Textural implications on Iron Ore Beneficiation outcomes – A Case study

SAIMM Geometallurgy Conference

October 2025

K. Netshikulwe, E.R Manjengwa, B.P. von der Heyden, M. Tadie

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

African Rainbow Minerals Chair in GeoMetallurgy

ARM African Rainbow Minerals

SYNOPSIS

1. Background
2. Objectives
3. Experimental setup
4. Results & Discussion
5. Closing remarks

BACKGROUND

BACKGROUND – IRON PRODUCTION

- Iron ore finds extensive use in different industries, e.g., construction, vehicle and weapons industries.
- South Africa is a notable player in the global iron ore supply chain.
- Major high-grade (>63%) contributing mines Include, Khumani, Sishen, Kolomela and Beeshoek.
- The country's high-grade reserves have been estimated to have almost 700 million tonnes as of June 2023.
- That translates to less two decades on mining, given the current production rate.
- Alternative ore deposits: low-grade ores, fine-grained, ores with complex mineralogy and ore textures.

pwc SA mine, (2023)

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

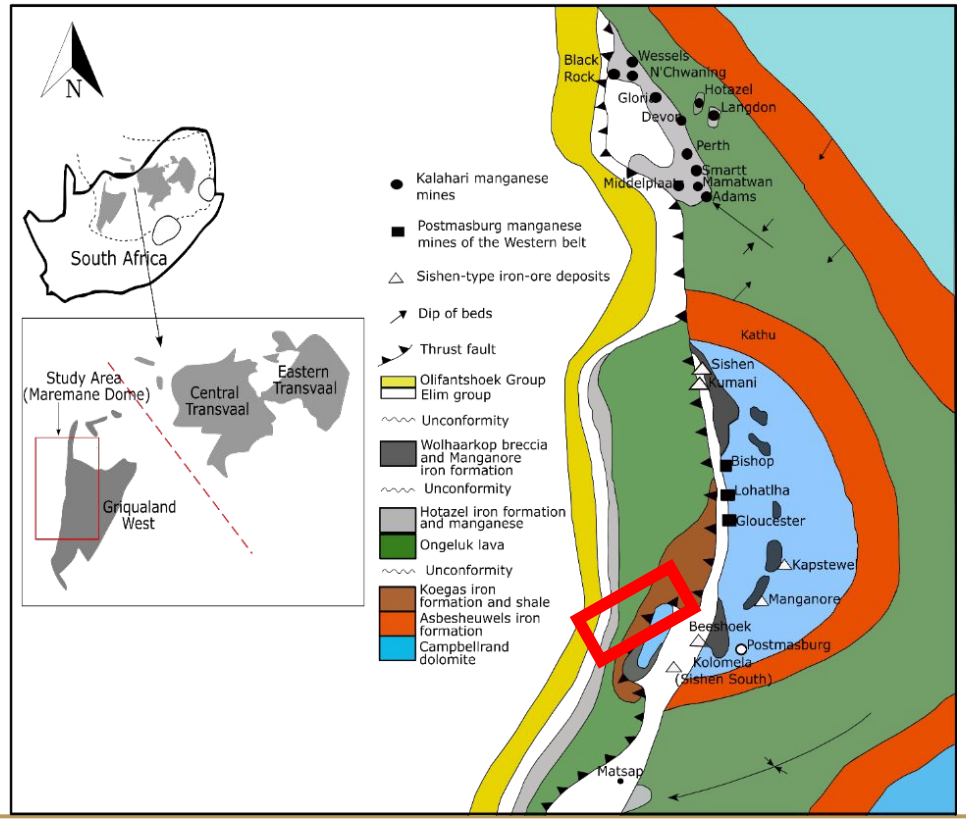
African Rainbow Minerals Chair in GeoMetallurgy

ARM African Rainbow Minerals

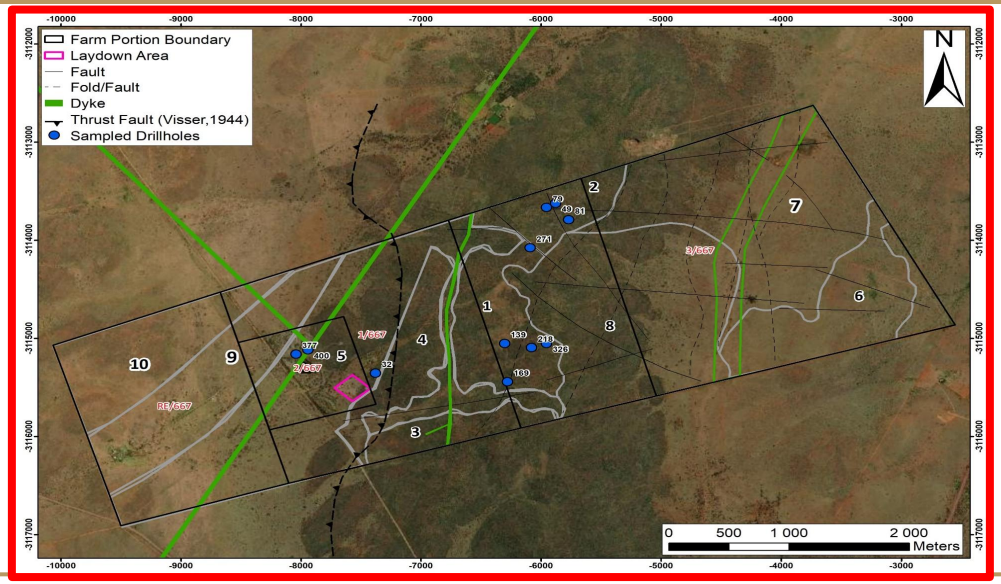
BACKGROUND

- Iron ore is globally classified as high grade when (+ 65% Fe),
- Medium grade (+ 62–65% Fe), and low grade (– 62% Fe).
- Typically, the integrated steel plants use medium/high grade iron ore.
- The sponge iron plants require only high-grade iron ore.
- The ore is crushed and sized to, e.g., 6.3–31.5 mm fraction if it is used as lumpy ore in blast furnaces.

STUDY AREA



- Maremane dome: BIF hosted iron ore & high-grade hematite ore
- Makganyene exploration site located northwest of Postmansburg town.



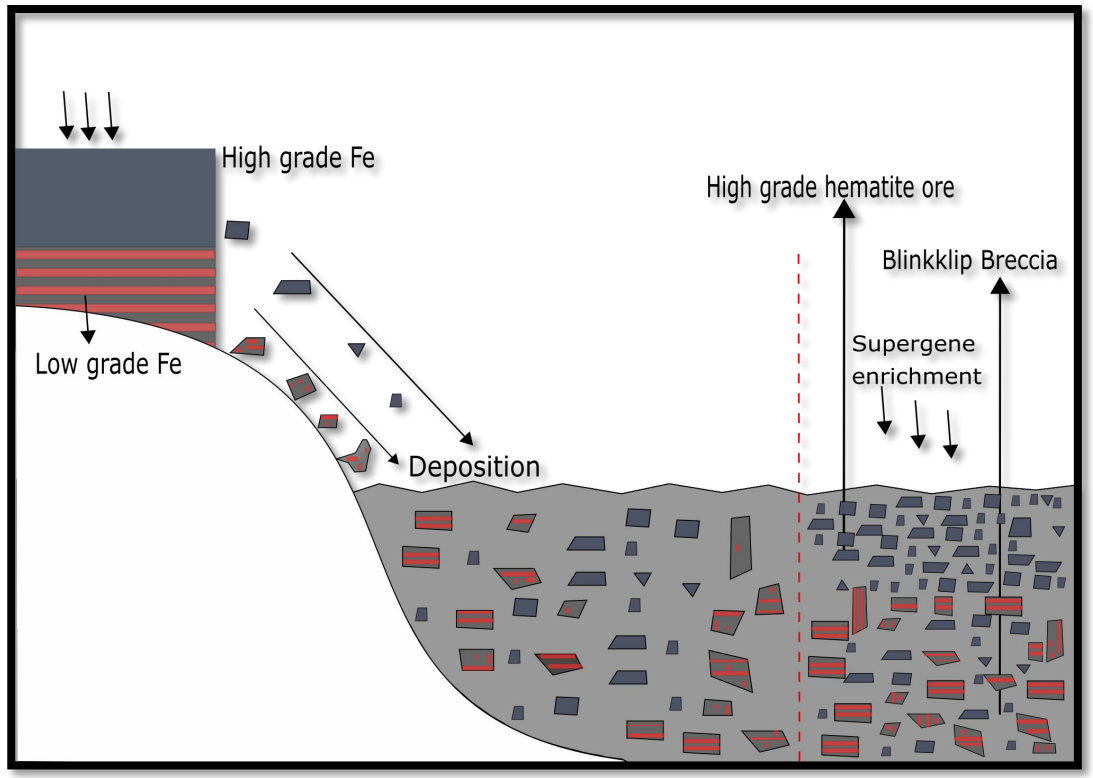
Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

African Rainbow Minerals Chair in GeoMetallurgy

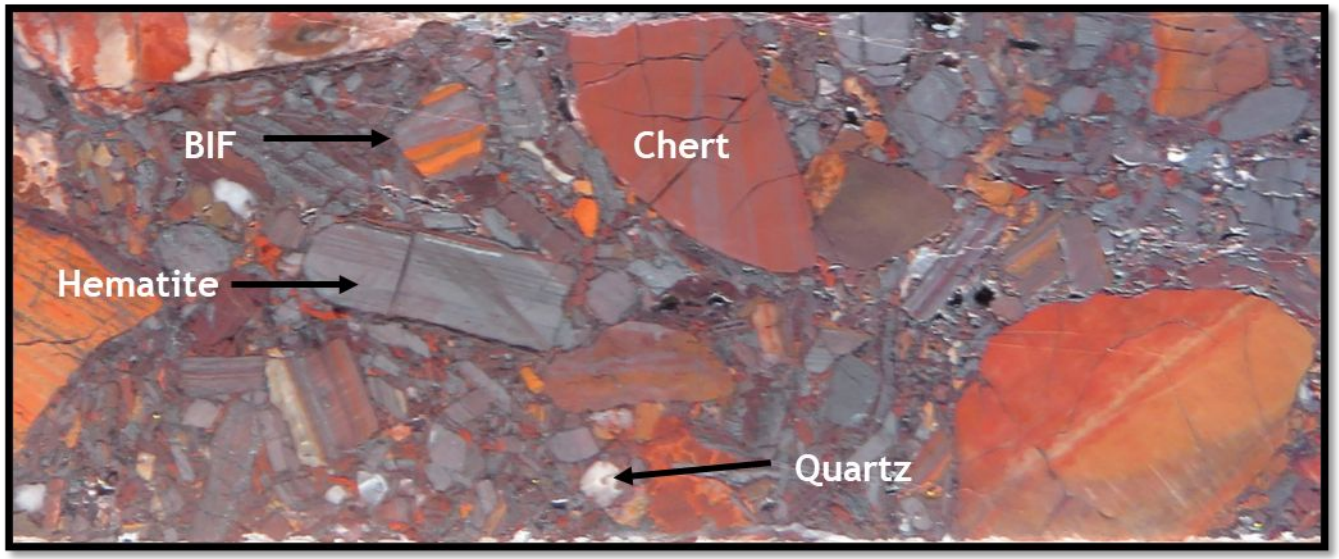
ARM African Rainbow Minerals

(2)

BACKGROUND – BLINKKLIP BRECCIA



- Karstic collapse in the late Paleoproterozoic
- Clast supported breccia
- Clast type: cherty BIF, Hematite, chert



OBJECTIVES

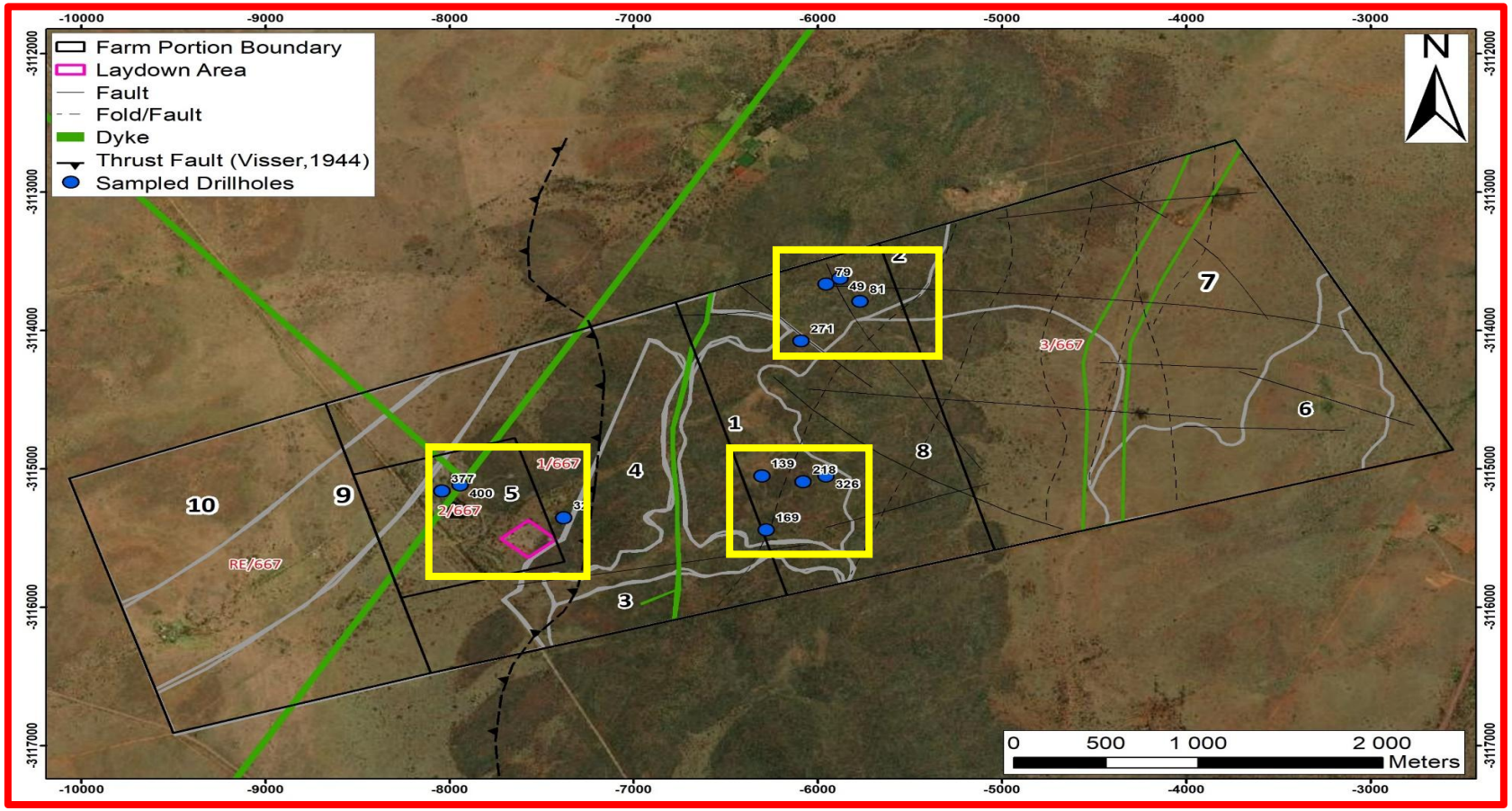
OBJECTIVES

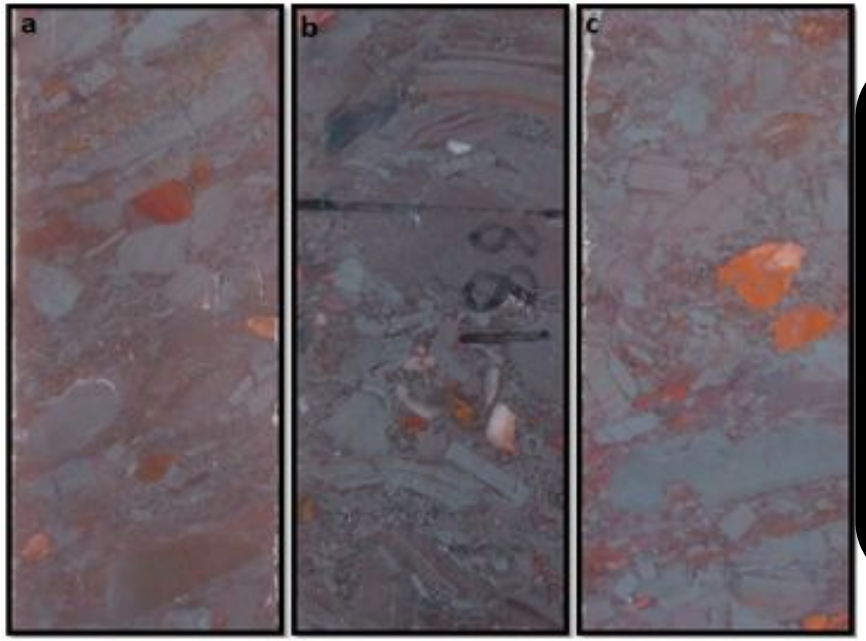
- Examine the extent to which coarse particle jigging can be used to beneficiate the low-grade Blinkklip breccia.
- Understand the implications of textural variations on concentrate grade
- Assess whether the coarse particle jigging alone is sufficient to beneficiate the Blinkklip breccia iron ore deposit.

EXPERIMENTAL SETUP

EXPERIMENTAL SETUP

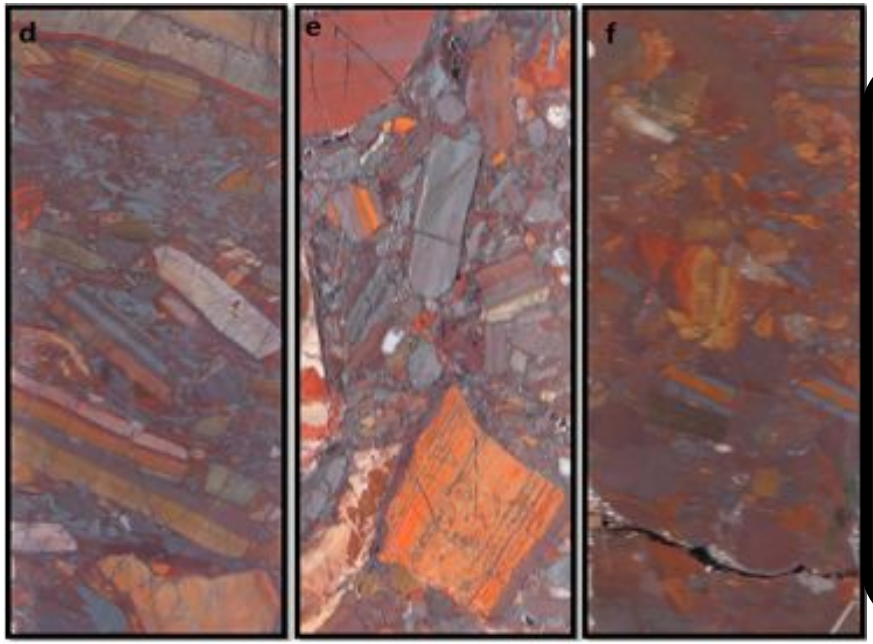
- 11 sampled boreholes.
- Sampled at 5 and 10 meter intervals.





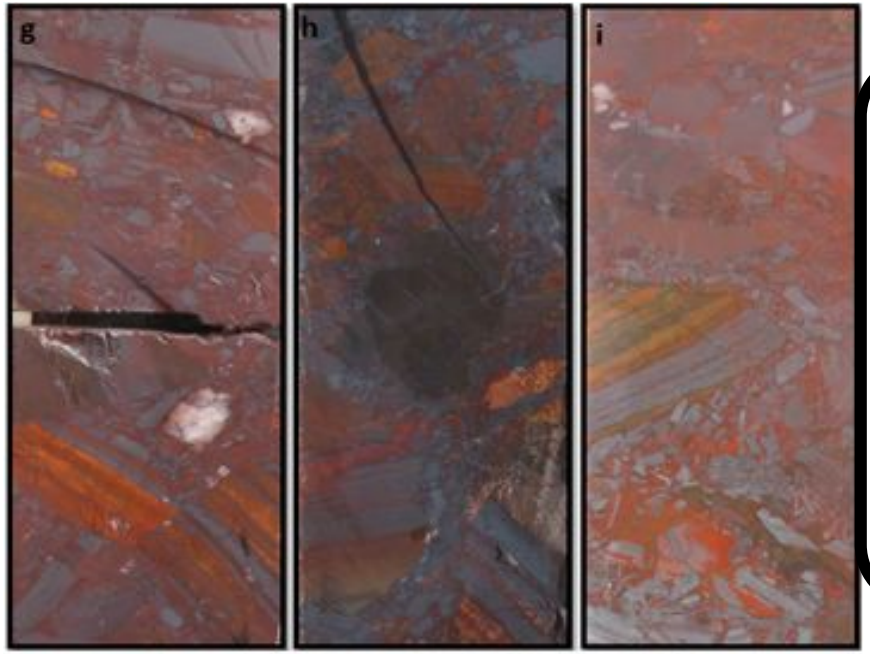
BK1

BK1 – clast supported hematite-rich type.



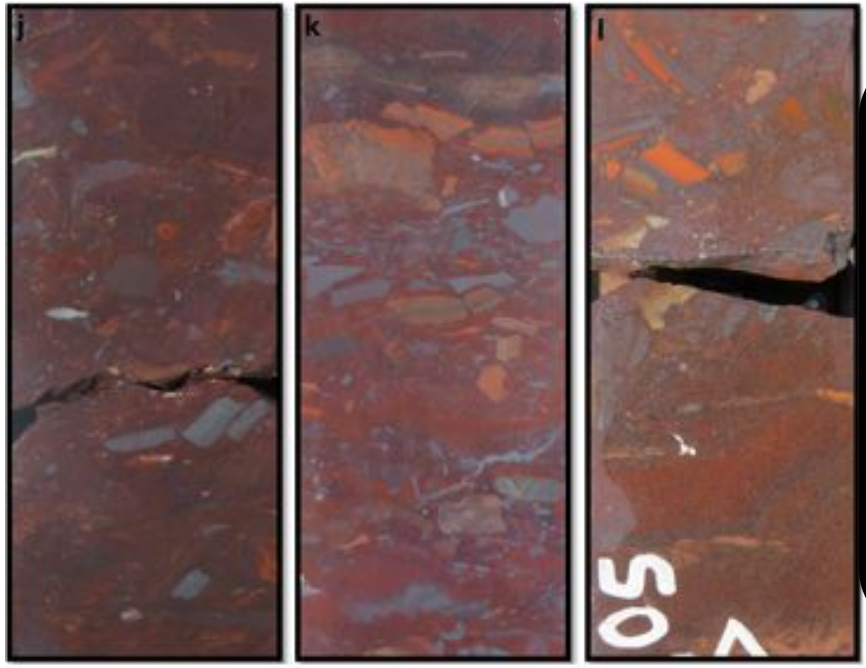
BK2

BK2 – clast supported silica-rich type.



BK3

BK3 - clast-supported hematite-silica mixture type

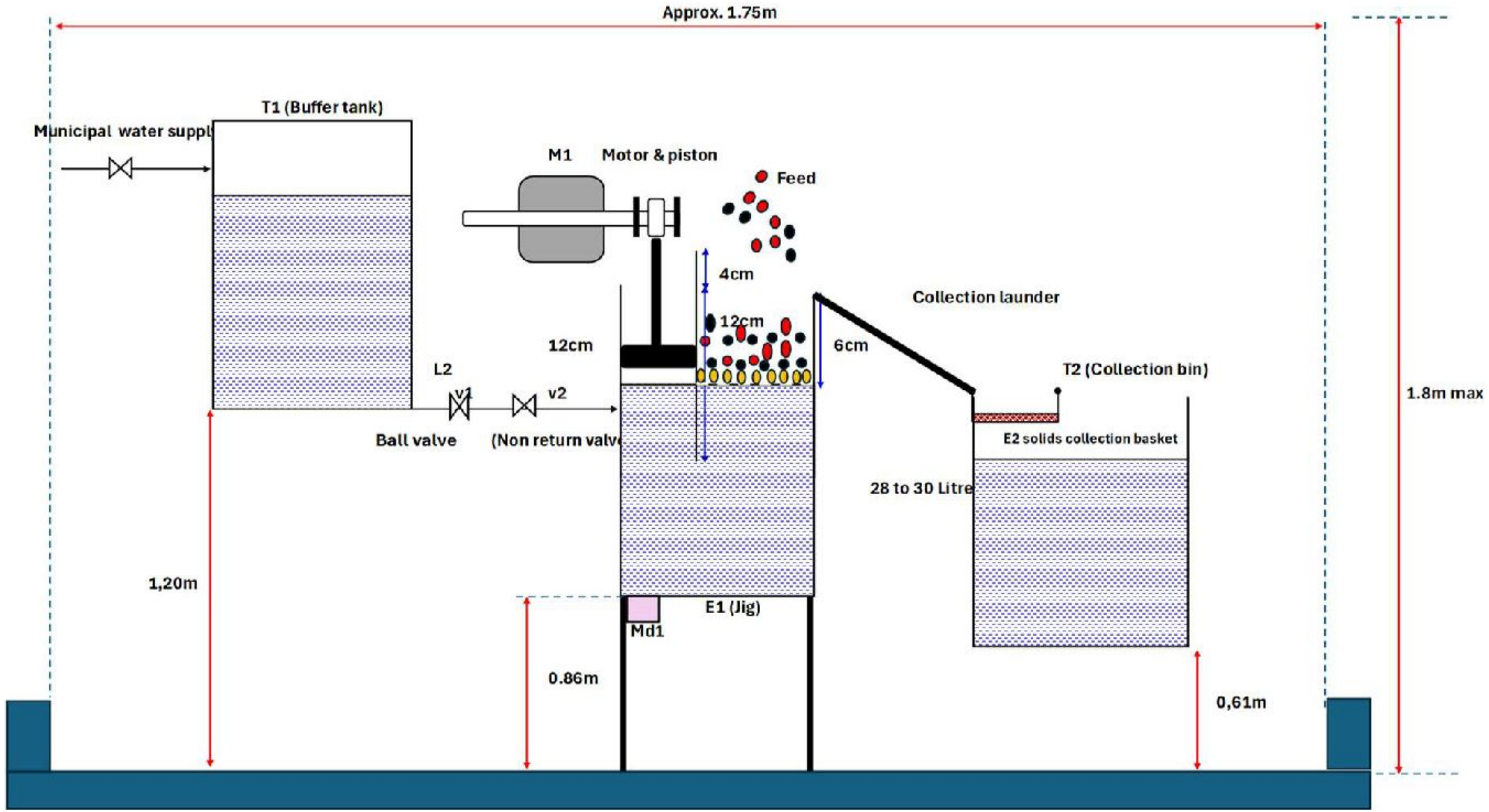


BK4

BK4 - matrix-supported hematite-silica mixture type

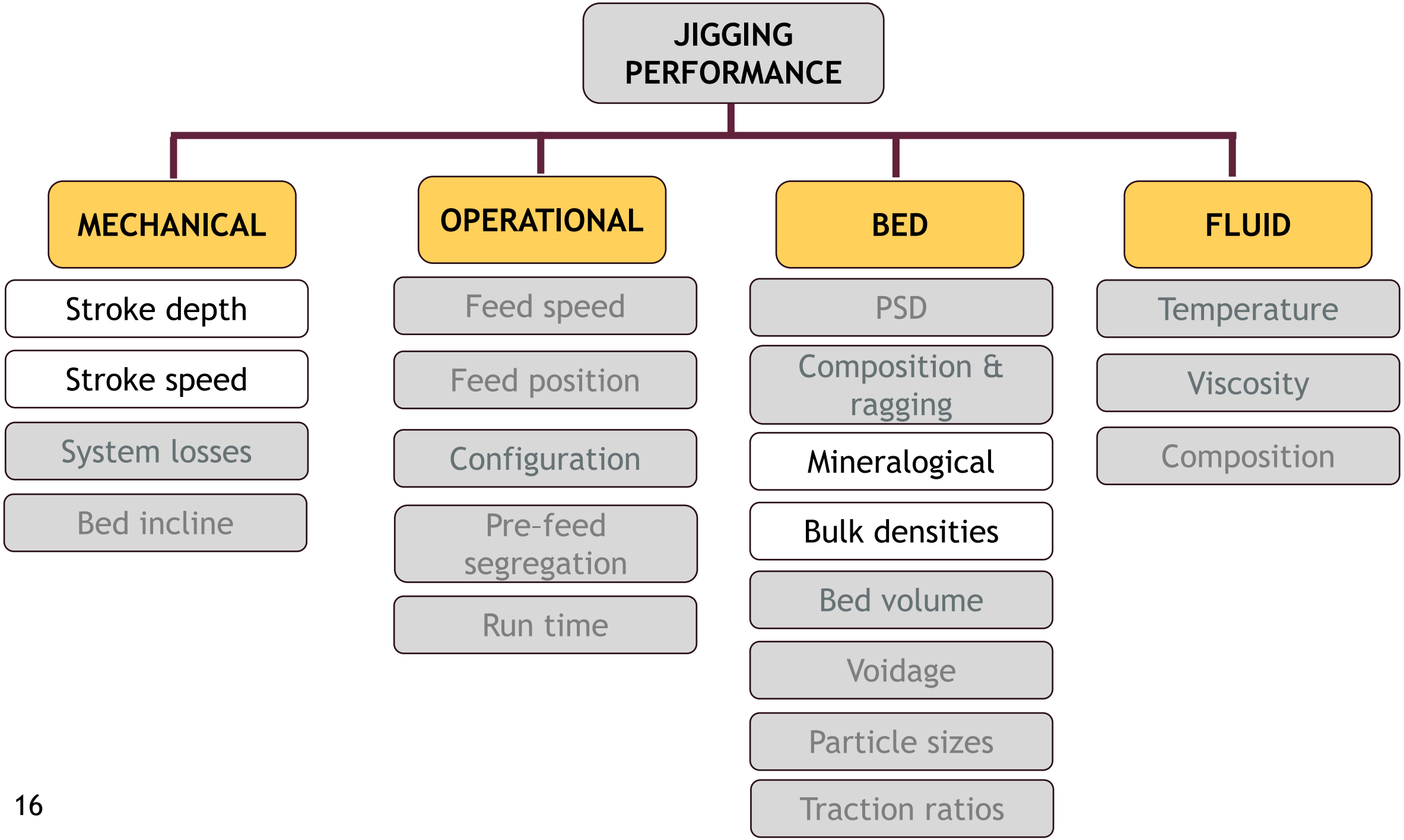
EXPERIMENTAL SETUP

- Two gravity-based separation methods were selected: DMS tests and Jigging tests.
- **Concentration criterion (CC)**
  - $CC = \frac{\rho(\text{heavies}) - \rho(\text{fluid})}{\rho(\text{lights}) - \rho(\text{fluid})}$
  - In this case we had a maximum CC value of **3.20**
- Targeting the +6.3 mm size range, preferred for blast furnace.
- In this presentation we will mainly discuss the Jigging tests.

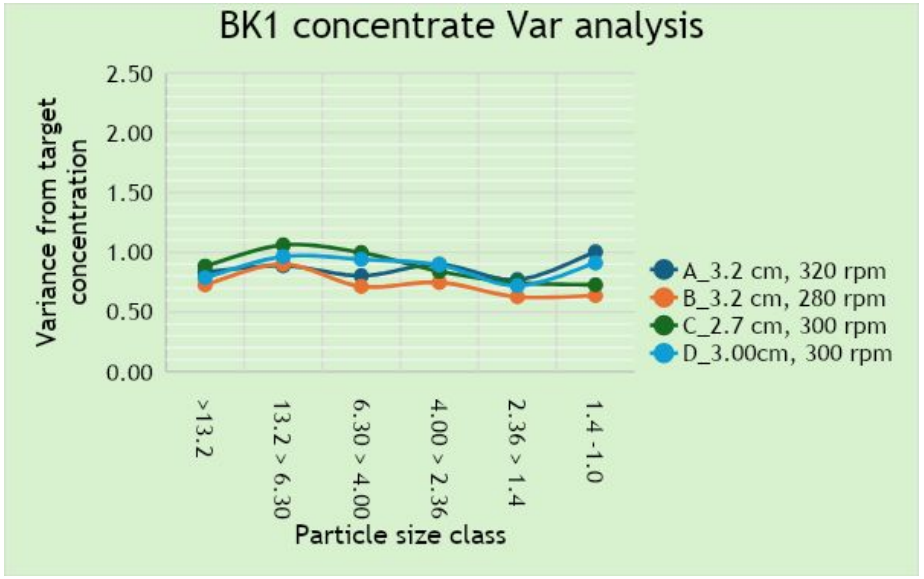

Approx. 1.75m
T1 (Buffer tank)
Municipal water supply
M1
Motor & piston
Feed
4cm
12cm
12cm
Collection launder
6cm
L2
v1
v2
T2 (Collection bin)
Ball valve
(Non return valve
E2 solids collection basket
28 to 30 Litre
1.8m max
1,20m
E1 (Jig)
Md1
0.86m
0,61m

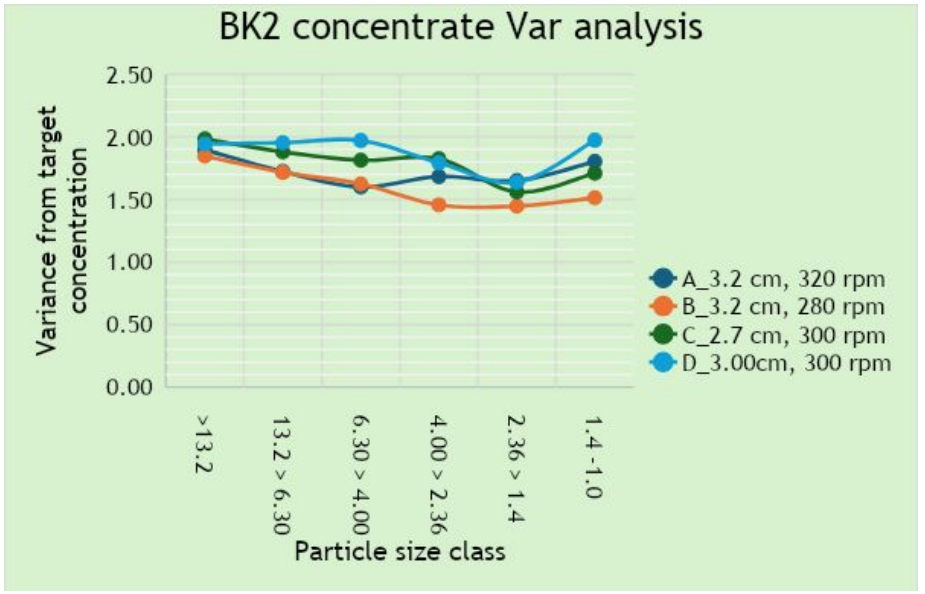
Construction by:
S. Milne et al.

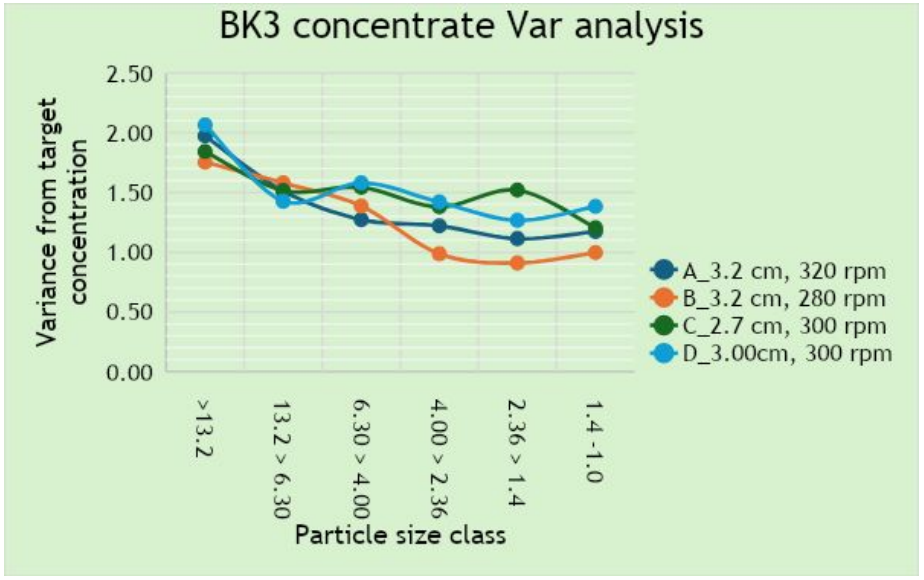
Explored jigging parameters from: Umadevi et al., 2014

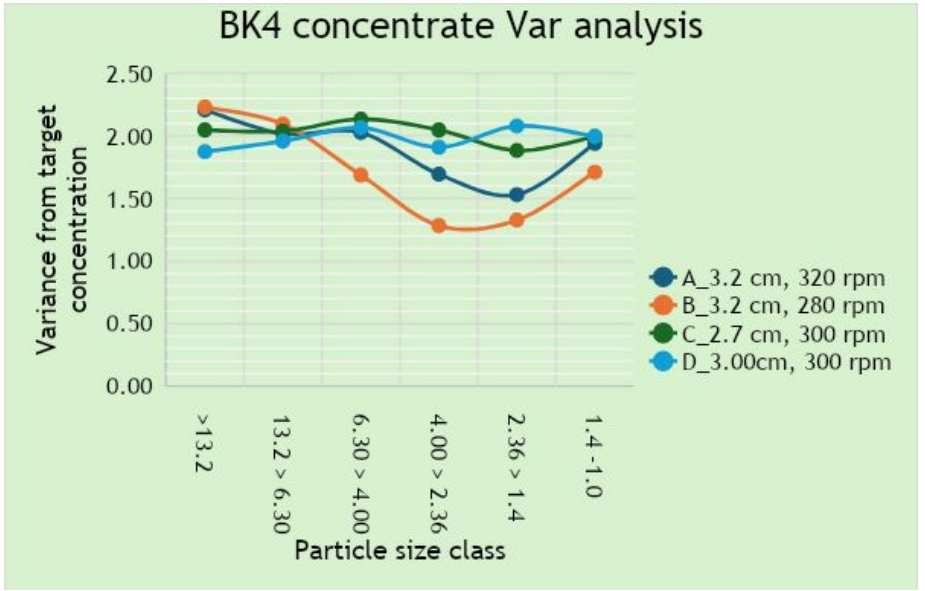

JIGGING PERFORMANCE
MECHANICAL
Stroke depth
Stroke speed
System losses
Bed incline
OPERATIONAL
Feed speed
Feed position
Configuration
Pre-feed segregation
Run time
BED
PSD
Composition & ragging
Mineralogical
Bulk densities
Bed volume
Voidage
Particle sizes
Traction ratios
FLUID
Temperature
Viscosity
Composition

RESULTS & DISCUSSION



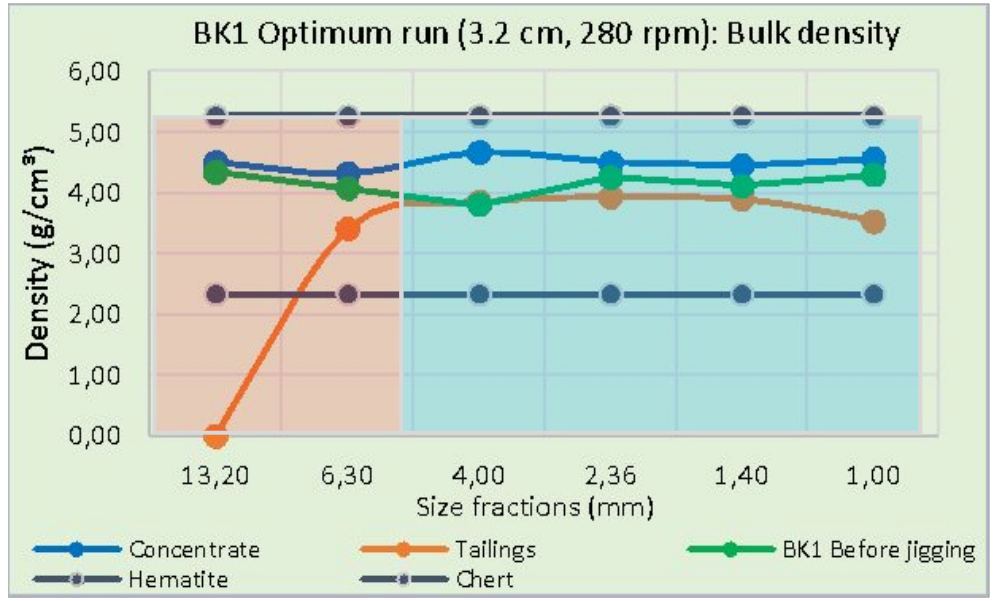


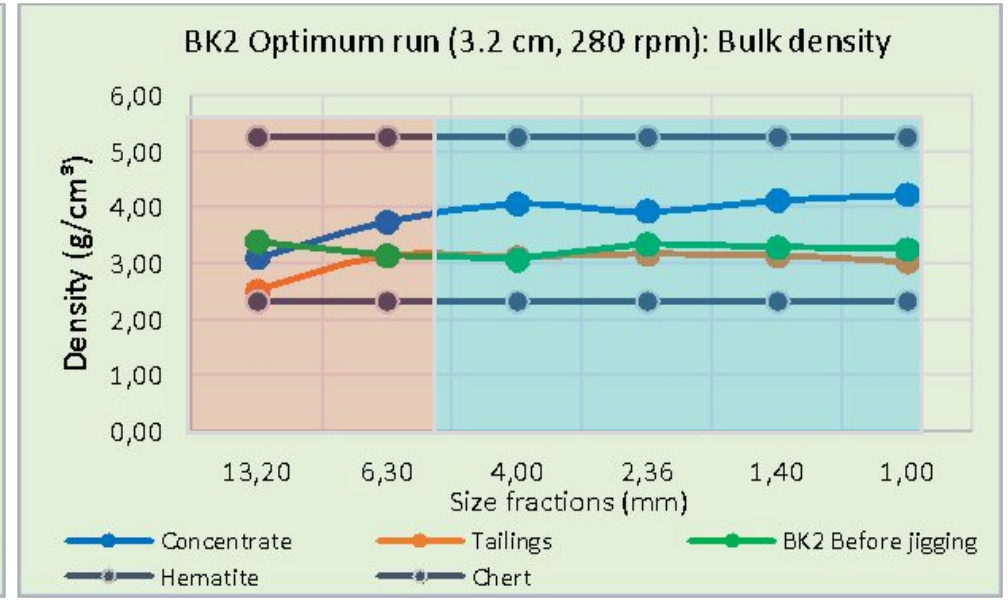


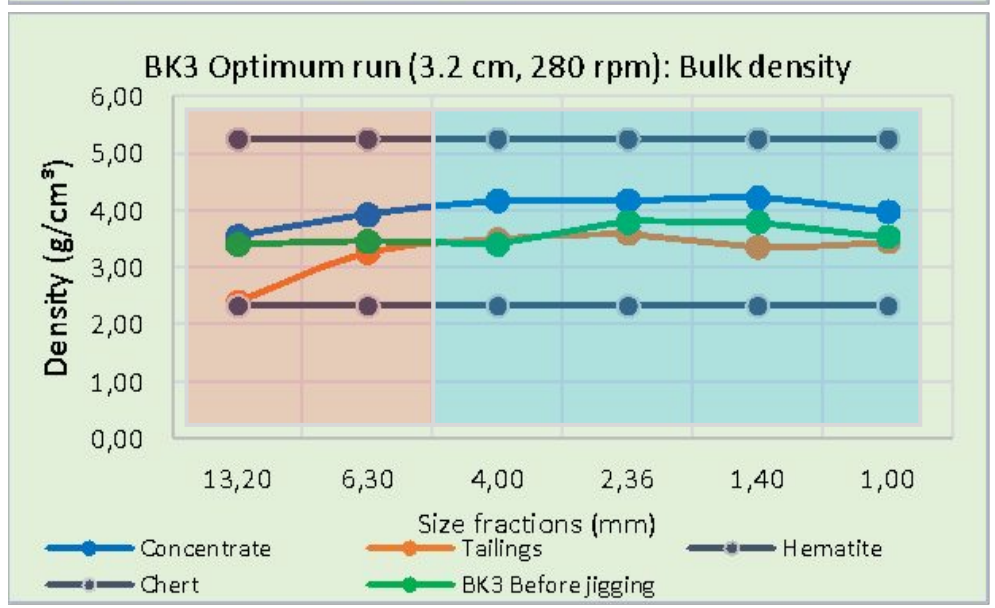


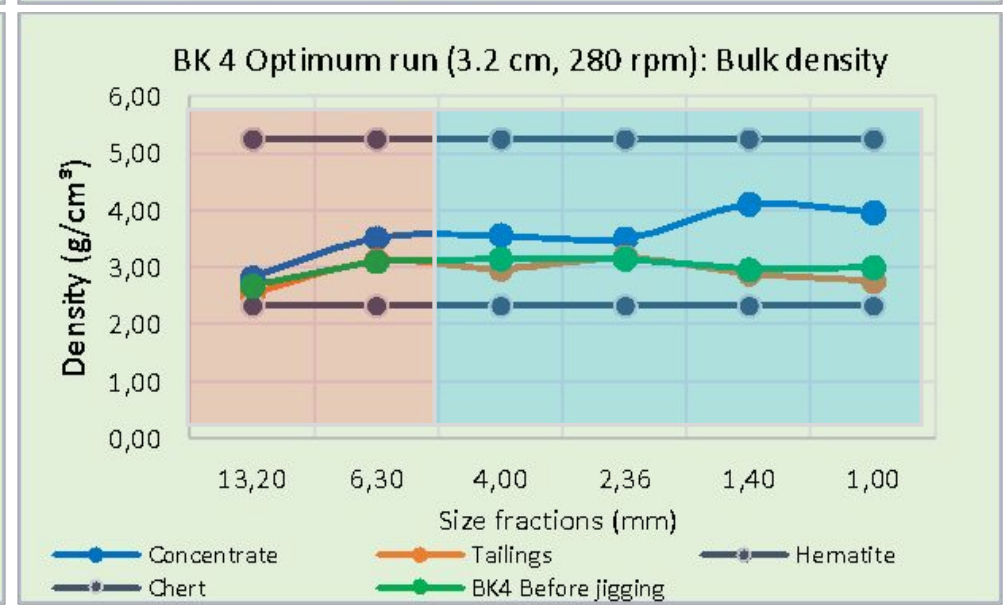
Optimal setting
(Run B)

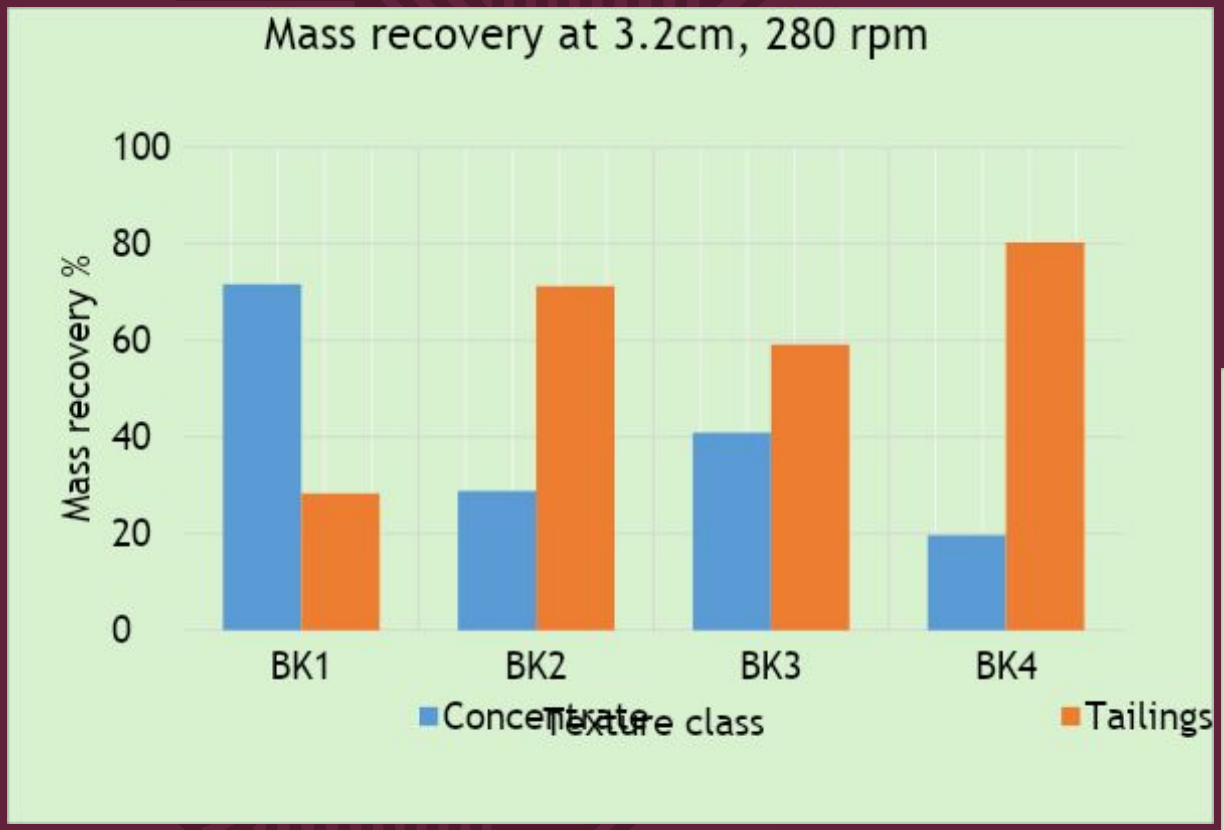
Stroke depth: 3.2 cm
Stroke speed: 280 rpm


BK1 Optimum run (3.2 cm, 280 rpm): Bulk density
Density (g/cm³)
6,00
5,00
4,00
3,00
2,00
1,00
0,00
13,20
6,30
4,00
2,36
1,40
1,00
Size fractions (mm)
Concentrate
Tailings
BK1 Before jigging
Hematite
Chert

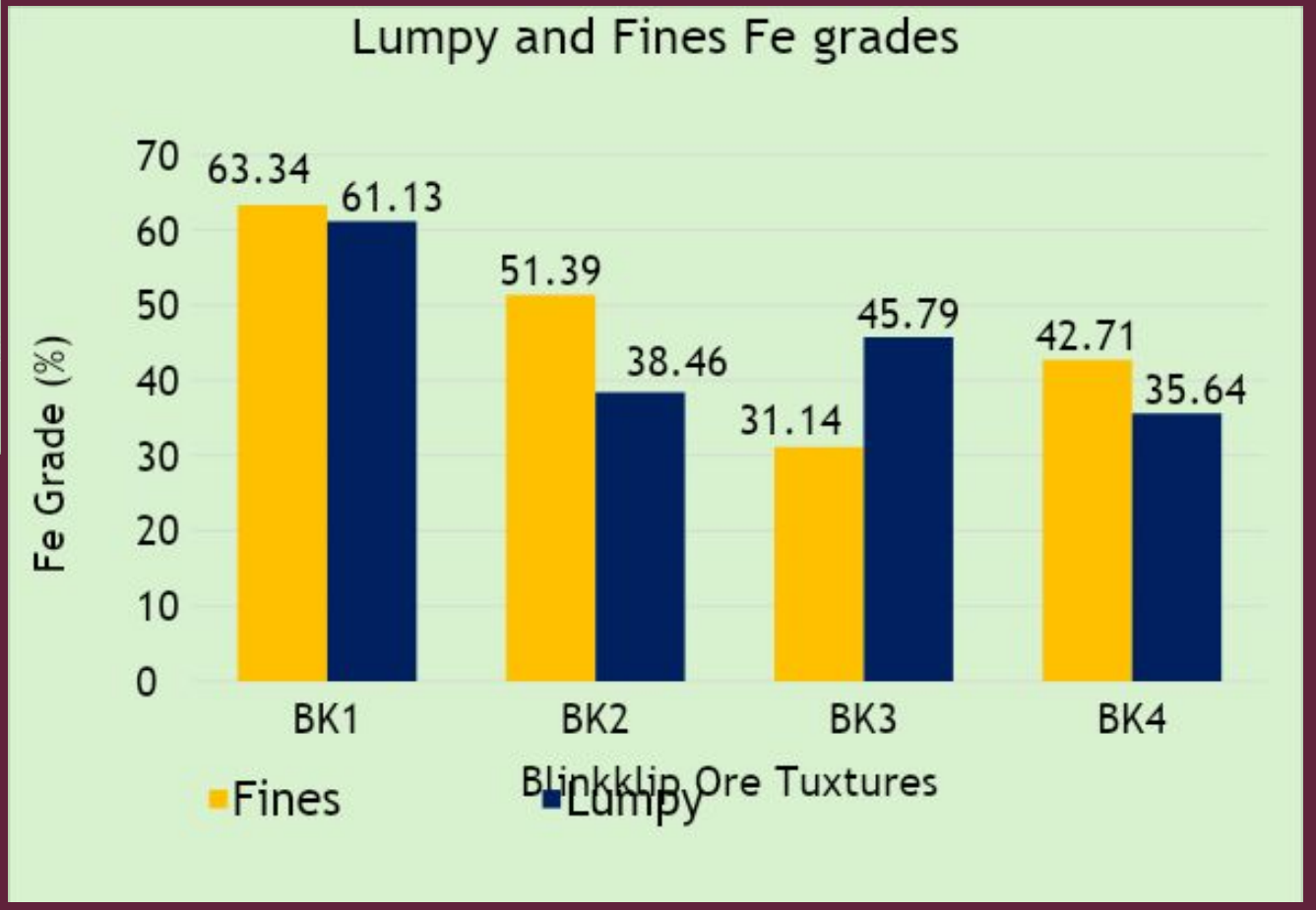

BK2 Optimum run (3.2 cm, 280 rpm): Bulk density
Density (g/cm³)
6,00
5,00
4,00
3,00
2,00
1,00
0,00
13,20
6,30
4,00
2,36
1,40
1,00
Size fractions (mm)
Concentrate
Tailings
BK2 Before jigging
Hematite
Chert


BK3 Optimum run (3.2 cm, 280 rpm): Bulk density
Density (g/cm³)
6,00
5,00
4,00
3,00
2,00
1,00
0,00
13,20
6,30
4,00
2,36
1,40
1,00
Size fractions (mm)
Concentrate
Tailings
Hematite
Chert
BK3 Before jigging


BK 4 Optimum run (3.2 cm, 280 rpm): Bulk density
Density (g/cm³)
6,00
5,00
4,00
3,00
2,00
1,00
0,00
13,20
6,30
4,00
2,36
1,40
1,00
Size fractions (mm)
Concentrate
Tailings
Hematite
Chert
BK4 Before jigging



- Both mass recovery and grade reveal textural influence.
- Ratio of high-grade clasts to low-grade clast determines the resulting grade.



CLOSING REMARKS

CLOSING REMARKS

Examine the extent to which coarse particle jigging can be used to beneficiate the Blinkklip breccia deposit.

- Results of empirical studies showed that jigging could be used to beneficiate the low-grade iron ore deposit from Magkanyene Farm.
- Limitations?

CLOSING REMARKS

Understand the implications of textural variations on concentrate grade

- Outcomes of the study revealed that textural variations do affect jigging outcomes.
- Mineral textures affect rock breakage patterns, Liberation.
- Therefore, textures inherently have an influence on the morphology of the particles formed and the extent of segregation during jigging.
- However other factors do come into play such as the operating conditions etc..

CLOSING REMARKS

Assess whether the coarse particle jigging alone is sufficient to beneficiate the iron ore deposit.

- Recovery of lumpy particle size fractions (>6.3mm) with bulk density >4.0g/cm3 (corresponds to an Fe Grade of roughly 39.88%) was not possible for textures BK2, BK3 and BK4 having low iron grades.
- The iron grade in the concentrate stream increased with decreasing particle sizes,
- Suggested that a single jigging cycle would be inadequate and,
- Further size reduction and beneficiation using other methods would be required.

REFRENCES

- Gutzmer J., (1996). Genesis and Alteration of the Kalahari and Postmasburg Manganese deposits, Griqualand West, South Africa. Thesis. University of Johannesburg.
- Umadevi et al., (2014). Development of a process flowsheet for the beneficiation of low-grade iron ore fines from the Bellary-Hospet region of Karnataka, India. Mining, Metallurgy & Exploration, 31, 162-168.
- Van Deventer, W. F. (2010). Textural and geochemical evidence for a supergene origin of the Paleoproterozoic high-grade BIF-hosted iron ores of the Maremane Dome, Northern Cape Province, South Africa. University of Johannesburg (South Africa).
- Wills, B. A., & Finch, J. (2016). Wills' mineral processing technology: an introduction to the practical aspects of ore treatment and mineral recovery. Butterworth-heinemann.
- Woollacott, L. C., & Silwamba, M. (2016). An experimental study of size segregation in a batch jig. Minerals Engineering, 94, 41-50.

THANK YOU FOR LISTENING

ACKNOWLEDGEMENTS

Prof. Bjorn von der Heyden, Dr. Margreth Tadie, Dr Evelyn Manjengwa
Earth Science Department
Chemical Engineering Workshop team
Makganyene exploration team

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

African Rainbow Minerals Chair in GeoMetallurgy

ARM African Rainbow Minerals