Beyond recovery rethinking reagent strategies for sustainable MG ore processing

Department of Materials, Chemical and Metallurgical Engineering,
Tshwane University of technology

phumlani.siwela@gmail.com

Tshwane University of Technology
We empower people

20 YEARS 2004-2024

PRESENTATION OUTLINE

- Introduction
- Objective(s) of the study
- Method & Materials
- Results
- Discussion & conclusions
- References

INTRODUCTION

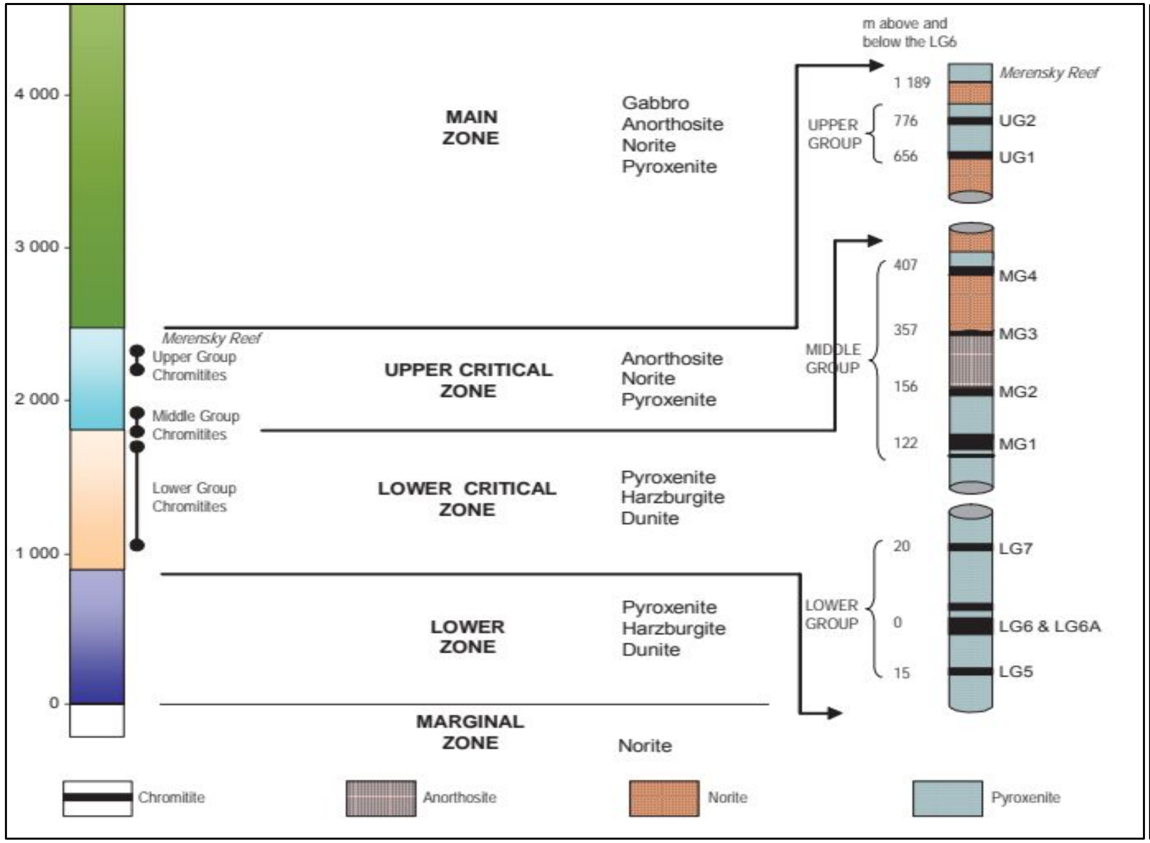

Figure 1 Stratigraphic Column of Rustenburg Layered Suite (after Viljoen and Schürmann, 1998)

- Marginal Zone consist of finer-grained rocks with abundant xenoliths; no economic mineralization
- Lower Zone consist of Orthopyroxenite with olivine-rich cumulates (harzburgites, dunites); may be absent in some areas
- Critical Zone has cyclic layering of chromite,pyroxenite, and plagioclase-rich rocks; hosts PGM deposits and chromitite layers
- Main Zone consist of Norites grading into gabbronorites; includes mottled anorthosite and Pyroxenite marker
- Upper Zone is Defined by cumulus magnetite layers; 25 layers, with the Main Magnetite layer exploited for vanadium

INTRODUCTION

Class	Minerals	Merensky Reef	UG2 Reef	Plat Reef
		Volume %		
PGM Alloys	Ferroplatinum Pt Alloy Pd Alloy	40	40	11–30
	Electrum (Au)	2	0.2	3
Arsenides	Pt-arsenides Pd-arsenides	4	0.1–1	1–20
	PGE-sulphurarsenides	3	0.8–7	16–35
PGM sulphides	PtPd-sulphide Pt-sulphide PtRh-sulphide	16	40–60	1–7
Tellurides	Pt-tellurides Pd-tellurides	35	0.5–5	20–50

Table 1. PGM mineralization of Merensky, UG2, and Platreef ores sourced from Baloyi et al. (2024)

Middle group reef

PGM species	Vol %	PGM Type	Vol %
PtS	12.0	PGE-sulfides	47.7
PtPdS	10.6		
PdS	1.4		
PtRhCuS	18.7		
PtPbCuNiS	0.2		
PtRhAsS	2.1		
PtPdAsS	1.4		
PtAsS	1.3		
PtAs	24.9	PGE-arsenides	25.0
PdAs	0.1		
PtBiTe	2.6	PGE-bismuthotellurides	2.9
PtPdBiTe	0.3		
PdPb	0.2	PGE-alloys	3.9
PdHg	1.6		
PtFe	2.2		
PdAsSb	2.2	PGE-others	6.0
PtSb	3.8		
Ru(Os,Ir)S	14.5	Laurite	14.5
TOTAL	100.0		100.0

OBJECTIVES

- Examine traditional xanthate-based flotation schemes for the MG ore (selectivity limitations)
- Identify areas of opportunity for reagent optimization from the base testwork
- Explore alternatives to traditional reagent strategies for PGMs beneficiation from MG ores

MATERIAL & METHODS

1. Sample collection
2. Crush to <1.7mm
3. Mill to 80% -75micron
4. Rate flotation
5. Process mineralogy
6. Results

Experimental Setup

- Denver flotation cell (laboratory-scale)
- Rotor speed maintained at 1200rpm
- 20-minute rate tests (scrapped every 15 sec)
- Products recorded for mass balance calculations
- Water addition for level control
- Kinetic data obtained

MATERIAL & METHODS CONT…

	100g/t SNPX				
Ore type	1:1:1:1	30g/t	40g/t	50g/t	60g/t
	125g/t SNPX				
Ore type	1:1:1:1	30g/t	40g/t	50g/t	60g/t
	150g/t SNPX				
Ore type	1:1:1:1	30g/t	40g/t	50g/t	60g/t
	175g/t SNPX				
Ore type	1:1:1:1	30g/t	40g/t	50g/t	60g/t
	200g/t SNPX				
Ore type	1:1:1:1	30g/t	40g/t	50g/t	60g/t
	225g/t SNPX				
Ore type	1:1:1:1	30g/t	40g/t	50g/t	60g/t

Reagent Regime

- Frother (Senfroth 200): 25g/t (kept constant)
- Activator (Cuphlex): 25 g/t (kept constant)

- Varied dosages:
  - Depressant (SENDEP 30E)
  - Collector (SNPX)
- Ore blend
  - 1:1:1:1 (25% each)

RESULTS

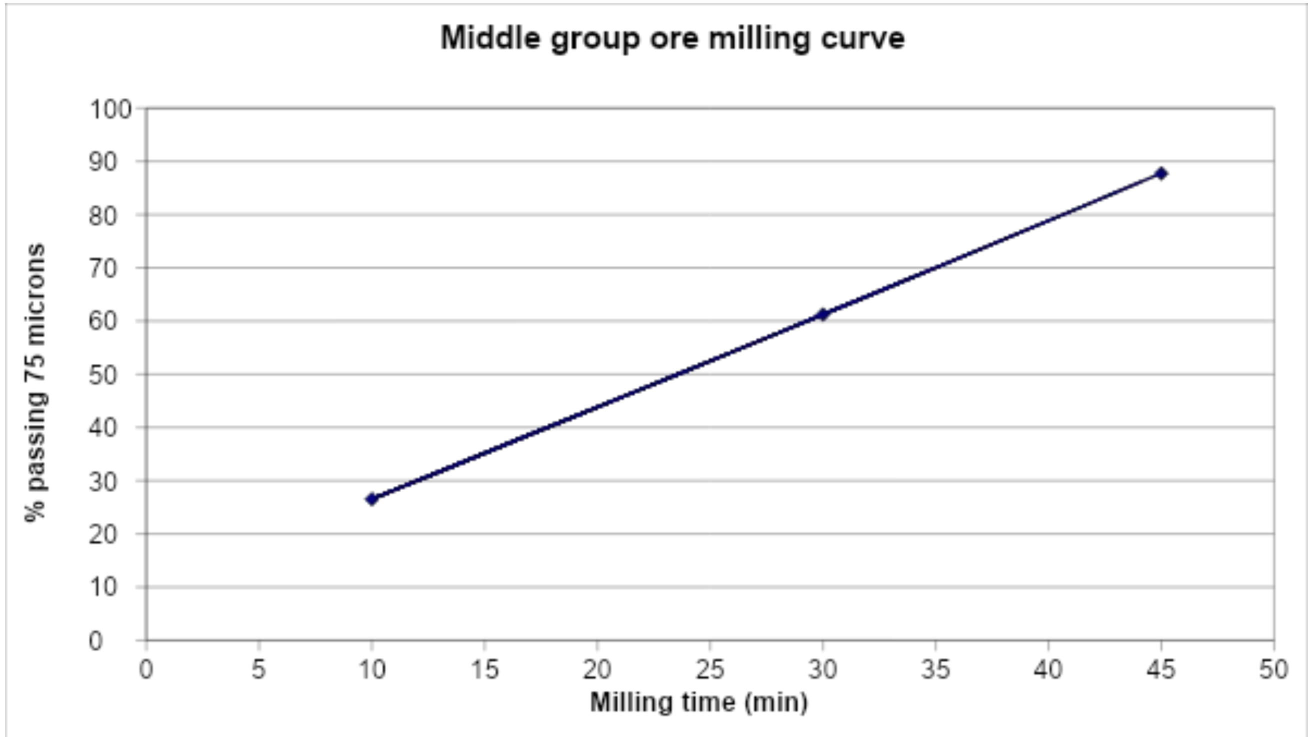

Figure2: Composite milling curve

RESULTS CONT…

Table 1. Head chemical assay results for the major oxides as determined by XRF (%)

Element	Percentage
Al_2O_3	15.88
BaO	<0.02
CaO	2.72
Cr_2O_3	30.32
Fe_2O_3	23.79
K_2O	0.06
MgO	9.76
MnO	0.19
Na_2O	0.44
P_2O_5	0.04
SiO_2	16.28
SO_3	<0.02
TiO_2	0.82
Fe	16.64
Mn	0.15
P_2O_5	0.02
TOTAL	**100**

- **Chromium oxide (Cr_2O_3)** is the most dominant component, accounting for **30.32%**.
- **Iron** is a significant constituent, with **Fe_2O_3 at 23.79%** and a total **Fe content of 16.64%**.
- Other major oxides include **Silicon dioxide at 16.28%**, **Aluminum oxide (Al_2O_3) at 15.88%**, and **Magnesium oxide at 9.76%**.
- Minor elements such as **Calcium oxide at 2.72%** and **Titanium dioxide at 0.82%** are also present.
- Trace amounts (<0.5%) of **Na_2O, K_2O, MnO, P_2O_5, BaO, and SO_3** were detected.

RESULTS CONT…

Table 2. Head 4E (3E + Au)

Ore type	Pt(g/t)	Pd(g/t)	Rh(g/t)	Au (g/t)	3PGE+Au (g/t)	Cr2O3 (%)	Cu (%)	Ni (%)	SiO2 (%)
1:1:1:1 (MG1-4A)	1,13	0,30	0,16	0,004	1,59	32,1	0,002	0,077	21,54

- High Cr_2O_3 necessitates careful circuit design for chromite rejection
- For PGM deportment an understanding mineral associations critical for optimizing recovery
- Silicates and chromite are the dominant gangue minerals driving reagent and process choices
- The flotation strategy is align collector (SNPX), depressant (CMC), and activator (copper sulfate) with mineralogy for improved selectivity and recovery

RESULTS CONT…

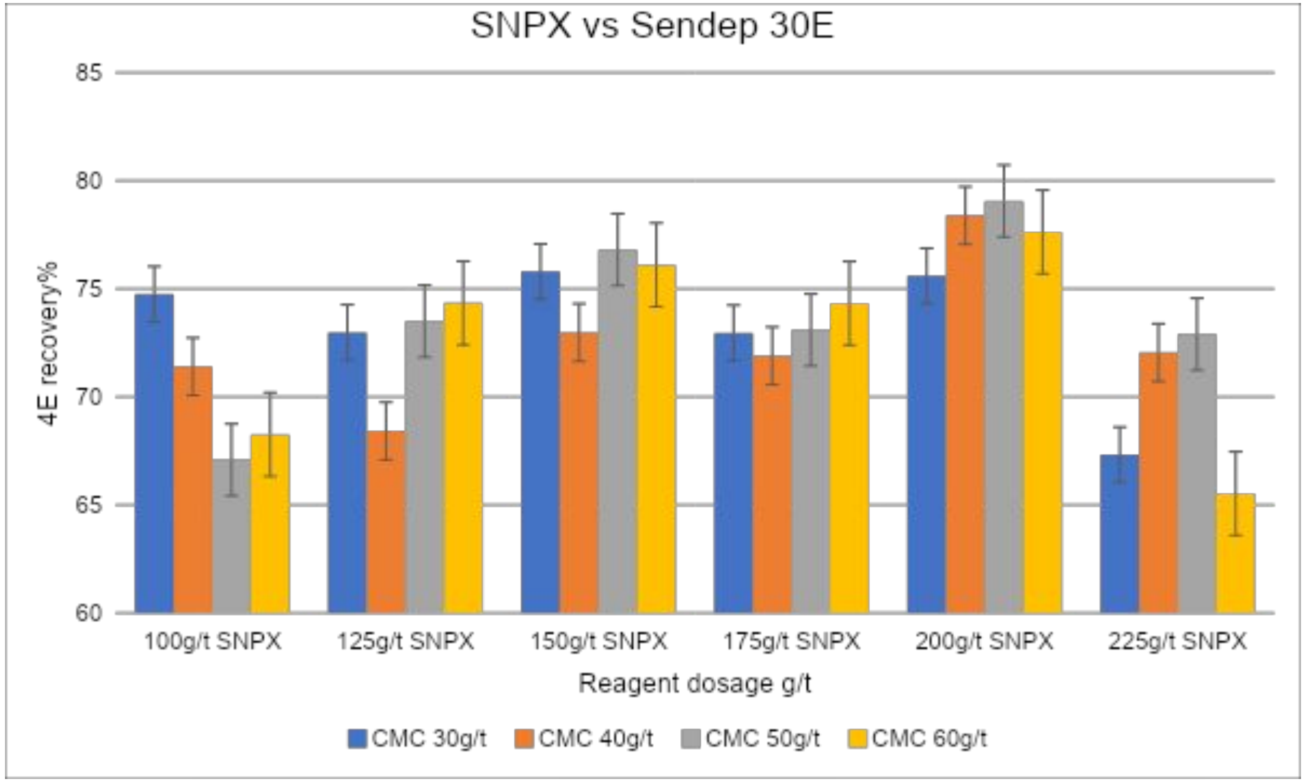

Figure 1 4E (3E + Au) recovery graph

- Optimal regime SNPX 200g/t & CMC 50g/t (79.06)
- SNPX 200g/t shows strong performance across CMC dosages (75.59 - 79.06)
- CMC 50g/t performs well with multiple SNPX dosages
- Performance variability indicates interplay between SNPX and CMC dosages
- SNPX 225g/t generally shows lower recoveries, suggesting potential upper limit for SNPX dosage effectiveness

RESULTS CONT…

Table 2. Bulk modal mineralogy (mass %)

Bulk Modal Mineralogy (Mass %)			
Mineral	**Feed**	**Concentrate**	**Tailings**
Pentlandite	0.3	2.1	0.5
Millerite	0.1	0.9	0.2
Pyrite	0.7	2.4	0.3
Pyrrhotite	0.8	2.7	0.5
Chalcopyrite	0.1	0.3	0.0
Pyroxene	15.9	43.4	30.3
Plagioclase	8.6	3.8	12.8
Chromite	74.4	19.3	56.1
Olivine	0.3	0.1	0.1
Talc	0.0	0.2	0.0
Amphibole	0.1	2.6	0.1
Mica	0.0	0.1	0.1
Quartz	0.2	0.3	0.3
Calcite	0.0	0.0	0.0
Rutile	0.0	0.0	0.0
Prehnite	0.3	0.0	0.0
Kaolinite	0.0	0.0	0.0
*Other	0.2	0.3	0.1
Total	**100.0**	**100.0**	**100.0**

- PGM sulfide association observed, with traces lost to tailings
- Unexpected high concentration of Pyroxene in concentrate suggests reagent suite optimization opportunity
- Effective Chrome rejection under current flotation conditions (depleted in concentrate)
- Amphibole floats with pyroxene, contributing to gangue in concentrate
- Flotation selectivity indicates areas for improvement to enhance PGM grade/recovery vs. gangue minerals

DISCUSSION & CONCLUSIONS

- Optimal reagent dosage is 200 g/t SIBX and 50 g/t Sendep 30E
- Highest 4E (3E + Au) recovery achieved was 79.06%
- Higher recovery leads to concentrate grade dilution
- Pyroxene enrichment from the feed (15.9%) to concentrate (43.4%)
- Amphibole floatability contributes to gangue material in the concentrate

END
Any questions?