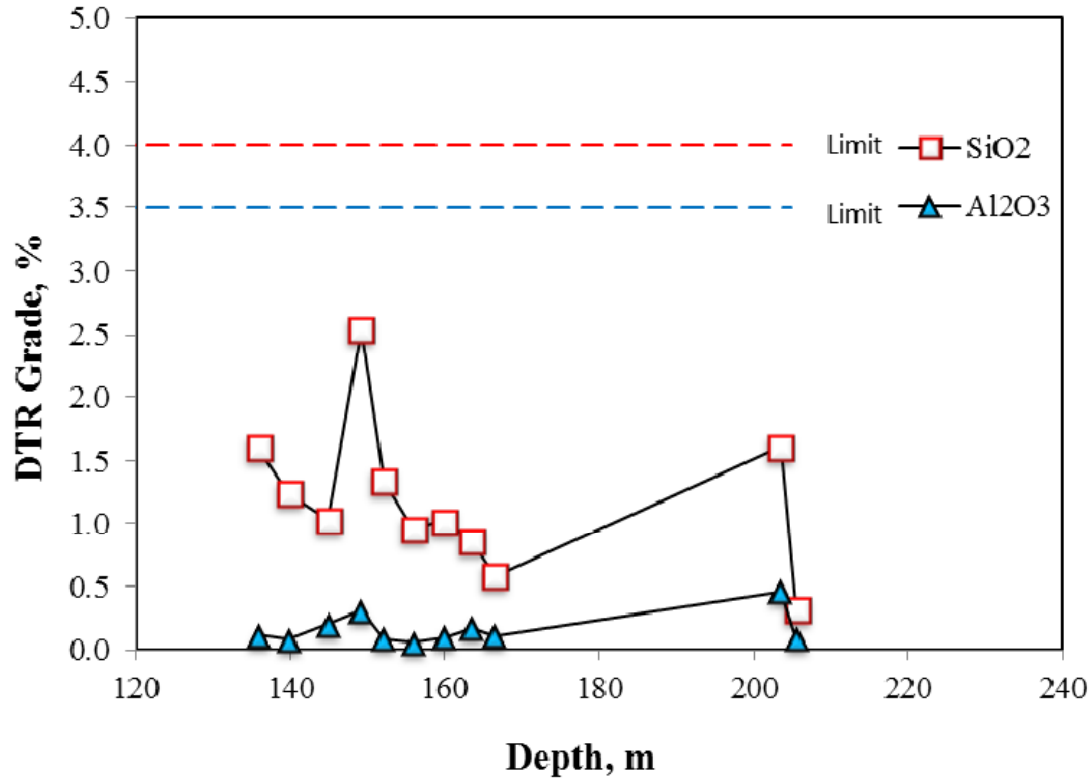
- > Vieto Borehole – Davis Tube Recovery
 - Iron upgrades readily by magnetic separation





Phase 1 - METS

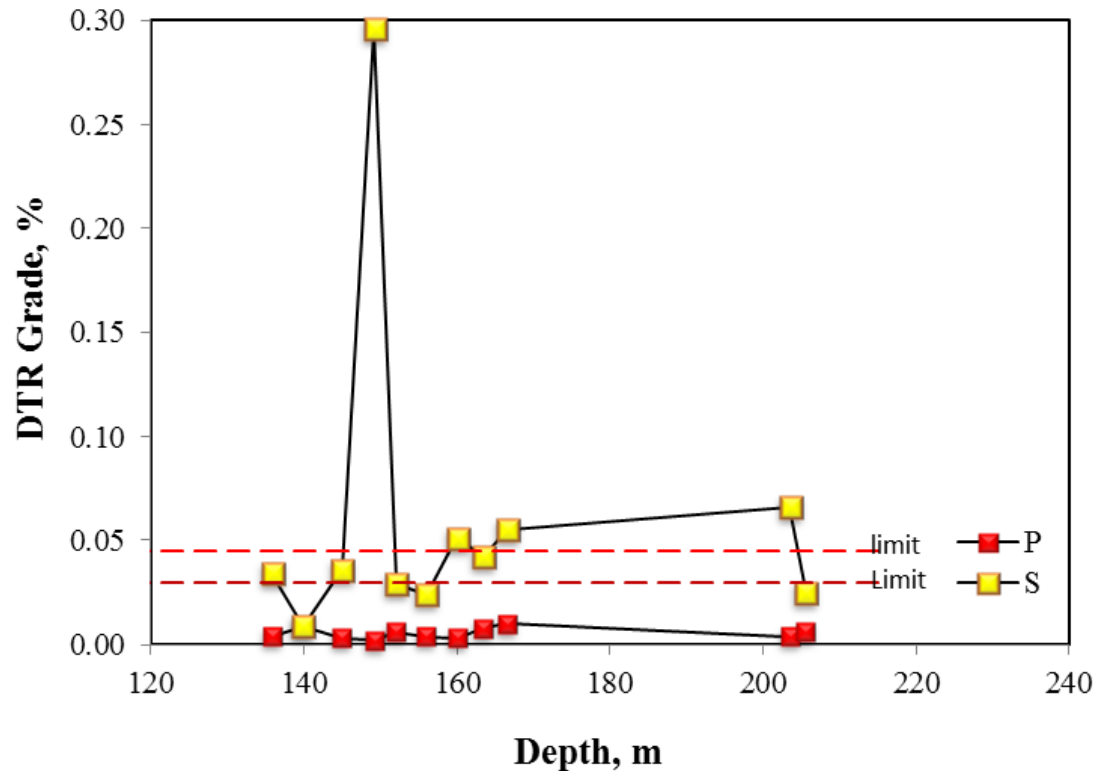
- > Vieto Borehole – Davis Tube Recovery
 - Alumina, and silica grades of the DTR concentrates were low.





Phase 1 - METS

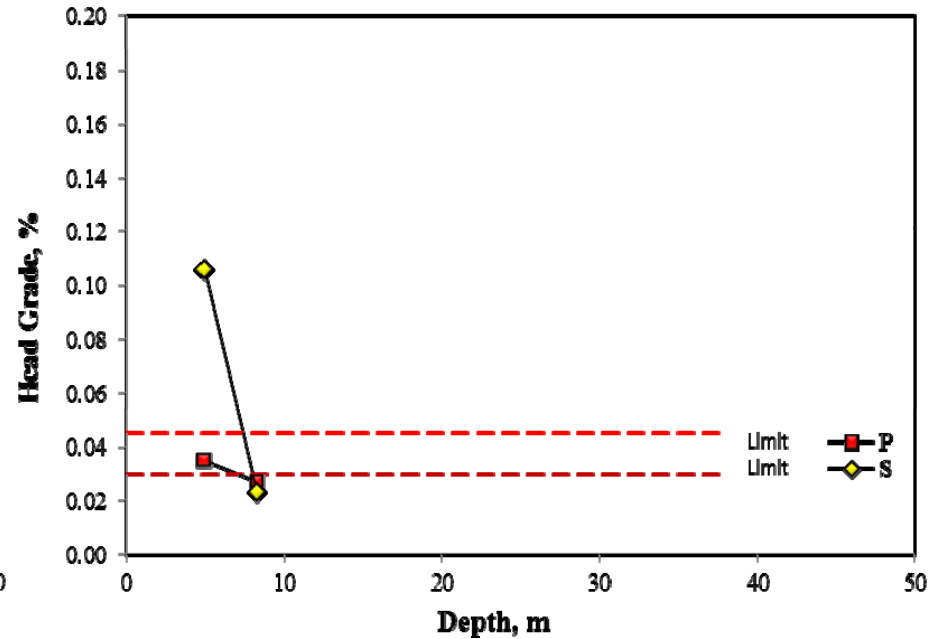
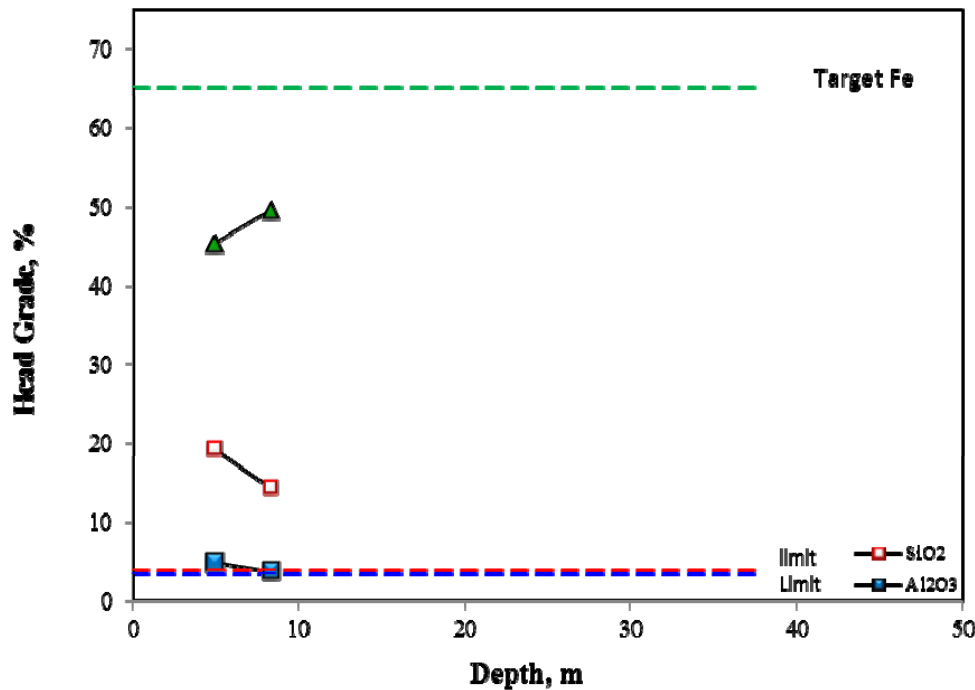
- > Vieto Borehole – Davis Tube Recovery
 - Sulphur grades a little inflated. Reverse flotation processing is available to remove sulphur

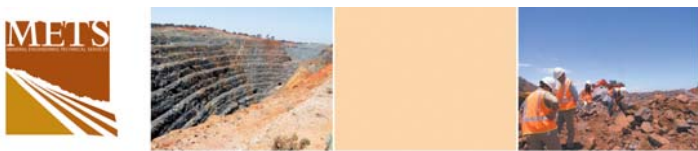




Phase 1 - METS

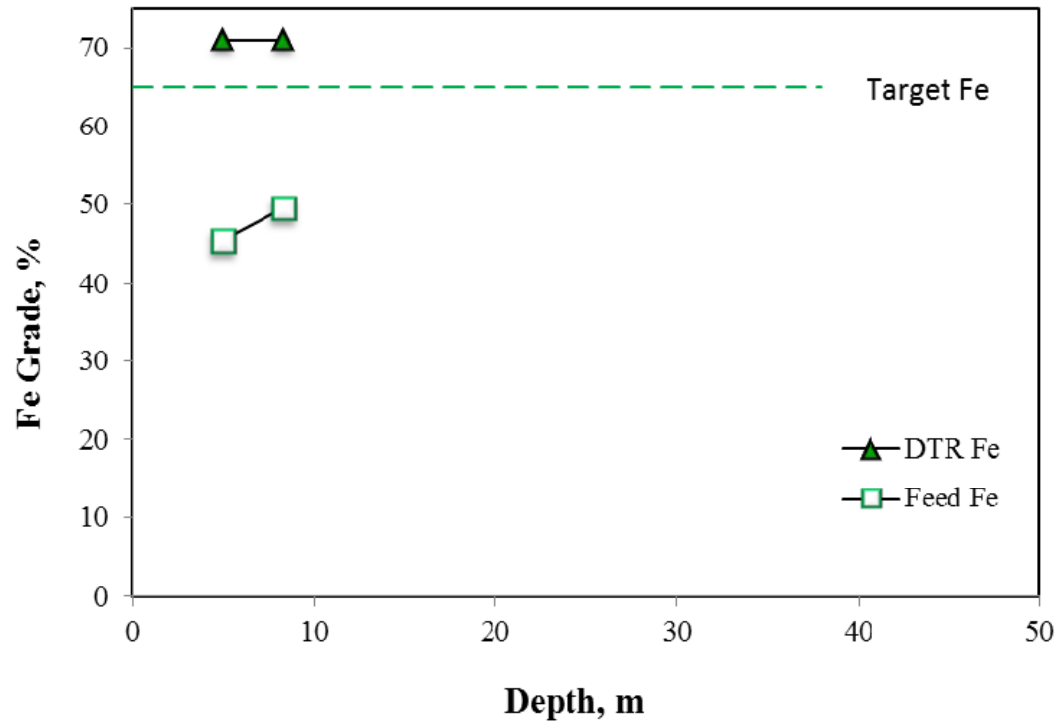
- > Laukkujärvi borehole – Assay
 - Head assay returned iron grade of 45.4 and 49.6% Fe
 - Small mineralised (high grade) zone

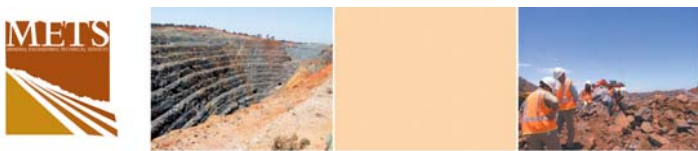




Phase 1 - METS

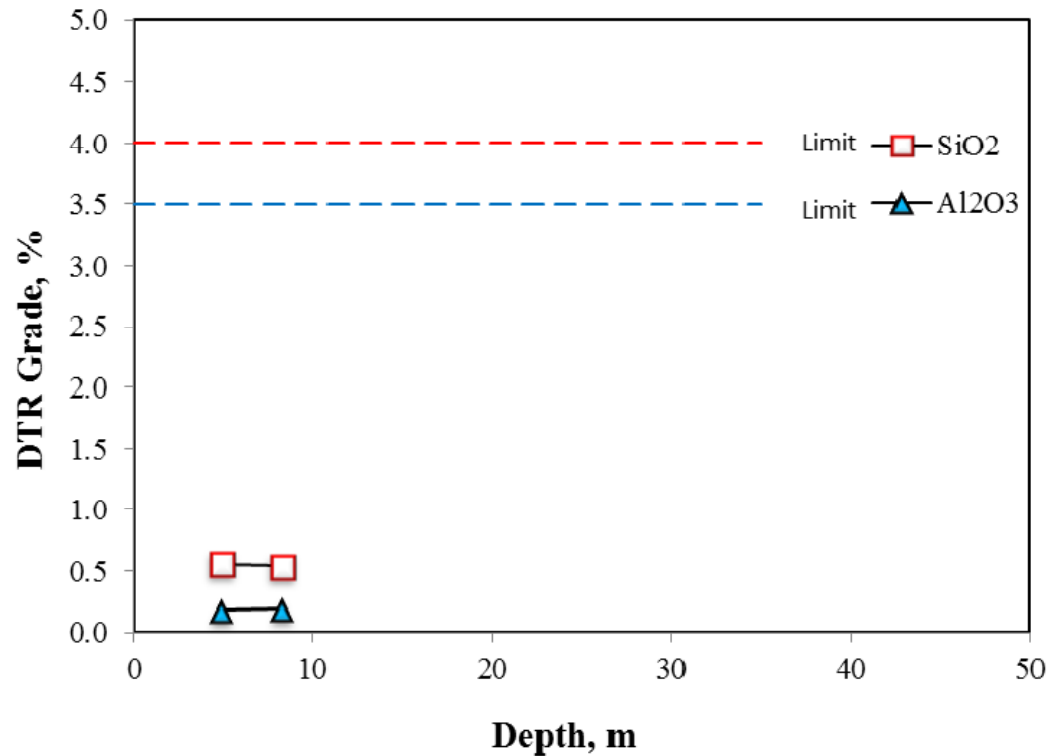
- > Laukkujärvi borehole – Davis Tube Recovery
 - Magnetic concentrate was over 71% Fe grade





Phase 1 - METS

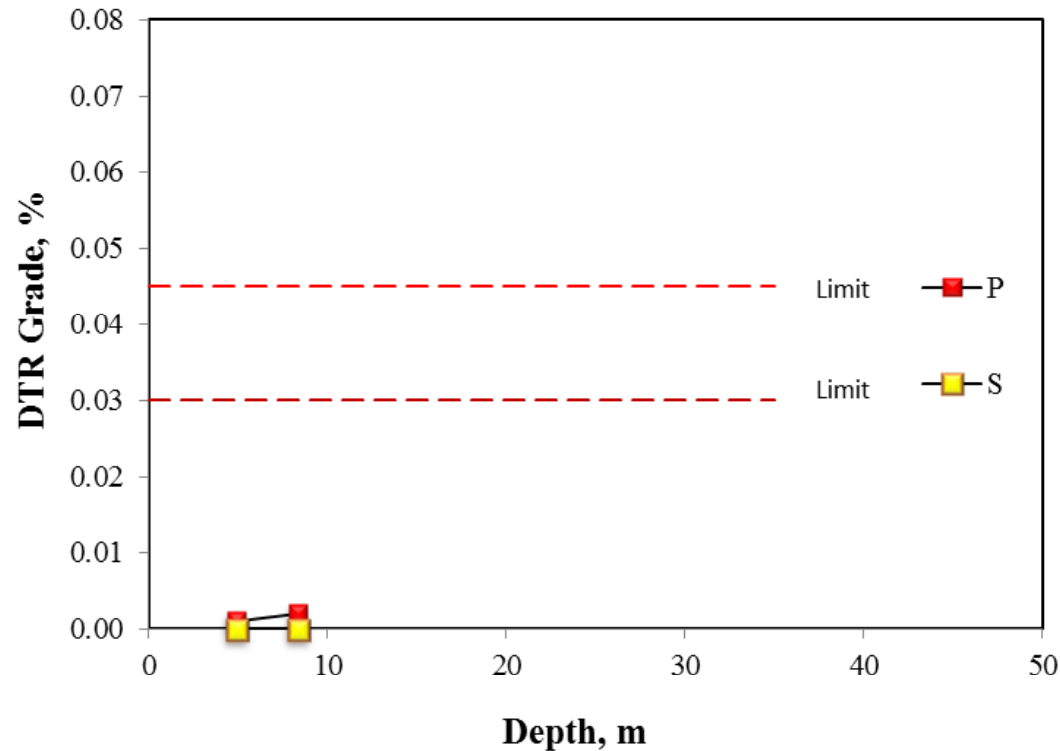
- > Laukkujärvi borehole – Davis Tube Recovery
 - High DTR concentrate iron grade complimented by very low silica and alumina grades





Phase 1 - METS

- > Laukkujärvi borehole – Davis Tube Recovery
 - And very low phosphorus and sulphur grades

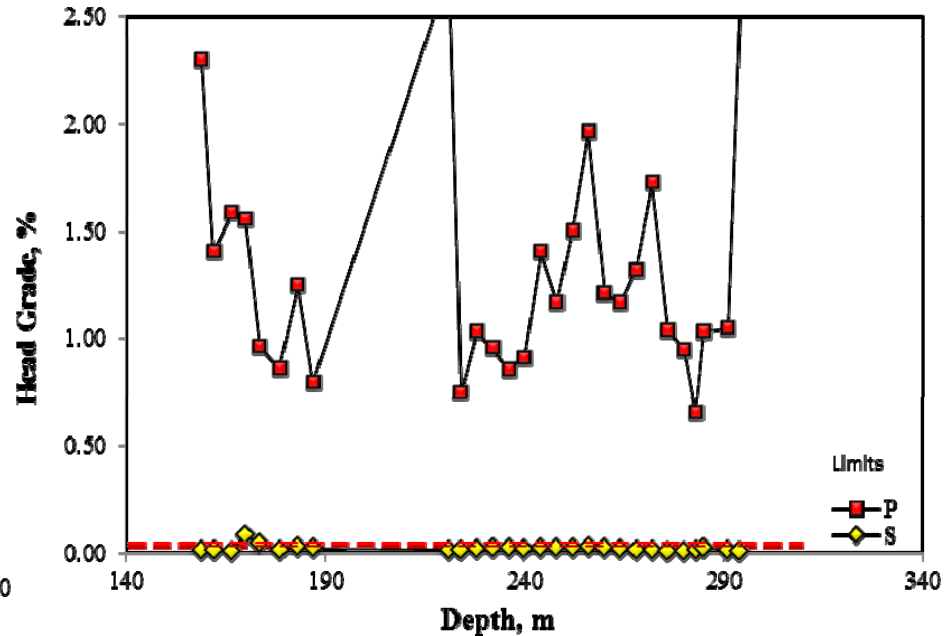
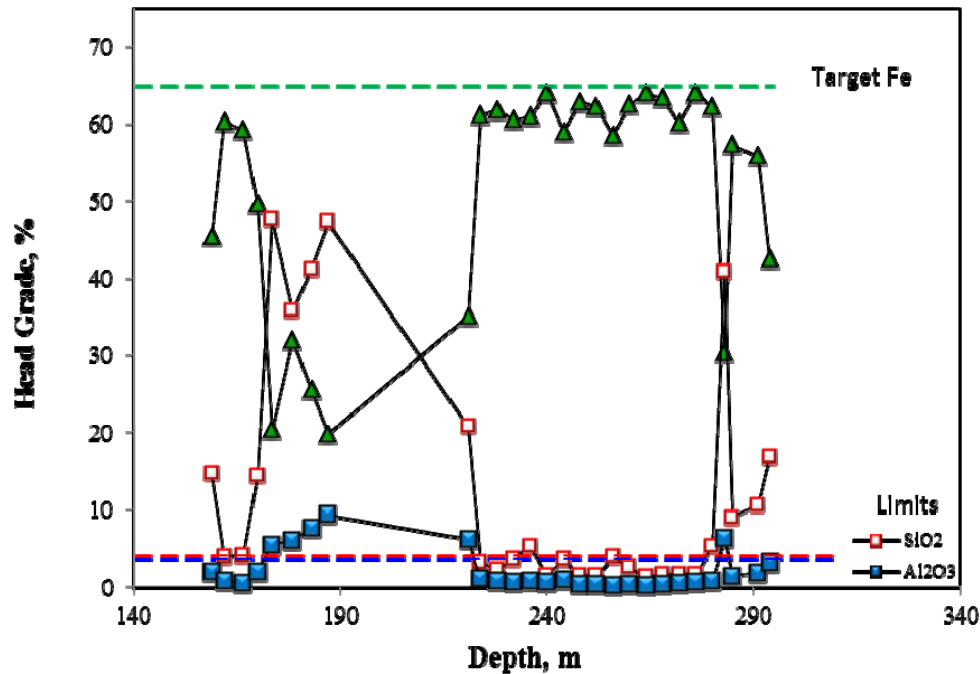


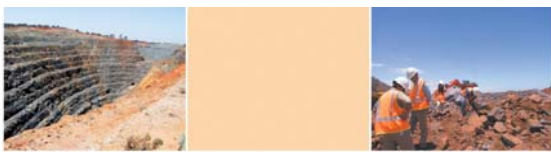


Phase 1 - METS

> Ekströmsberg borehole – Assay

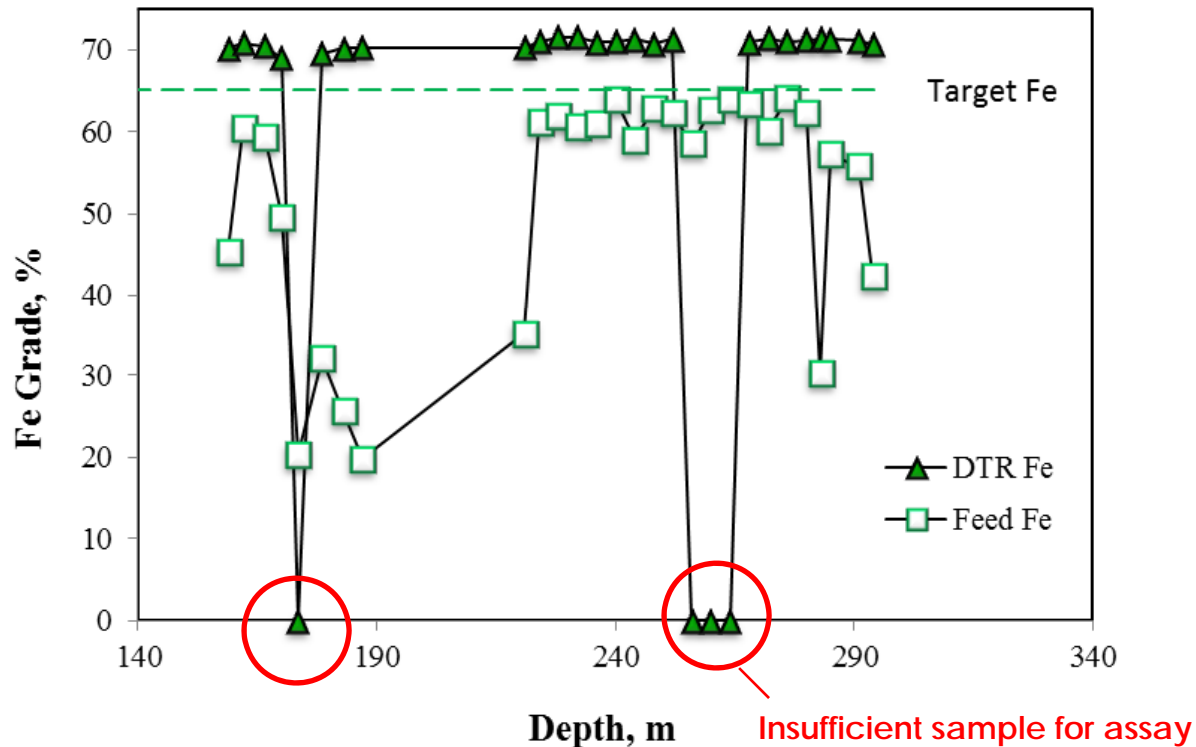
- Head assay averaged 52.2% Fe with a maximum of 64.1% Fe
- A high grade zone of ~60 meters averaging 61.8% Fe could potentially be DSO except for high levels of phosphorus

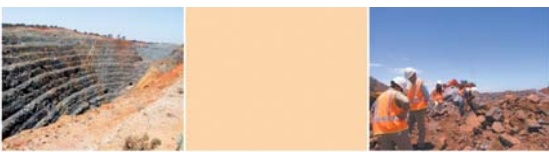




Phase 1 - METS

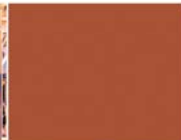
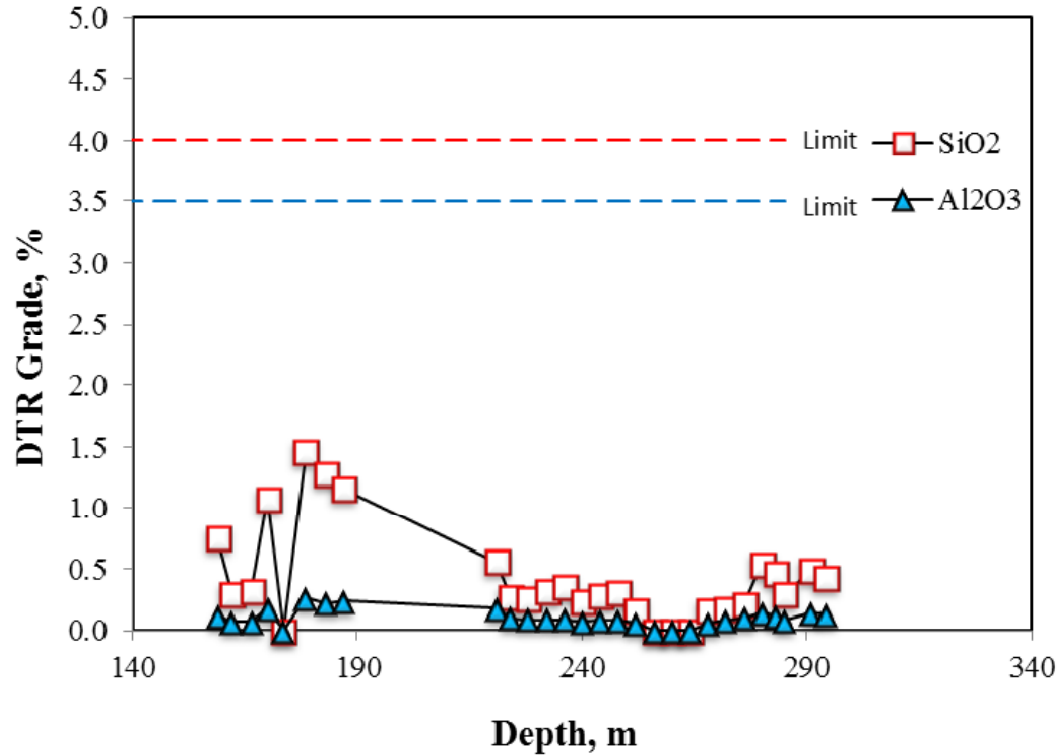
- > Ekströmsberg borehole – Davis Tube Recovery
 - Magnetic concentrate 70-71% Fe
 - Some high grade intervals gave low DTR recoveries indicating hematite





Phase 1 - METS

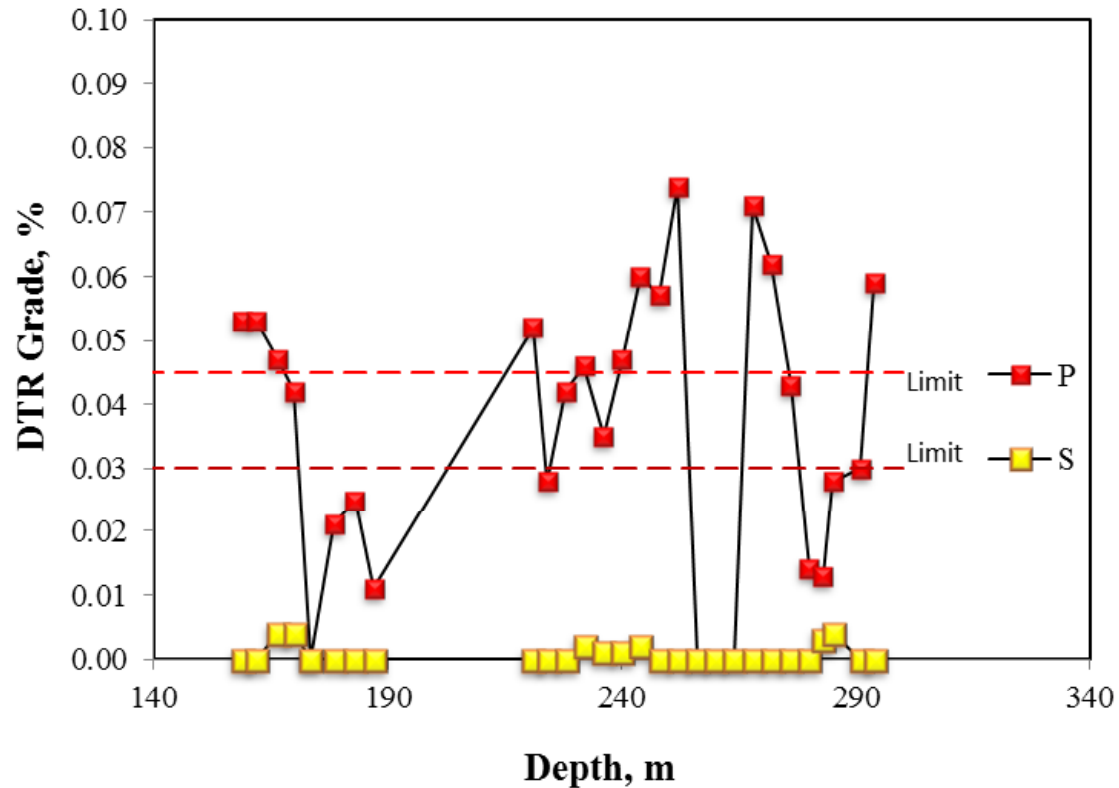
- > Ekströmsberg borehole – Davis Tube Recovery
 - High DTR concentrate iron grade complimented by very low silica and alumina grades





Phase 1 - METS

- > Ekströmsberg borehole – Davis Tube Recovery
 - Very low sulphur grades (most below detection limit of 0.001%)
 - Some phosphorus grades above the nominal iron ore specification

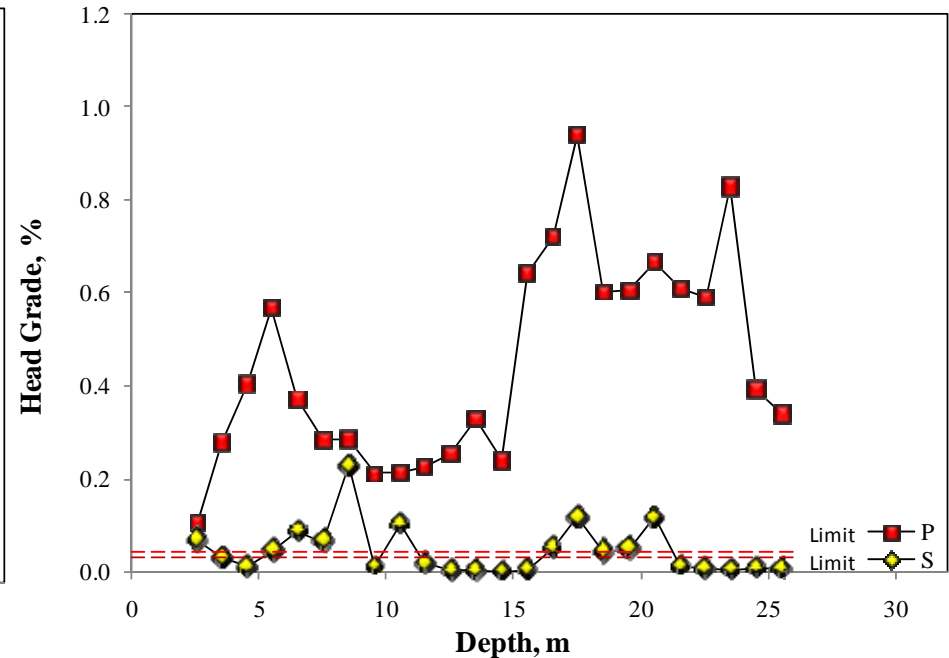
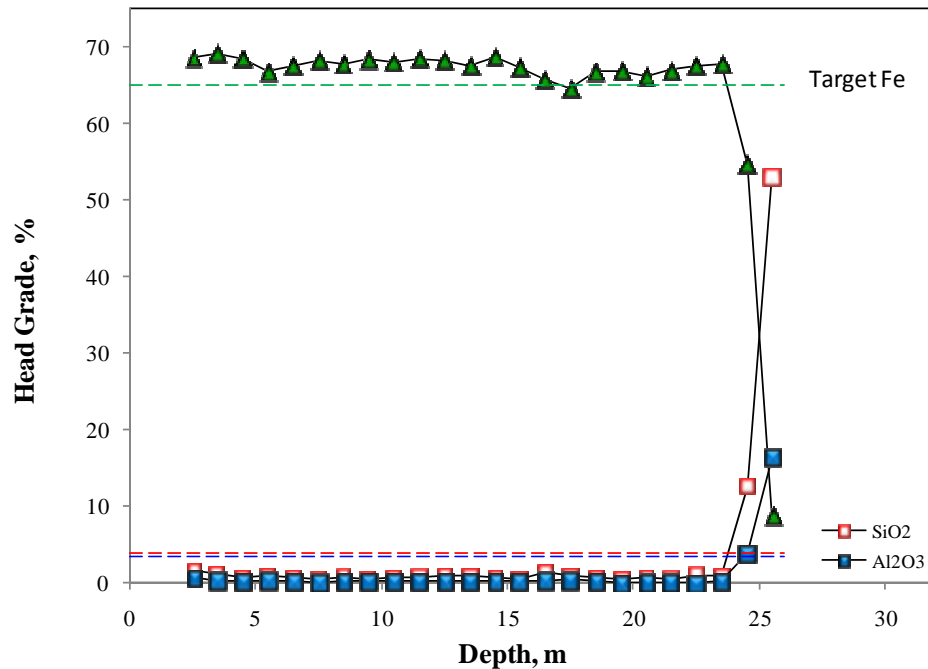


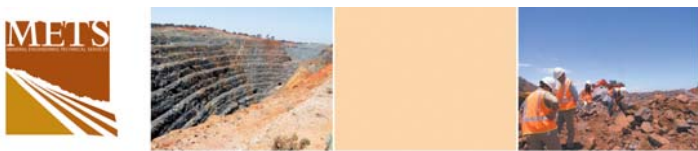


Phase 1 - METS

> Gäddmyr borehole – Assay

- Head assay returned iron grade up to 69% Fe (average of 65% Fe)
- Results indicate potential for direct shipping ore (DSO)
- Phosphorus and sulphur grade too high for DSO but can be reduced after processing

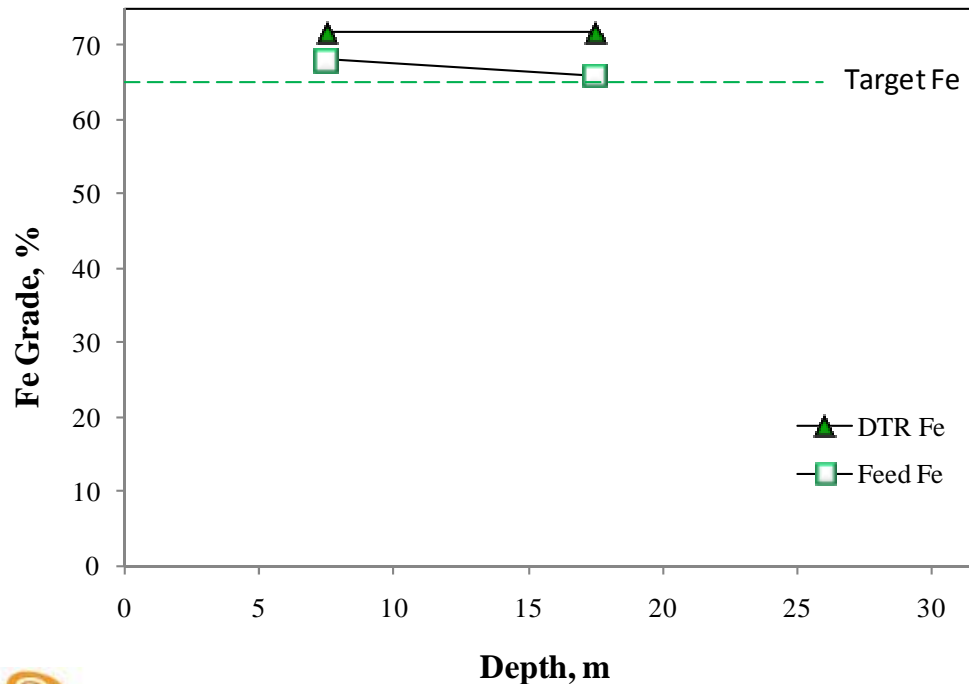


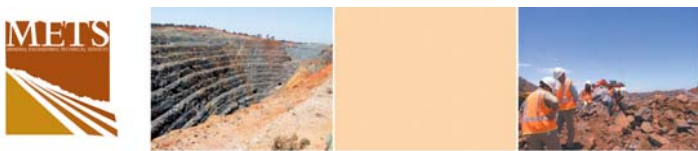


Phase 1 - METS

> Gäddmyr borehole – Davis Tube Recovery

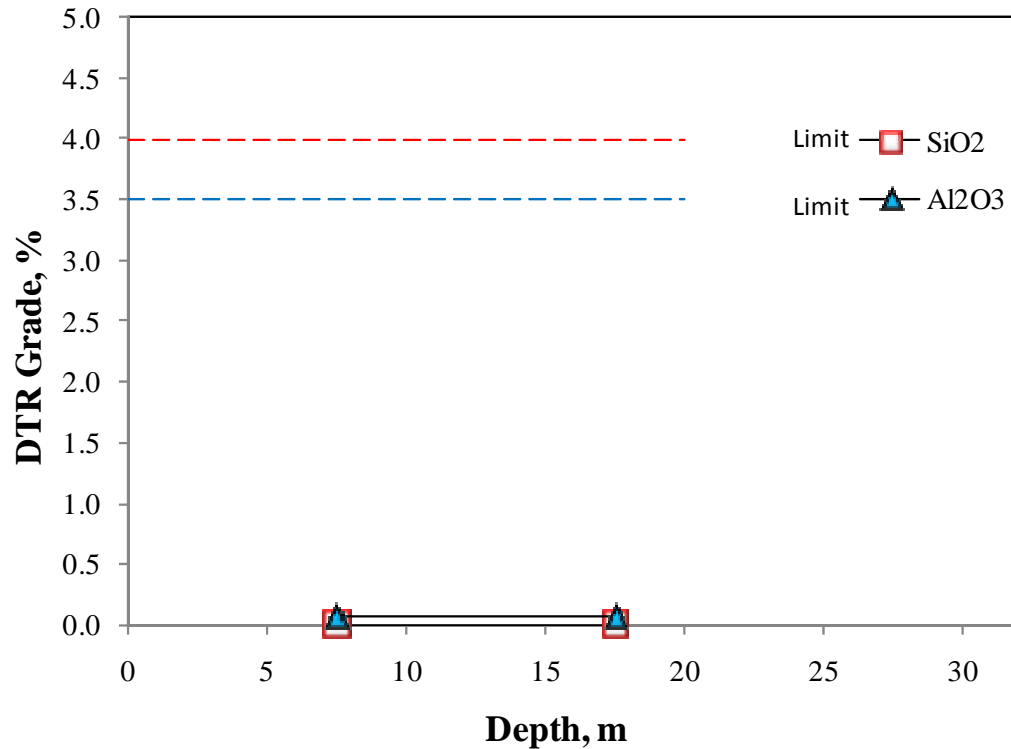
- Iron assay upgraded further through magnetic separation to over 70% Fe
- Non-magnetic fraction also high at >64% Fe
- Only ~20% of samples are magnetite, ie. ~80% of iron is hematite and not recovered by LIMS





Phase 1 - METS

- > Gäddmyr borehole – Davis Tube Recovery
 - Alumina and silica grades were very low and should not be considered as an issue.

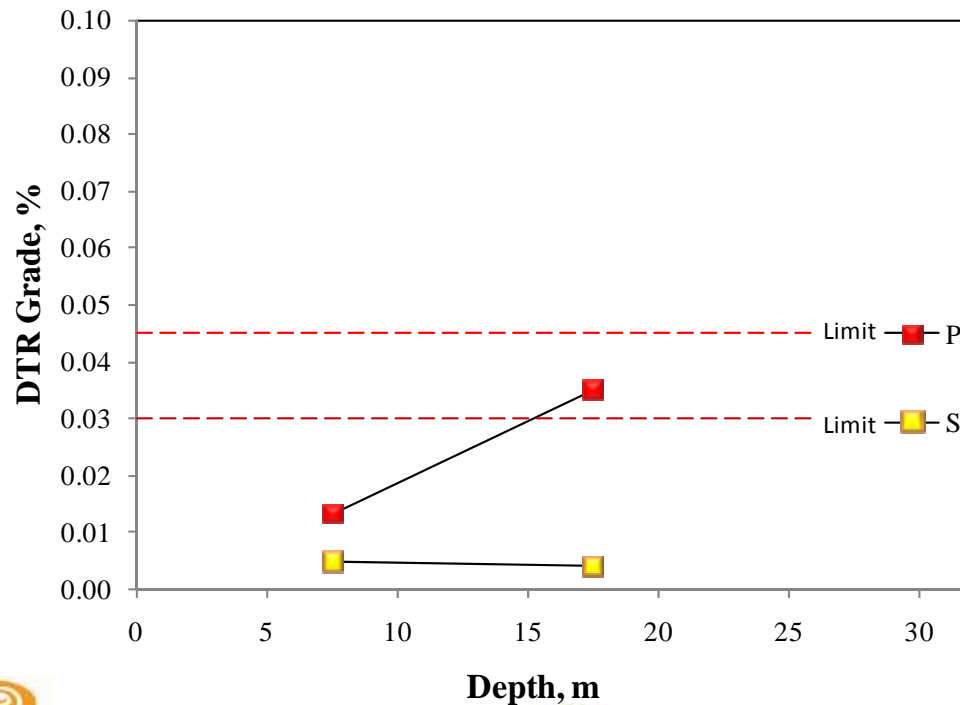




Phase 1 - METS

> Gäddmyr borehole – Davis Tube Recovery

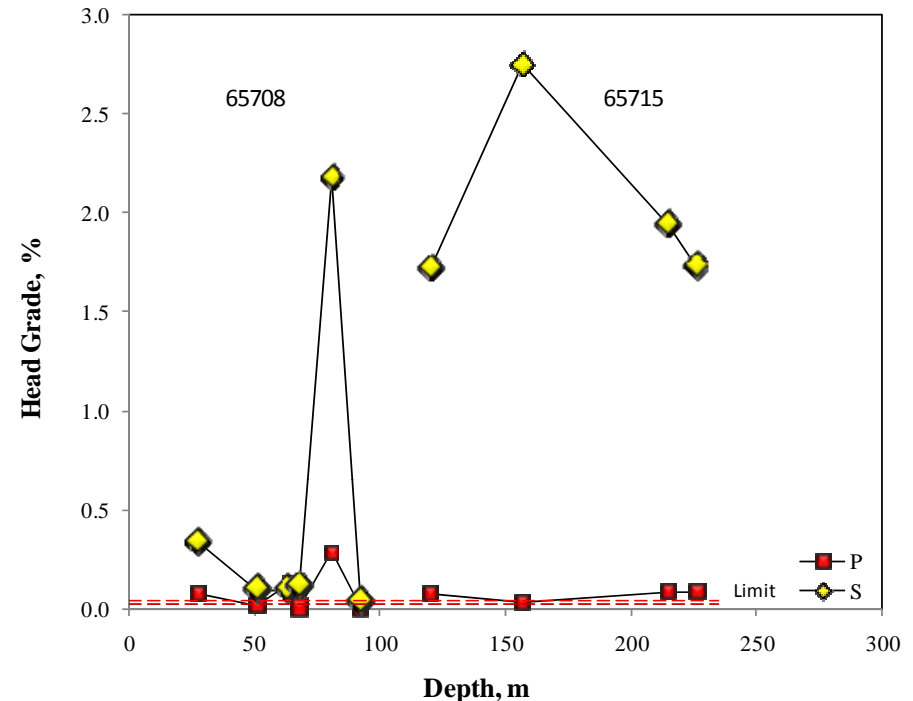
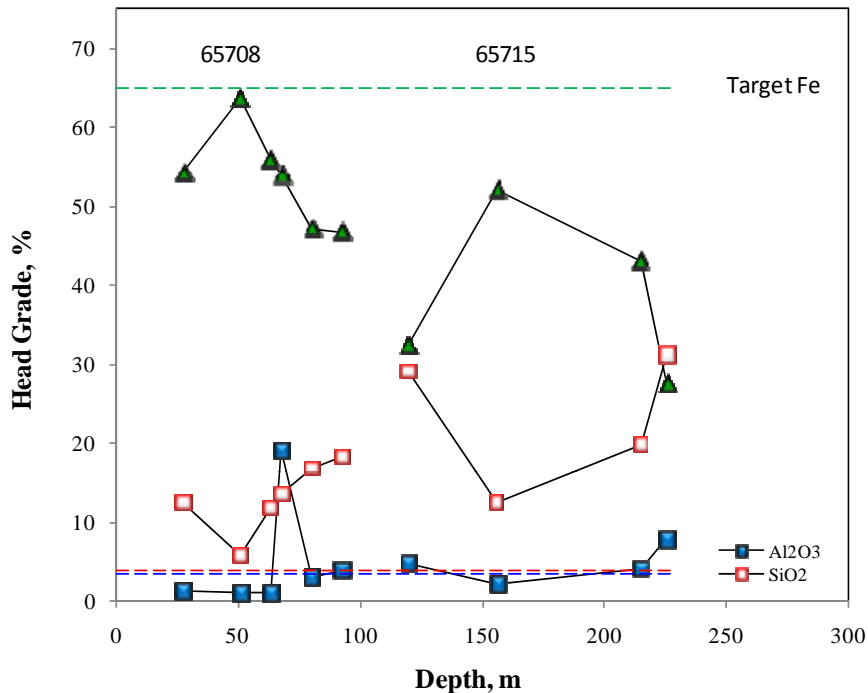
- A high level of phosphorus and sulphur in the unprocessed ore
- Phosphorus and sulphur reduced to acceptable levels by magnetic separation
- In the high hematite ores, phosphorus and sulphur can potentially be reduced by further processing (magnetic, gravity or flotation)

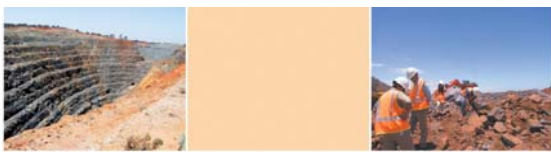




Phase 2 - JKTech

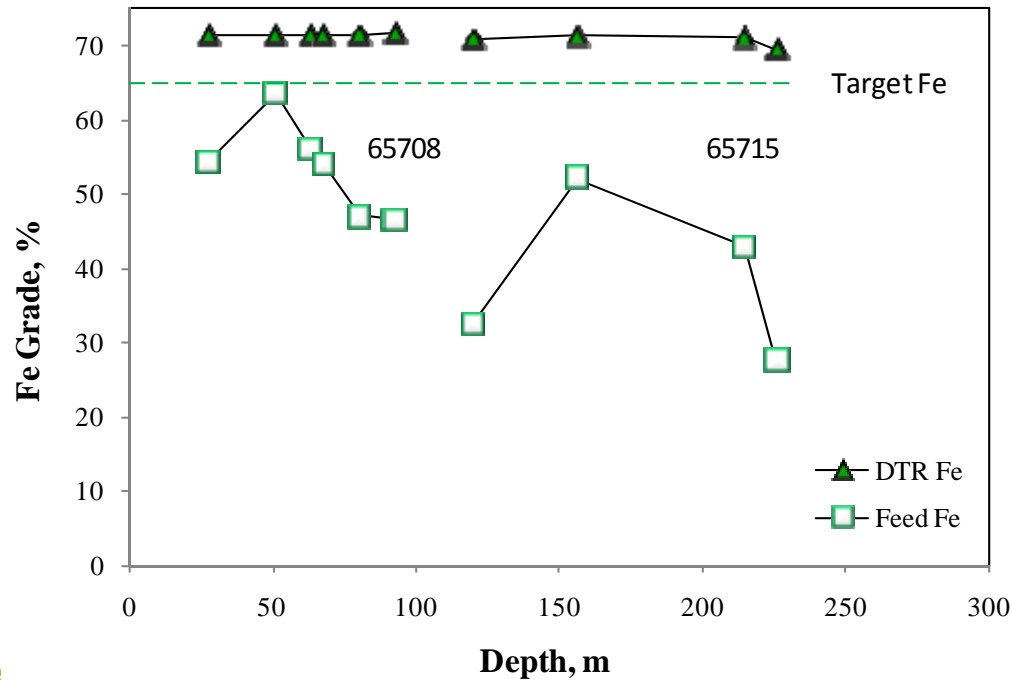
- > Sautasvaara borehole – Head Assay
 - Hole 65708: high grade iron; up to 63.6% Fe, medium silica, high S and P
 - Hole 65715: medium grade iron; 27.6-52.1% Fe; high silica, sulphur

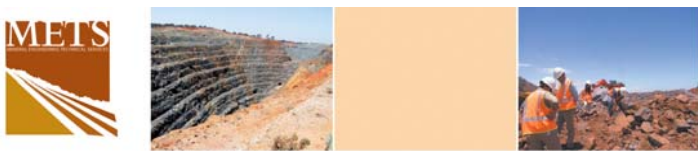




Phase 2 - JKTech

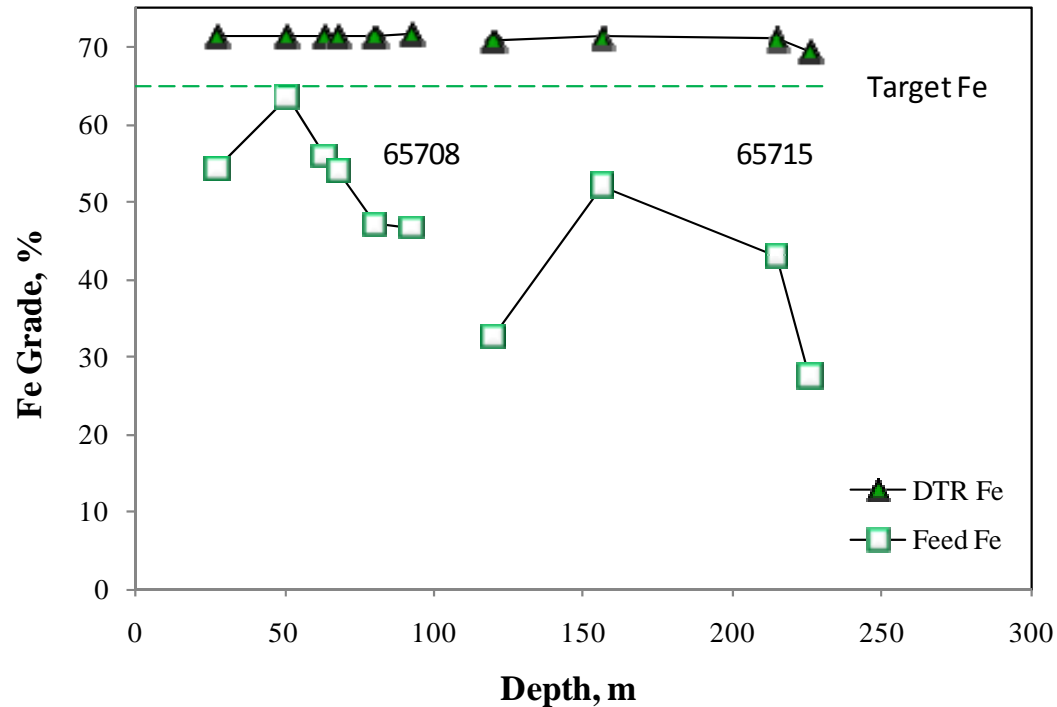
- > Sautasvaara borehole – DTR testwork
 - DTR tests returned magnetic products exhibiting iron grades greater than 69% Fe
 - DTR magnetic products exhibited low silica, phosphorus and sulphur
 - Iron recoveries ranged from 72 – 98%

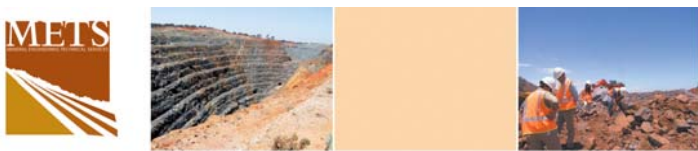




Phase 2 - JKTech

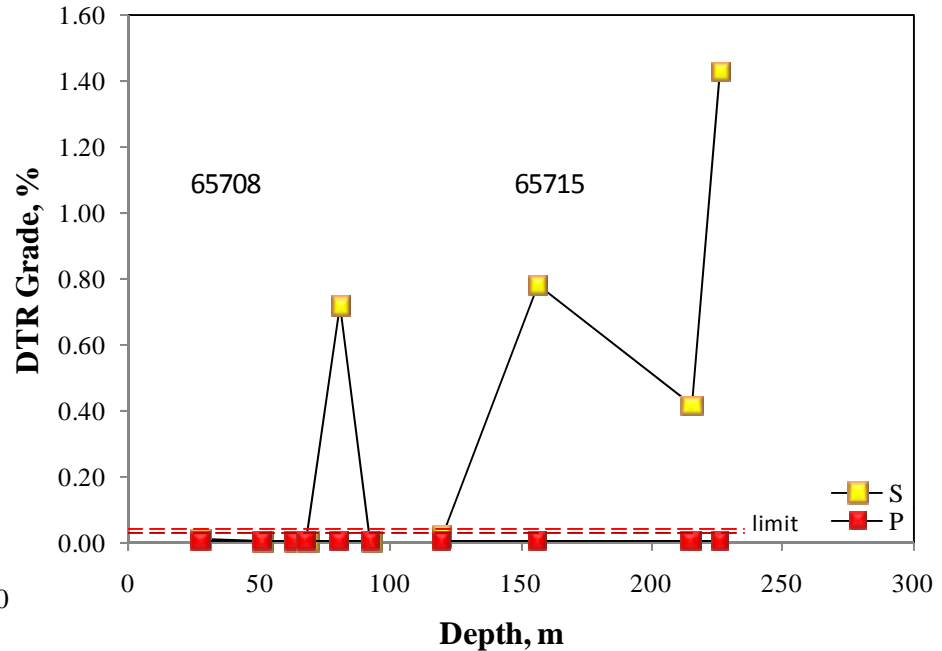
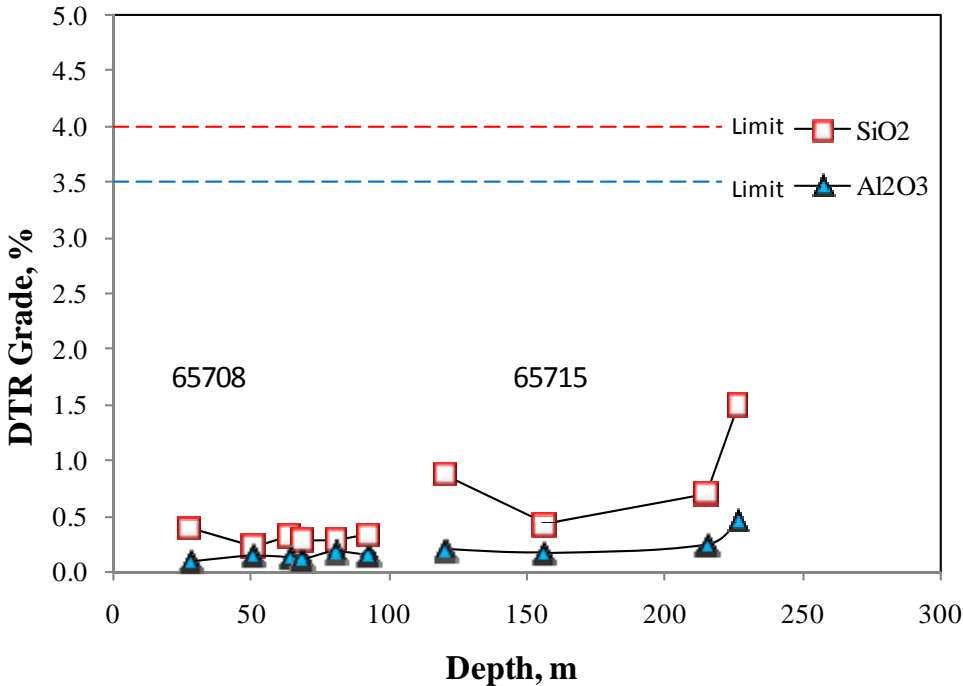
- > Sautasvaara borehole – DTR testwork
 - DTR tests returned magnetic products exhibiting iron grades greater than 69% Fe
 - Iron recoveries ranged from 72 – 98%





Phase 2 - JKTech

- > Sautasvaara borehole – DTR testwork
 - DTR magnetic products exhibited low silica, phosphorus
 - Some high sulphur





Phase 2 - JKTech

- > Sautasvaara borehole – Comminution testwork
 - Crushing characteristics reflect consistent crushing indices (GeMCI tests)
 - Grinding characteristics indicate two grinding domains – related to mineralogy
 - Further testwork is required to estimate grinding index

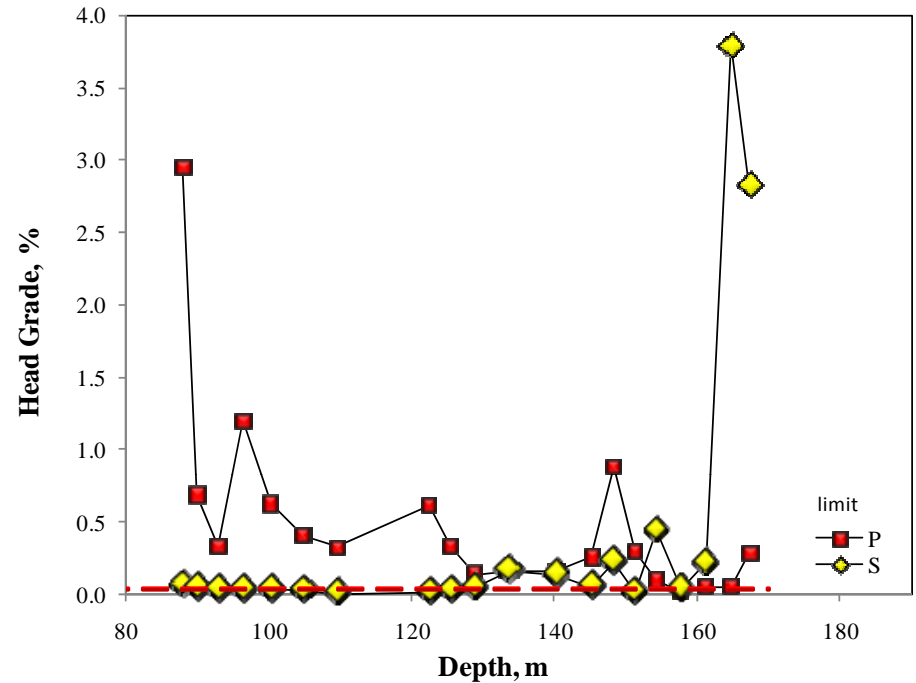
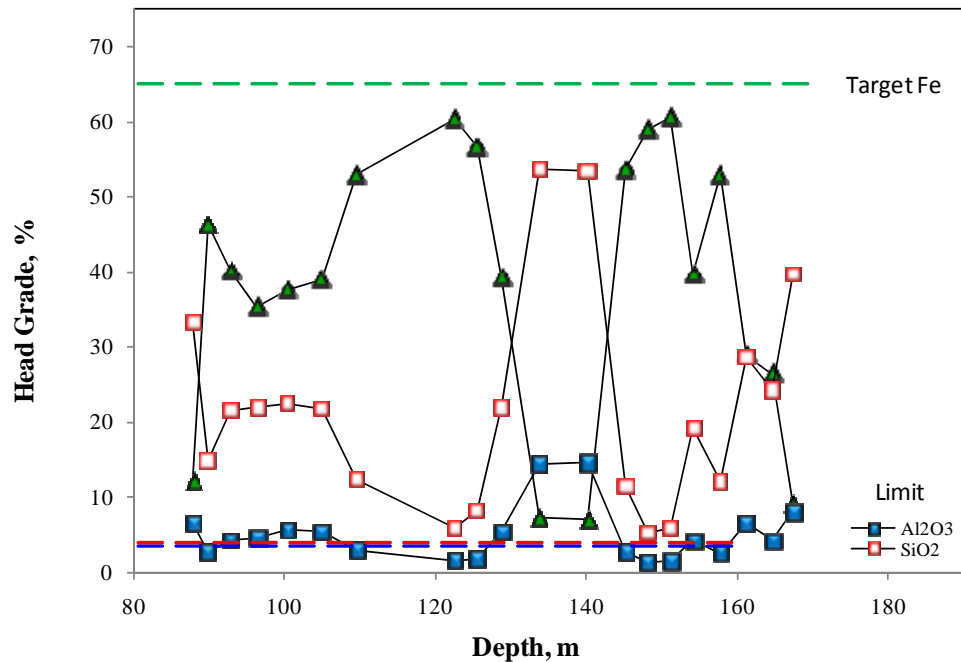


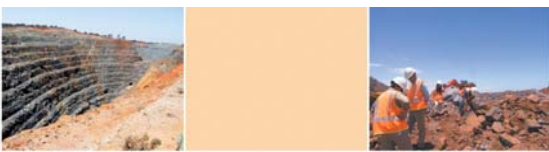


Phase 3 - METS

> Rakkurijoki – Assay Rjo11001

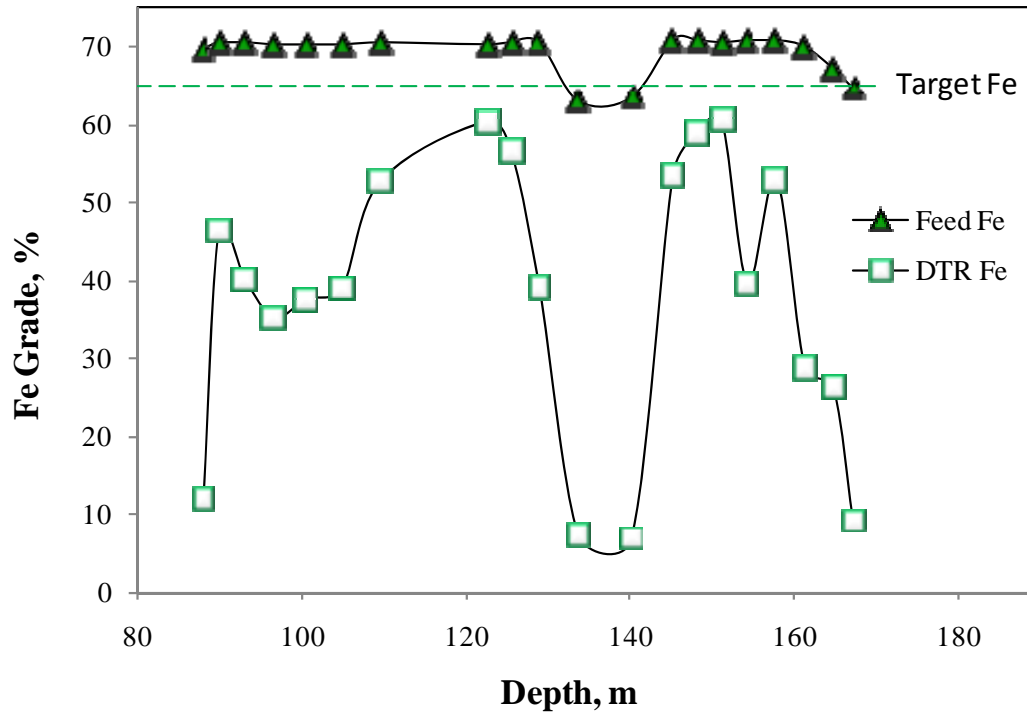
- Head assay averaged 38% Fe with a maximum of 60% Fe
- Silica is high in the iron mineralised zones
- Alumina, phosphorus and sulphur grades are moderate to high





Phase 3 - METS

- > Rakkurijoki, Roj 11001 – Davis Tube Recovery
 - Magnetic concentrate averaged 69% Fe at up to 99% recovery (average 83%)

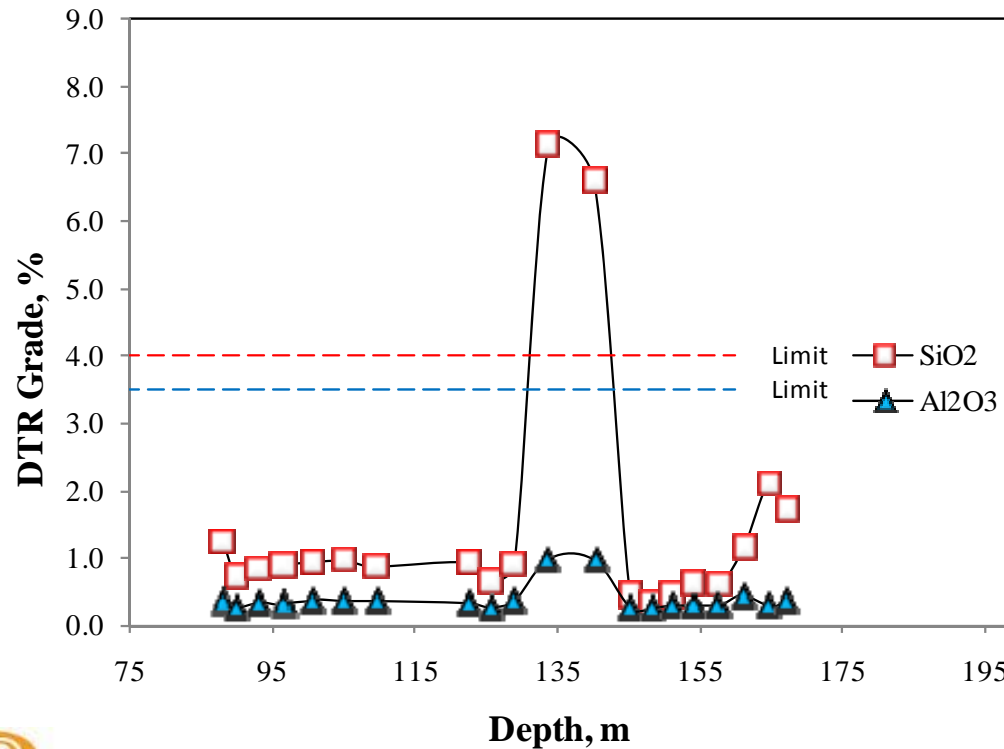




Phase 3 - METS

> Rakkurijoki, Roj 11001 – Davis Tube Recovery

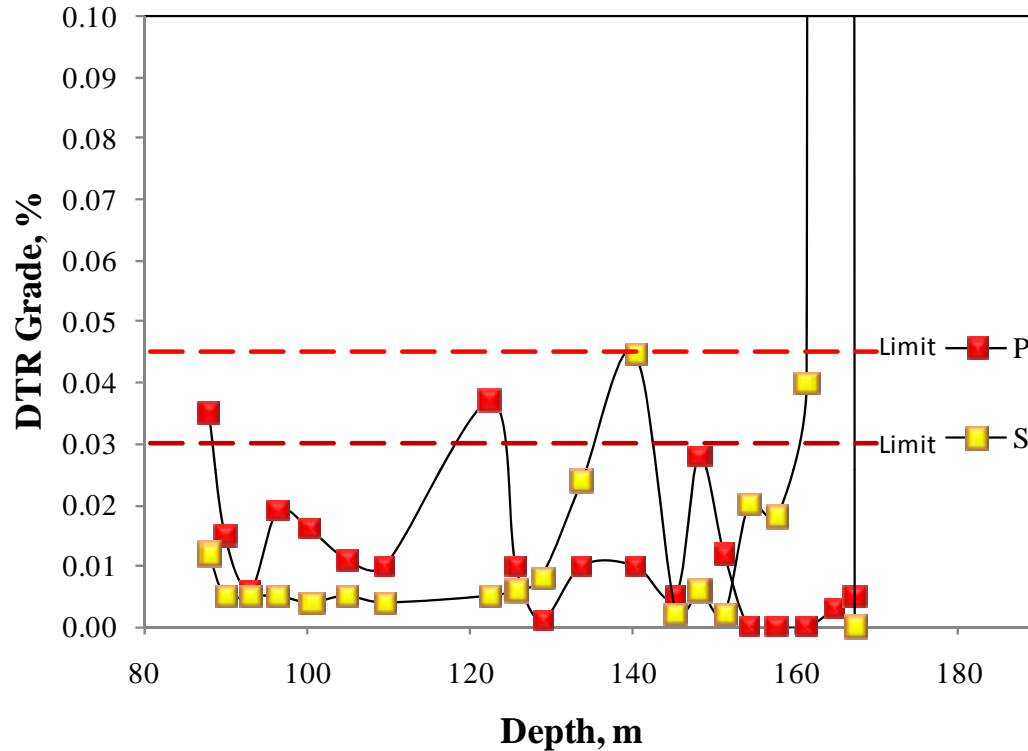
- High DTR concentrate iron grade complimented by very low silica and alumina grades
- The very high silica in the low iron feed grade area of the hole (>50%) has been reduced significantly but is still above the target 4%





Phase 3 - METS

- > Rakkurijoki, Roj 11001– Davis Tube Recovery
 - Low sulphur grades (most below target grade of 0.03%)
 - Two composites of 5% S at end of mineralised zone
 - Phosphorus grades acceptable





Phase 1 Summary - METS

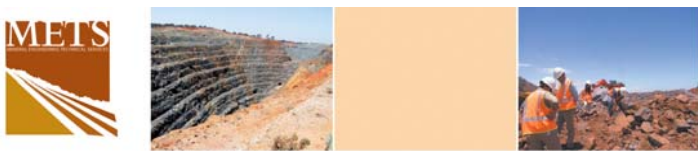
> Laukkujärvi Borehole

- Head grades were low <10% Fe however, DTR magnetic product recovered over 70% of the iron with low impurity levels.
- This suggests that the majority of the iron is present as magnetite
- Magnetic separation alone is acceptable processing for this ore

> Ekströmsberg Borehole

- Head iron grades were high, many reached 60% Fe.
- The high grade iron zones exhibited acceptable levels of alumina, silica and sulphur
- DTR magnetic product exhibited high iron grades (70% Fe) low in silica, alumina and sulphur and phosphorus
- Testwork suggests that a mixture of magnetite, hematite/martite is present





Phase 1 - Summary

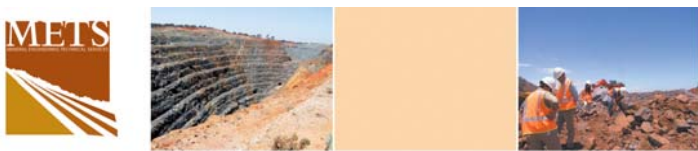
> Puoltsa borehole

- Outstanding magnetic separation results
- Low phosphorus, sulphur, silica and alumina in the magnetic product
- Magnetic product recovered over 90% of the iron (mainly magnetite)
- Testwork suggests that only magnetic separation would be required to produce a high grade saleable product
- Could be suitable for direct reduction (DR) feed
- Comparable with LKAB's Kiruna B and MalMBERGET A fines

> Gäddmyr borehole

- High iron grades achieving up to 72% Fe (equivalent to 99% magnetite)
- Lower iron recoveries than Puoltsa.
- Significant iron remaining in the non-magnetic product suggests the presence of hematite
- Non-magnetic product contained high phosphorus and sulphur suggesting that both are associated with hematite





Phase 1 - Summary

- > Vieto, Laukkujärvi and Ekströmsberg
 - A range of head iron grades present
 - Many head iron grades were greater than 60% Fe
 - DTR magnetic product exhibited high Fe grades from each borehole
 - Many DTR magnetic products exhibited low silica, alumina and sulphur levels
 - Some moderate phosphorus levels exhibited which may be removed by further beneficiation

- > QEMSCAN mineralogical analysis (Gäddmyr deposit) has identified that the phosphorus contaminant of the ore is the mineral apatite and the sulphur contaminant is in the form of pyrite and pyrrhotite

- > The contaminant minerals are liberated at 45 microns and should be rejected by a beneficiation process





Summary

	Puoltsa	Gaddmyr	Vieto	Laukkujarvi	Ekstromsberg	Sautasvaara	Rakkurijoki
Head Fe grade	49.3	64.6	32.8	10.3	52.6	47.7	38.5
% Magnetite	62.4	No data	47.9	69.9	28.2	No data	30.9
Mass Recovery, %	67.9	17.9	42.2	65.7	25.9	54.5	49.5
DTR Fe recovery	96.2	20.4	82.8	98.4	44.6	88.5	85.4
DTR conc Fe grade	70.3	71.9	70.0	71.0	70.8	71.1	69.8
DTR conc SiO ₂ grade	0.58	0.01	1.2	0.6	0.7	0.5	1.1
DTR conc Al ₂ O ₃ grade	0.16	0.07	0.2	0.02	0.1	0.2	0.3
DTR conc P grade	0.0017	0.02	0.01	0.002	0.04	0.05	0.01
DTR conc S grade	0.005	0.005	0.06	0.001	0.003	0.3	0.2

Note:

1. Where the iron is predominantly present as magnetite, then the mass recovery will follow the % magnetite in the ore
2. The mass recovery and iron recovery are related by the iron feed grade . ie. If the iron grade is 10% Fe and this is present as only magnetite (equivalent to 14% magnetite in the feed) then a mass recovery of 14%, in a perfect separation, would achieve 100% iron recovery
3. If the iron grade is made up of 50:50 magnetite:hematite then a mass recovery of 7% would achieve 50% iron recovery. If the mass recovery was 14%, as a result of gangue included with the magnetic concentrate, the iron recovery would still be ~50%, if the gangue material did not contain iron





Summary – Further Testwork

- > The DTR testwork has been carried out at 45 microns
- > Further work will optimise the grind size for magnetic separation
- > With the low grade feeds, rejection of some waste at coarse sizes (coarse cobbing) is a possibility and will be investigated
- > Further testwork will investigate the reduction of sulphur and phosphorus from the magnetite and hematite ores by beneficiation
- > The ores tested produce a concentrate of very low silica and alumina



A world map with Australia highlighted in white. Numerous white lines radiate from Australia to various parts of the world, symbolizing global connectivity. The text "THANK YOU" is centered over the map in a large, bold, black, sans-serif font.

THANK YOU

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