

INVESTIGATION OF CARBON-BASED REDUCTANT, LOW-TEMPERATURE PROCESS FOR CONVERSION OF HEMATITE IN RED-MUD TO MAGNETITE

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STATUS OF RED-MUD

- Red-Mud is a residue generated from the Bayer's processing of bauxite.
- Primary Aluminum production: 50 mT, Bauxite mined: 200 mT (2013).
- 109 Bayer processing plants around the world, 49 alone in China (700 % increase since 2001).
- Annual generation of red mud: 120 mT, 6 % growth rate estimated.
- Operating and closed sites: 3 billion tons of red mud accumulated.



WHAT IS THE PROBLEM?

- Variability of Red-Mud composition with variation in Bauxite composition.
- Complex mineralogy associated with mineral phases of Red-Mud: Lack of Liberation.
- Complex physical and chemical properties associated with Red-Mud: Basicity, Fine particle size: Problems in Diposal and storage.
- Processing strategies developed for Red-Mud utilization are not economical.
- Products generated from Red-Mud cannot compete with traditional products.



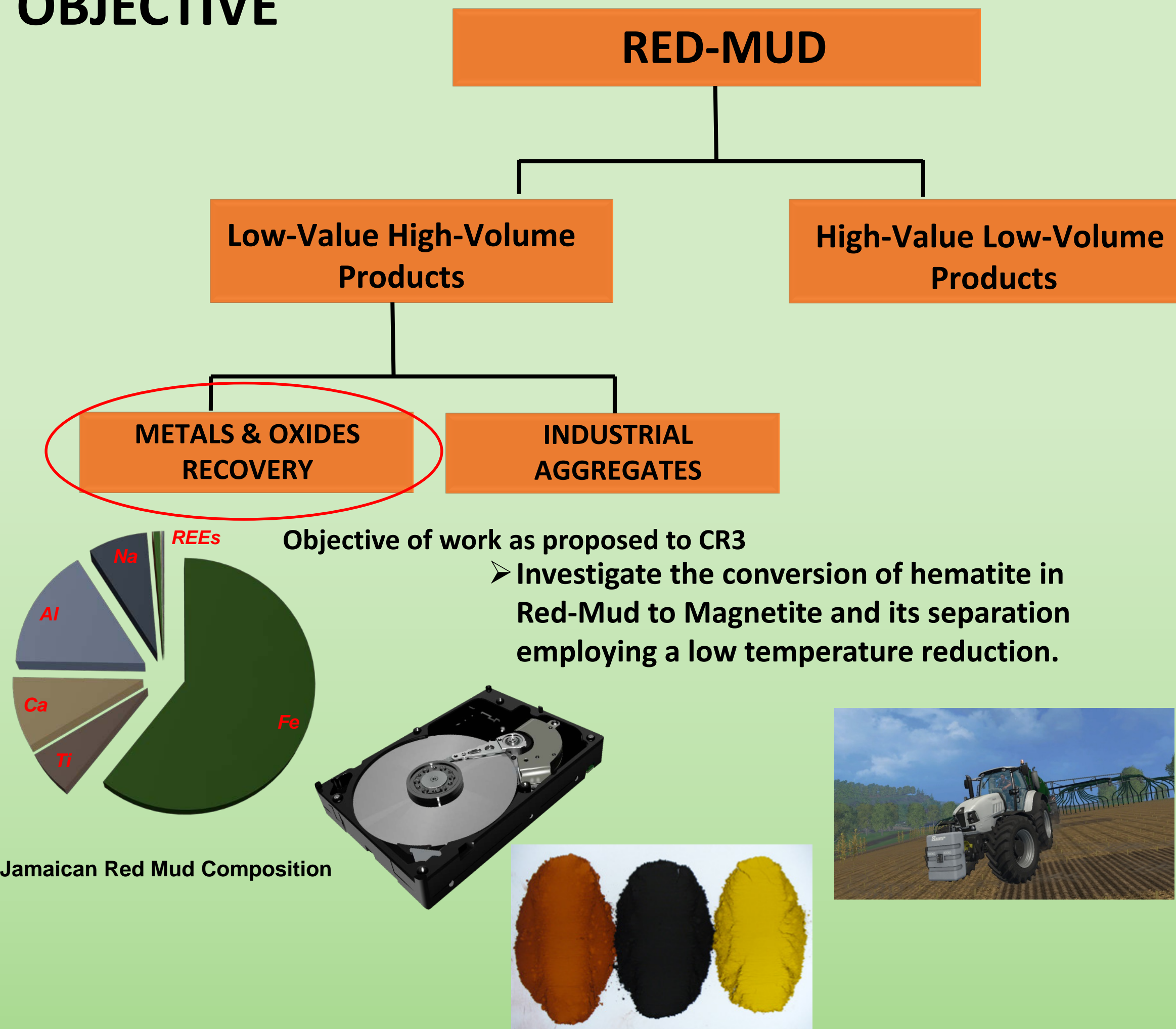
WPI



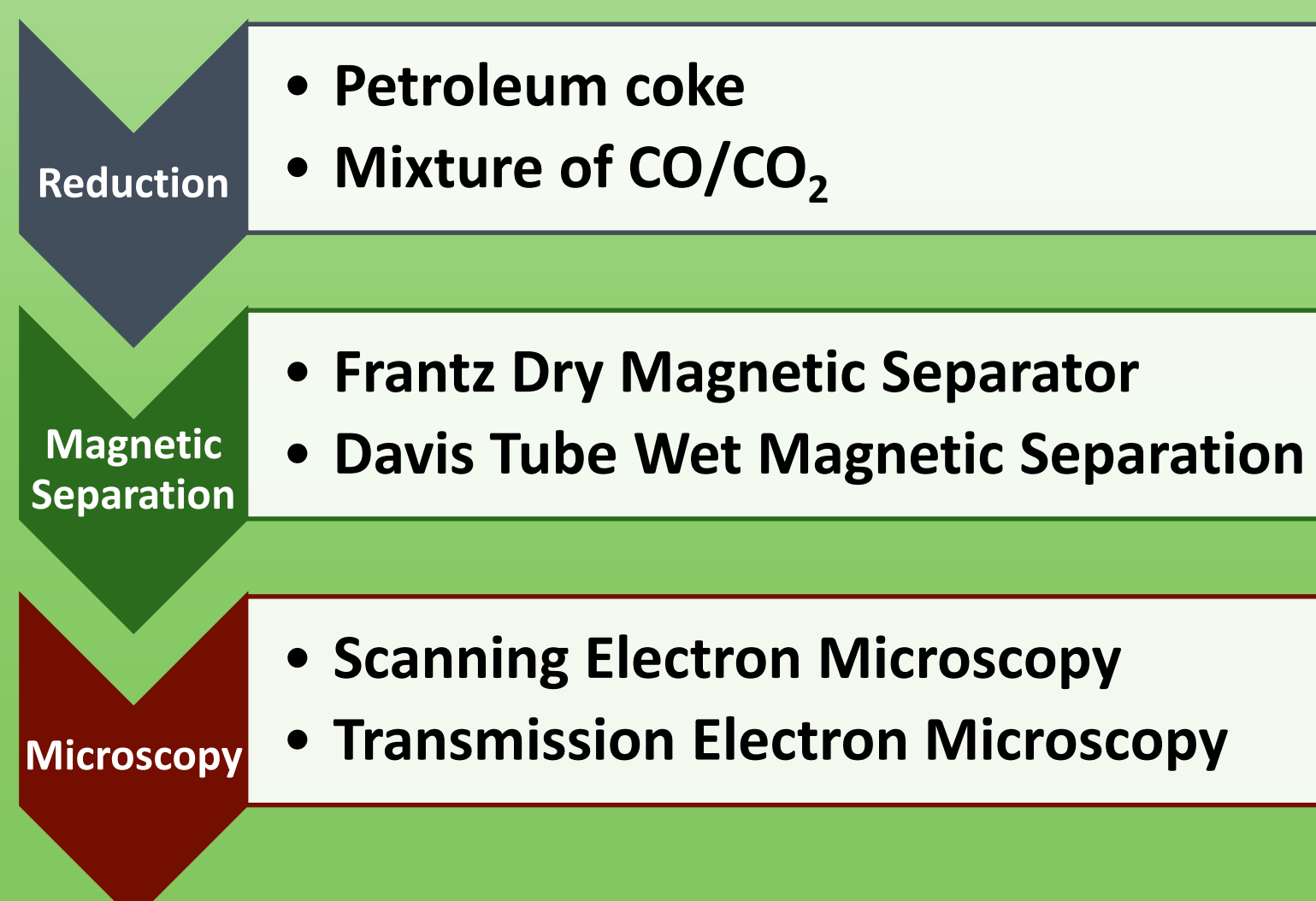
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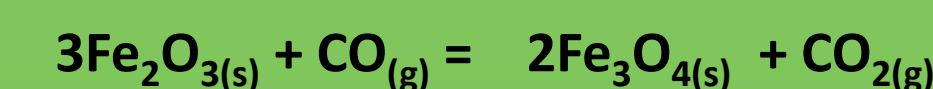
OBJECTIVE



EXPERIMENTAL



REDUCTION: EXPERIMENTS & RESULTS

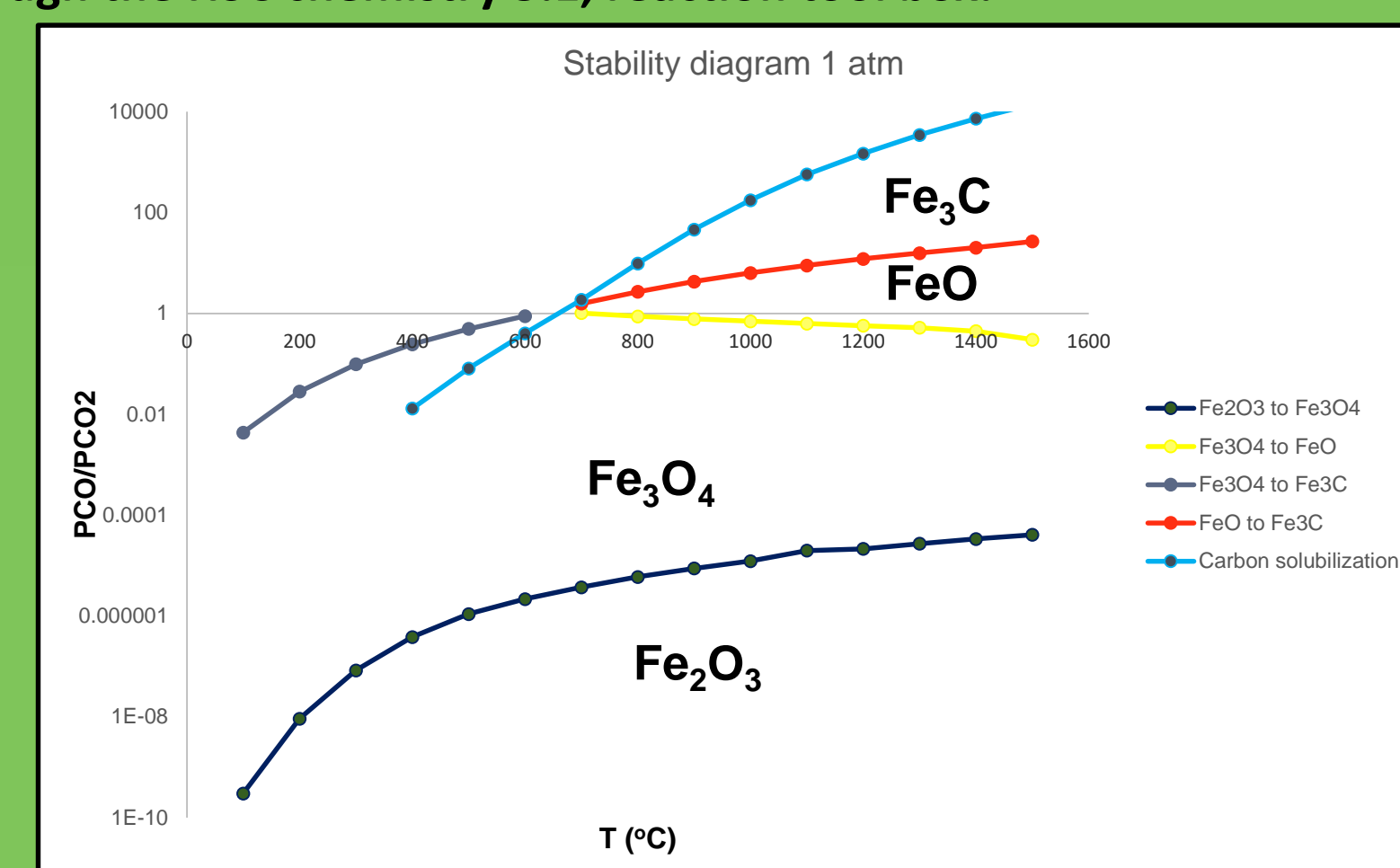


$$\Delta G^\circ = -RT \ln K$$

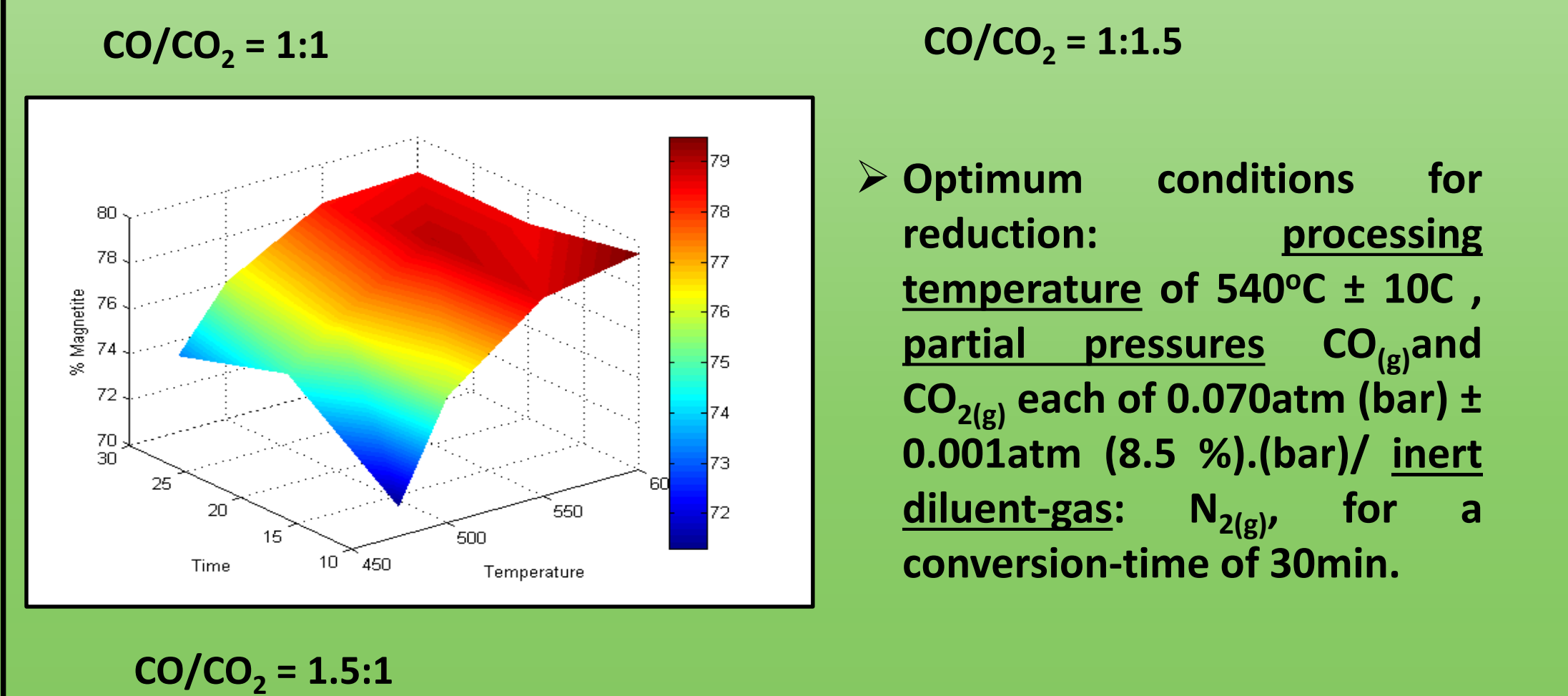
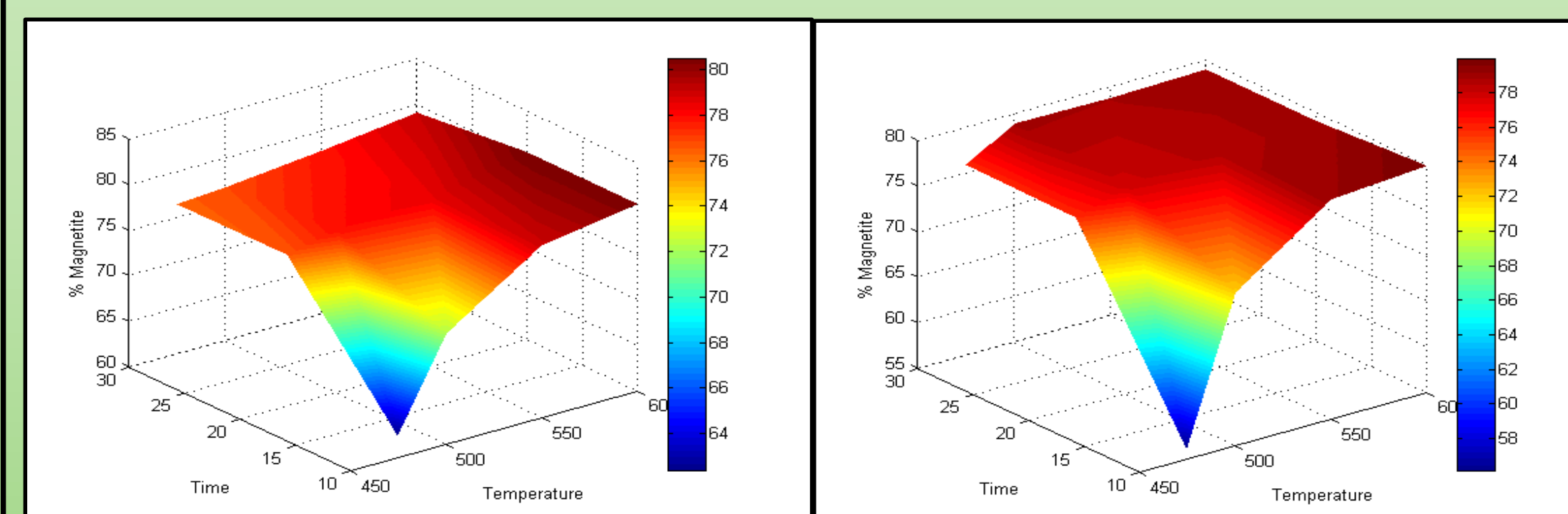
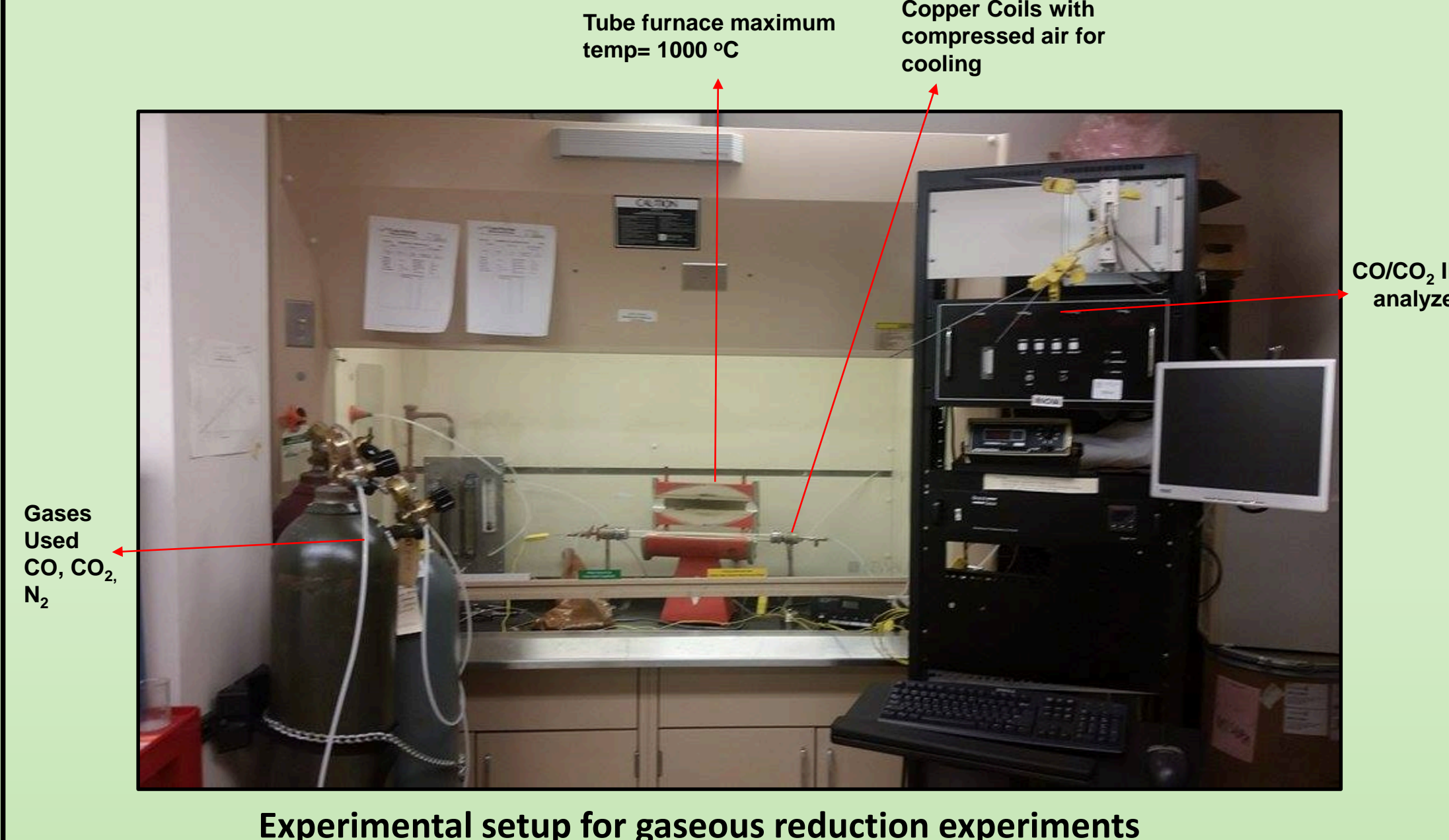
$$\Delta G = -RT \ln \left[\frac{a_{\text{Fe}_3\text{O}_4}^2 \cdot \text{PCO}_2}{a_{\text{Fe}_2\text{O}_3}^3 \cdot \text{PCO}} \right]$$

$$\Delta G = -RT \ln (\text{PCO}_2 / \text{PCO}) \quad (\text{The basis for construction of stability diagram})$$

The values of ΔG are obtained at various Temperatures are obtained through the HSC chemistry 5.1, reaction tool box.



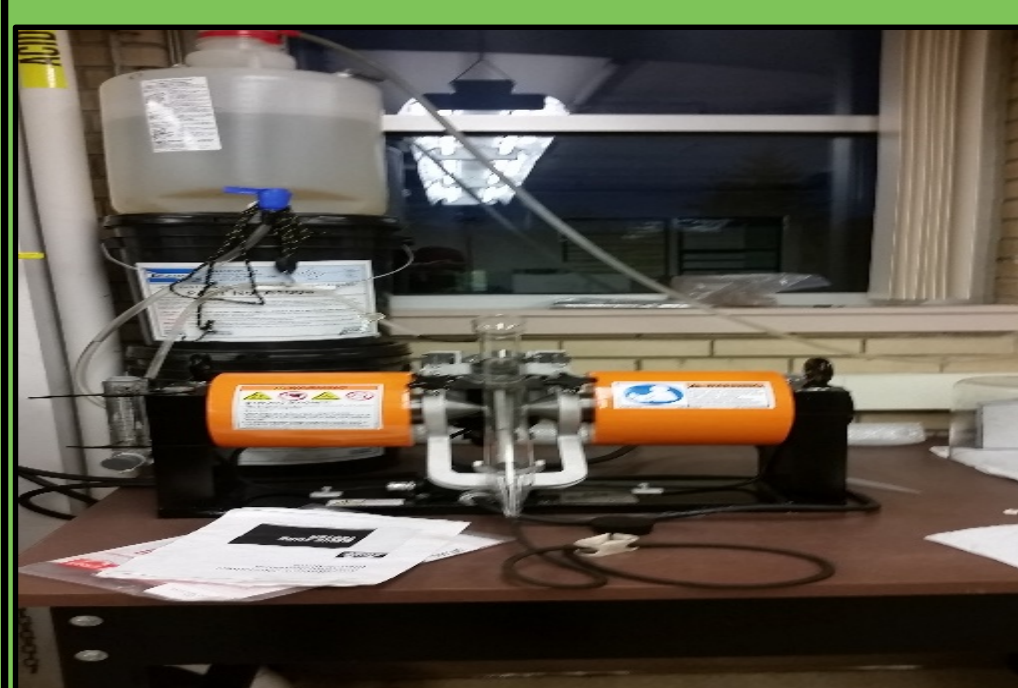
Stability Diagram for Fe-C-O system at 1.0 atm



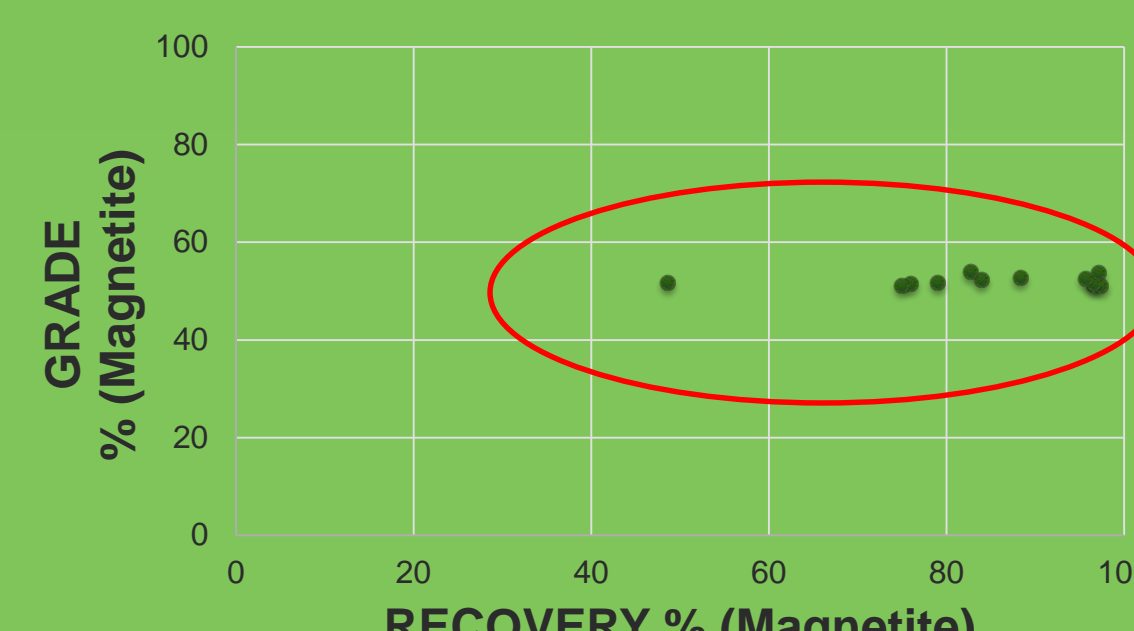
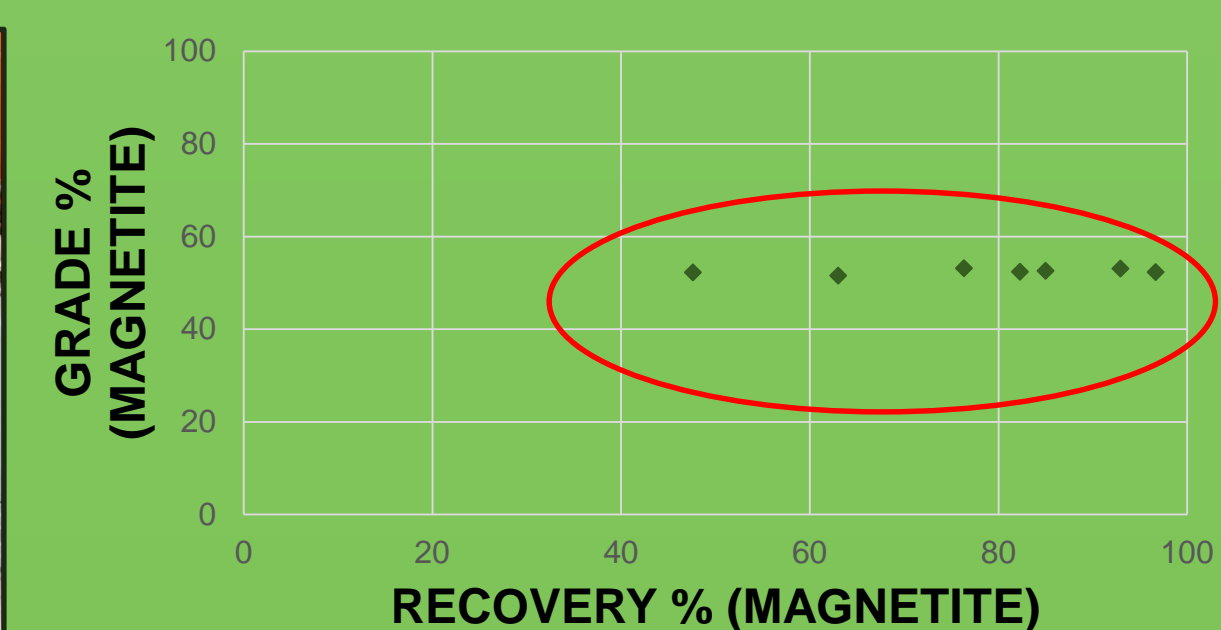
MAGNETIC SEPARATION



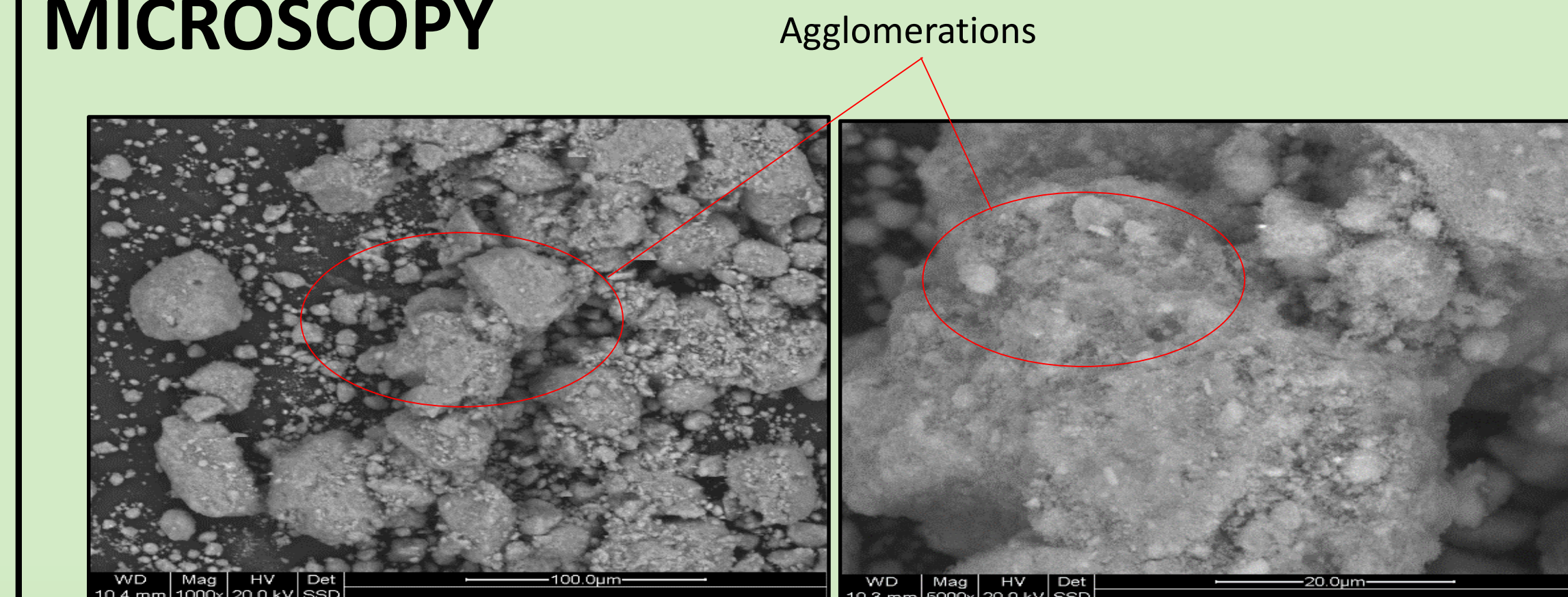
Frantz Dry Magnetic Separator



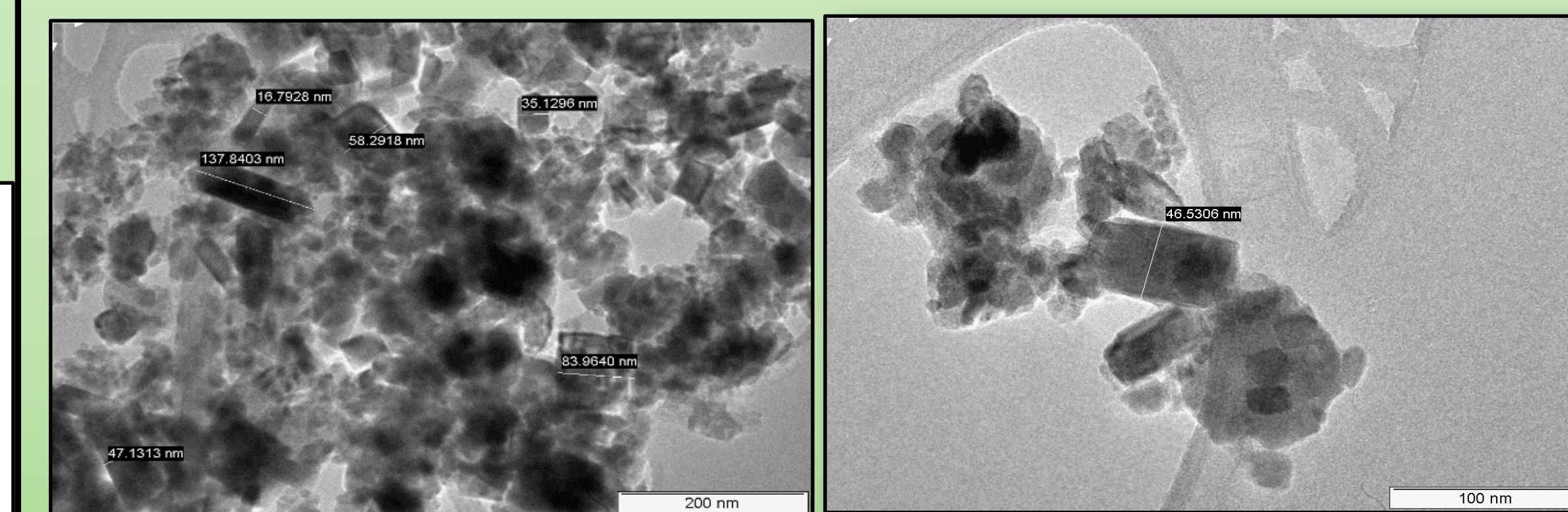
Davis tube Magnetic Separator



MICROSCOPY



- Agglomeration of fine particles is seen in a larger particle mass.



- Agglomerates of Nano crystallites.
- Particle size assigning to red mud is highly ambiguous !!!!

CONCLUSION

- A red-mud particle is composed of agglomerated entities of small Nano-particulates. The Nano-particulates are in the size range of 16-140 nm.
- Low temperature (475°C to 600°C) gas-phase reduction of hematite in red-mud to magnetite is viable conversion-process that can be achieved with low partial-pressures of CO_(g) and CO_{2(g)}. N_{2(g)}
- Solid-phase reduction-products obtained from the gas-phase reduction of red mud contained Fe₃O₄ (56.4 – 80.5 m%), Fe₂O₃ (0 – 20 m%), Fe₃C (4.8 – 6.8 m %) and paramagnetic 2+ and 3+ phases (14 - 22 m%).
- Dry and wet magnetic-separation performed on the reduced samples did not achieve a high grade of separated magnetite.
 - 1) The cation substitution of, primarily, Al³⁺ and Ti⁴⁺/Ti³⁺ cations in the hydrated-oxide nanoparticles being converted to magnetite or,
 - 2) Nano-size particles of aluminum and titanium "oxides" occluded within the predominantly "large-particles/clusters".

FUTURE RECOMMENDATION

- Structural characterization of nanometer length scale constituents of red-mud.
- Development of a strategy to segregate the Al^(III) and Ti^(III/IV) constituents so as to yield a low Al, Ti magnetic fraction and low Fe non magnetic fraction.

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