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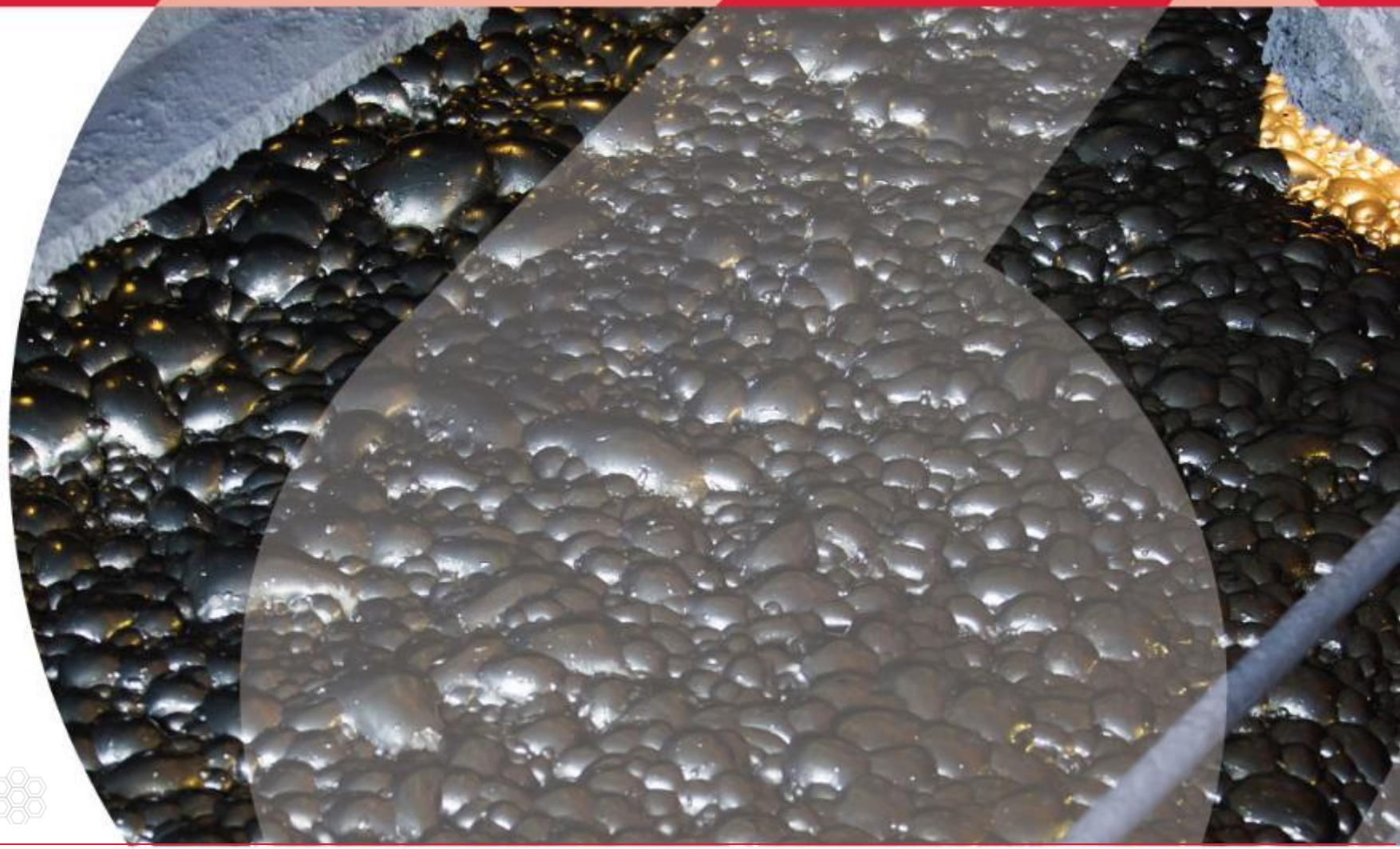

TRANSFORMING PGM TAILINGS INTO VALUABLE RESOURCES FOR A CLEANER WORLD

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AECI® MINING CHEMICALS

OUTLINE

- BACKGROUND
- OBJECTIVES
- FACTORS INFLUENCING VALUABLE MINERALS REJECTION TO TAILINGS
- FLOTATION CHALLENGES
- RESULTS
- CONCLUSIONS

BACKGROUND

Literature Insights

Tailings Retreatment: Unlocking Critical Mineral Value

- **Tailings represent untapped secondary sources** of *Platinum Group Elements (PGEs)* and *Base Metal Sulphides (BMS)*, offering a sustainable route to recover critical minerals from discarded material
- **PGEs are vital** for *emission reduction* (catalytic converters) and *clean energy technologies* (hydrogen fuel cells)

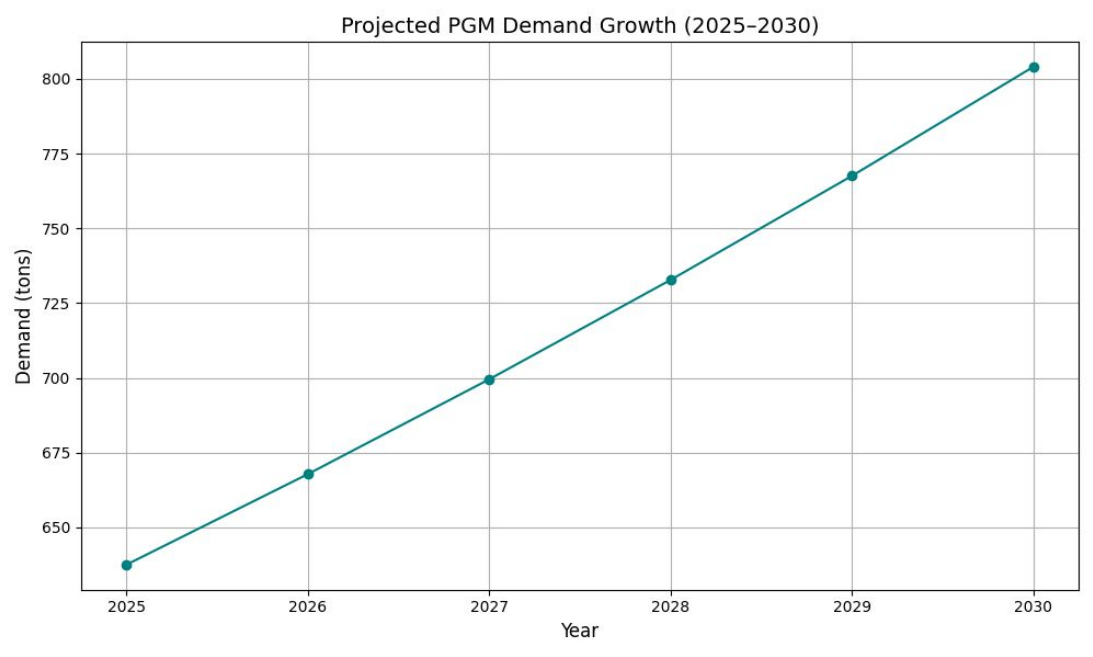
South Africa, holding **~80% of global PGM reserves**, is **strategically positioned** to benefit from surging global demand — projected to reach **350,000 oz by 2030**

This study investigates how tailored *flotation reagents* can improve PGE and BMS recovery from tailings, advancing **resource efficiency** and **sustainability**

It also **highlights the difficulties** in treating these ore sources

BACKGROUND

PGM Demand Insights



Starting demand: 637.51 tons in 2025
Projected demand: 805.16 tons by 2030
Compound Annual Growth Rate (CAGR): 4.75%
Fastest Growing market: Asia Pacific
Largest Market: Asia Pacific
Market Concentration: High
Major Players:

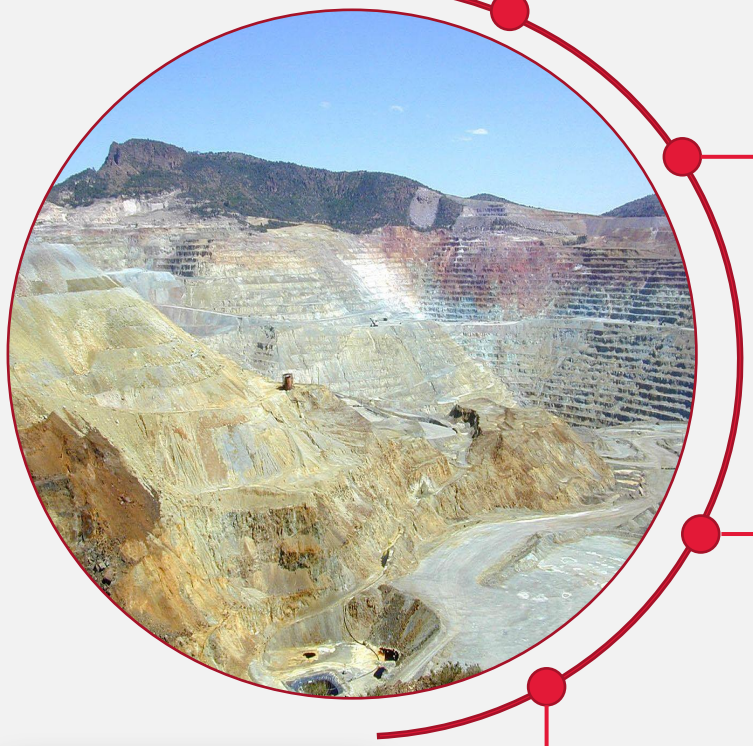
Sibanye Stillwater, IMPLATS EXCELLENCE IN PGMs, JM Johnson Matthey, AngloAmerican, Valterra PLATINUM

Market Highlights (2024–2030)

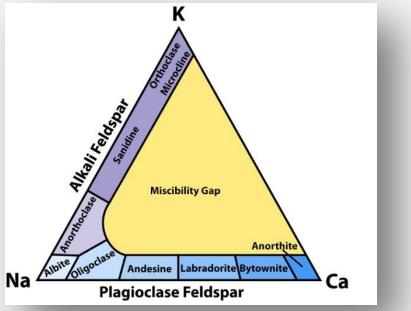
- **Metal Type:** Palladium leads with **47% revenue share**; Iridium to grow fastest (**+9.0% CAGR**)
- **Application:** Jewelry dominates (**29% share**); Fuel cells rising rapidly (**+29.7% CAGR**)
- **Source:** Primary mining contributes **72% of volume**; Secondary recycling growing fastest (**+7.2% CAGR**)
- **End-Use Industry:** Automotive leads (**60% share**); Renewable & hydrogen applications expanding (**+9.5% CAGR**)
- **Geography:** Asia holds **52% of market**; growth expected at **+5.1% CAGR**

Source: Mordor Intelligence – Platinum Group Metals Market Analysis (2025–2030), https://www.mordorintelligence.com/industry-reports/platinum-group-metals-market [Platinum G...telligence]

ORE BACKGROUND



1. Ore is from a Platreef low-grade tailings
2. The bulk tailing materials deposited in dams or impoundments may have significant mineralogical variations
3. The Platreef tailing streams are predominantly silicate gangues – pyroxenes and plagioclases
4. Assay Head : ~0.68 g/t 4E PGM ~0.02 % Cu and ~0.09% Ni



STUDY OBJECTIVES

Guiding study toward reagent optimization and enhanced resource efficiency

Objective 1: *Quantify achievable recoveries and grades*

- 4E PGMs (Pt, Pd, Rh, Au), Ni, Cu
- *No targets specified*

In most real-world cases, **4E PGM recoveries above 55–60%** are needed to make tailings reprocessing economically sustainable, **unless grades are high (>1.5 g/t)** or power/reagent costs are unusually low

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Objective 2: *Recommend optimal reagent regime*

- Maximize PGM & base metal concentrate grade and recovery

This is a **BIG** ask!

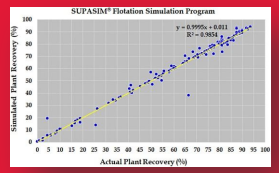
FACTORS INFLUENCING VALUABLE MINERALS REJECTION TO TAILINGS

Partial value mineral liberation

- Most of the valuable PGM and BMS minerals in the ore remain partially liberated, occurring mainly in the middling and fines fractions, often attached to or enclosed within silicate and oxide minerals

Plant operational stability

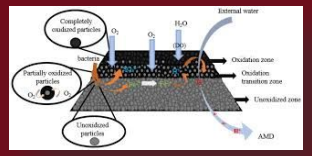
- Flotation inefficiencies and plant instability can cause value losses
- Ore variability affects the concentrator throughput & flotation response



Valuable Minerals

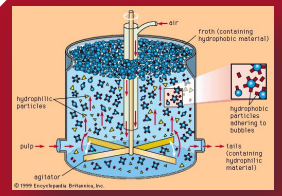
Surface passivation

- Mineral surface oxidation impairs metallurgical performance



Slow floating minerals

- Slow floating valuable minerals (i.e. PGE-alloys and PGE arsenide's) are known to have slower flotation kinetics subsequently are more likely to report to the tailings



FLOTATION CHALLENGES

1

Particles Size

- Fine particles have difficulty attaching to air bubbles, resulting in poor recovery
- Coarse particles tend to report to the tailings, as they are too heavy to remain attached to air bubbles

2

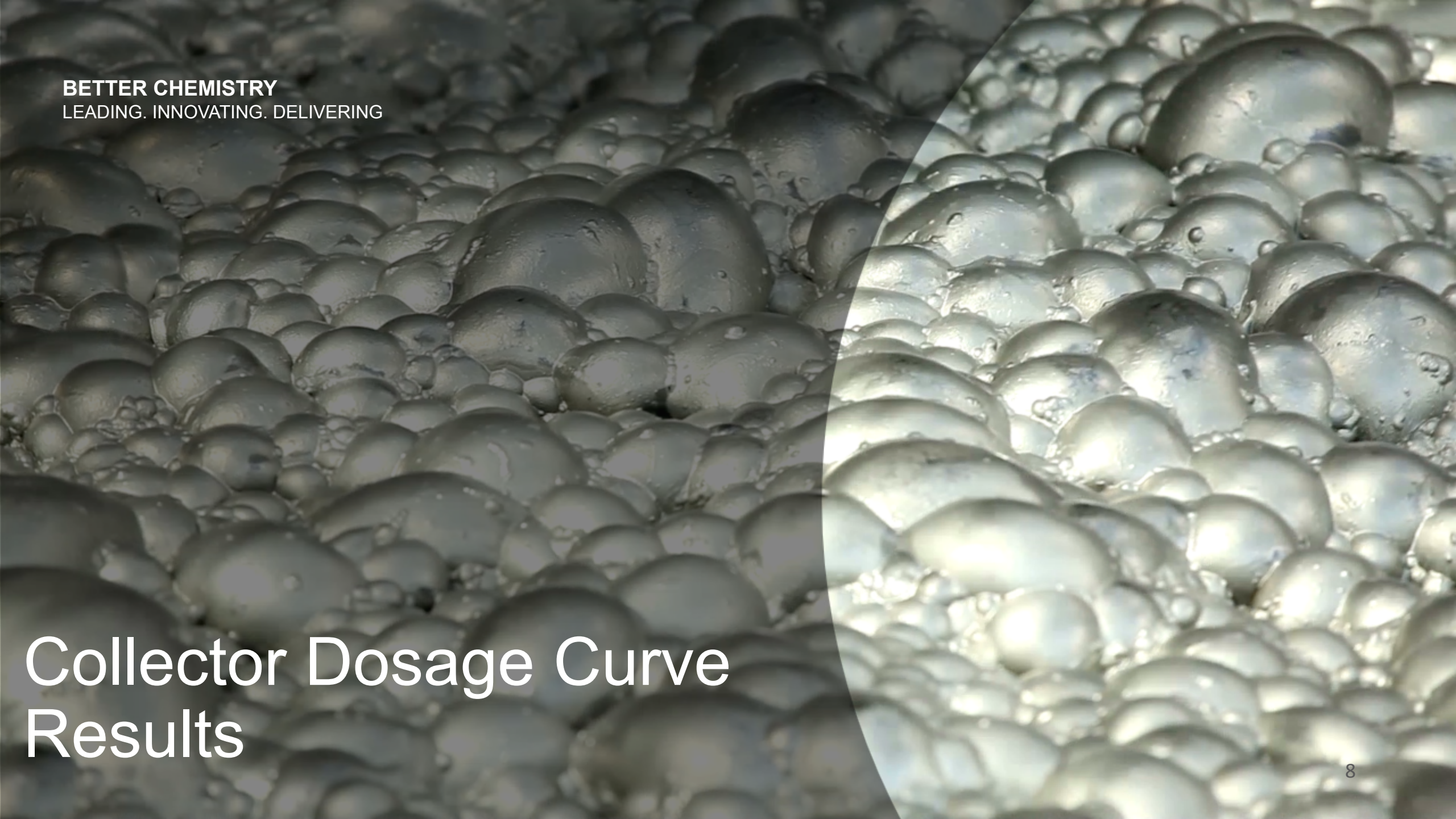
Reagents Impact

- A large amount of flotation reagents is needed to treat fine particles
- Residual reagents may interfere with the flotation efficiency

3

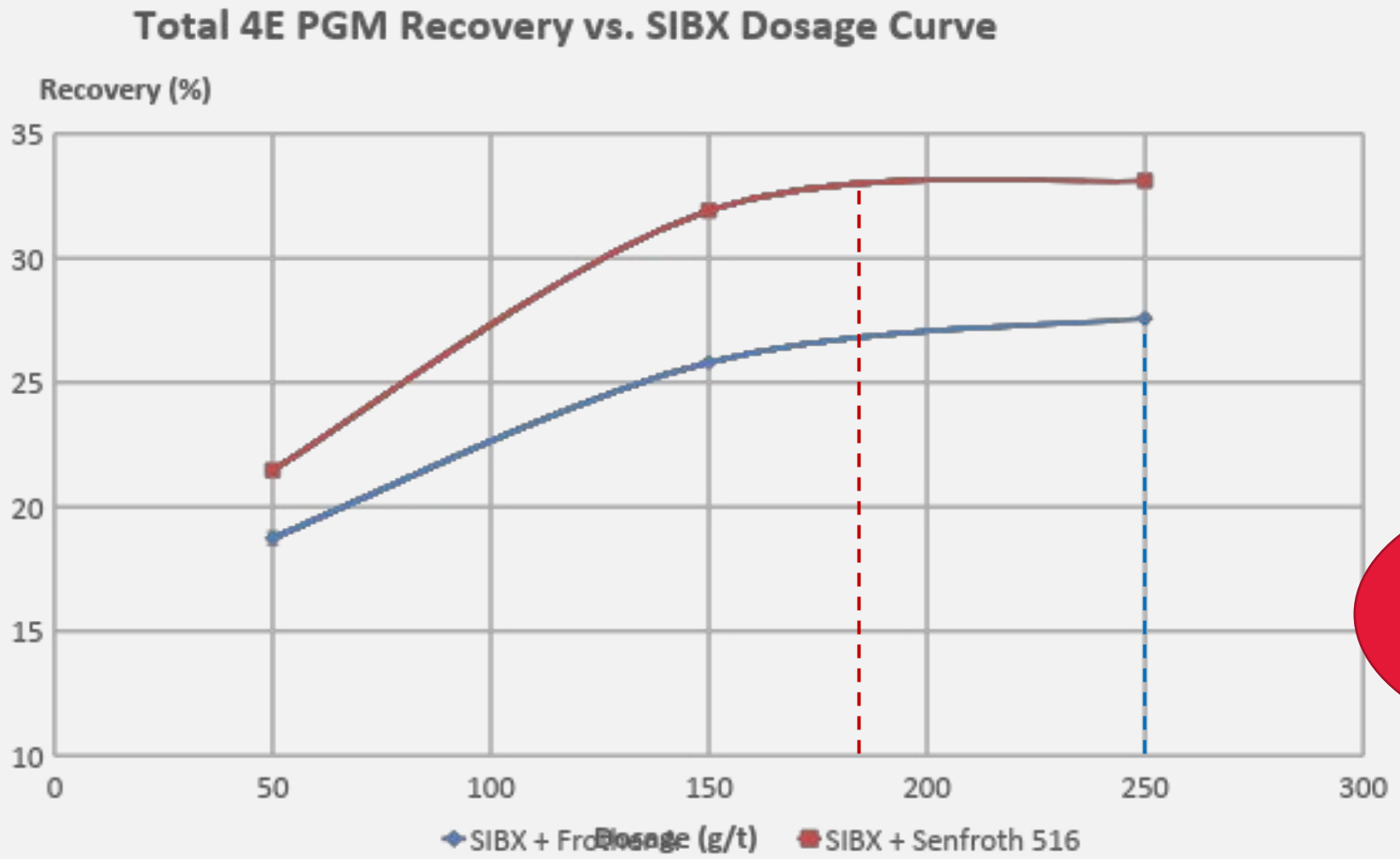
Quality of the Feed

- Tailings re-treatment has challenges in the feed grade and consistency resulting in low recovery & concentrate grade

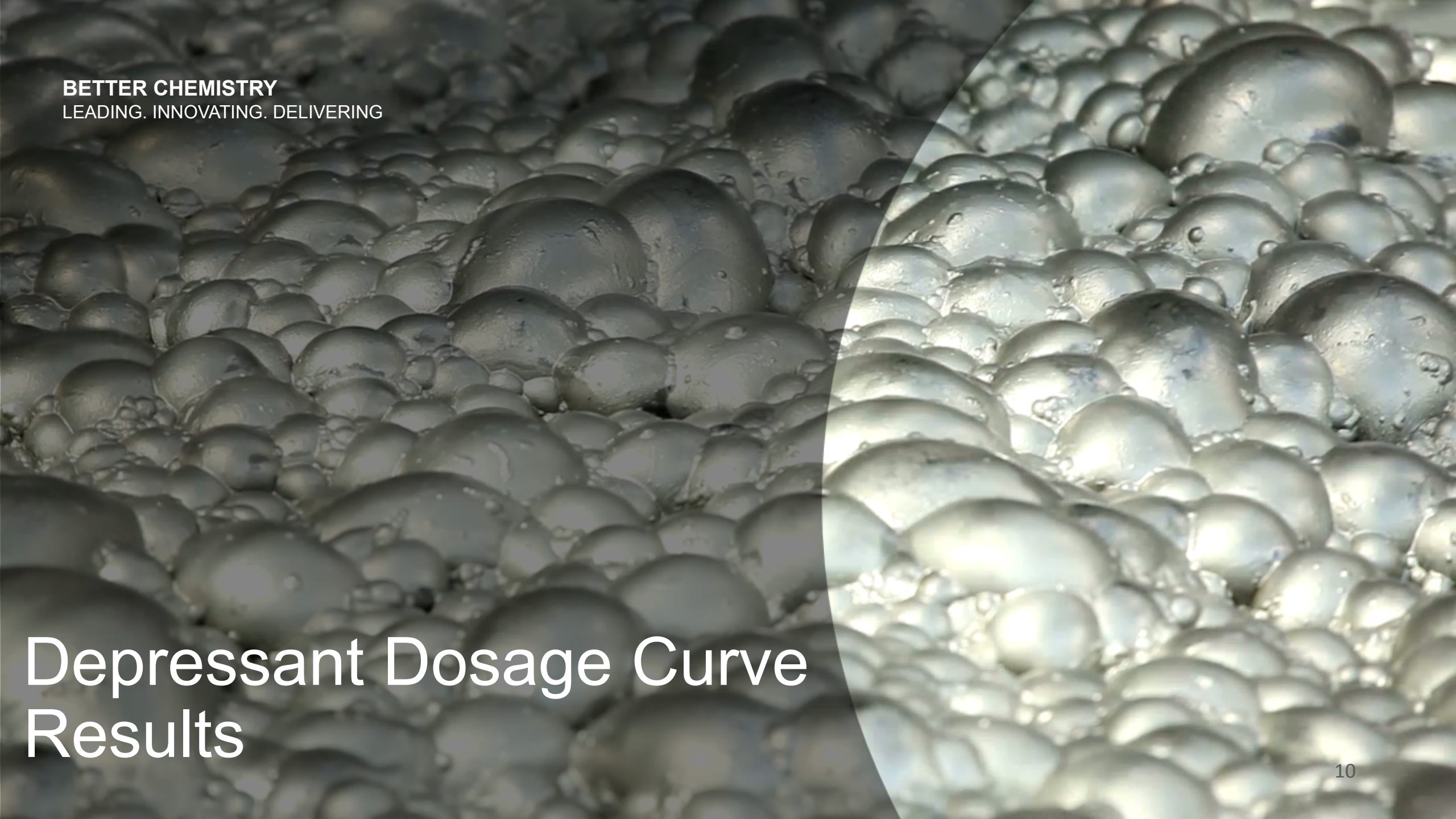


Collector Dosage Curve Results

COLLECTOR DOSAGE CURVES

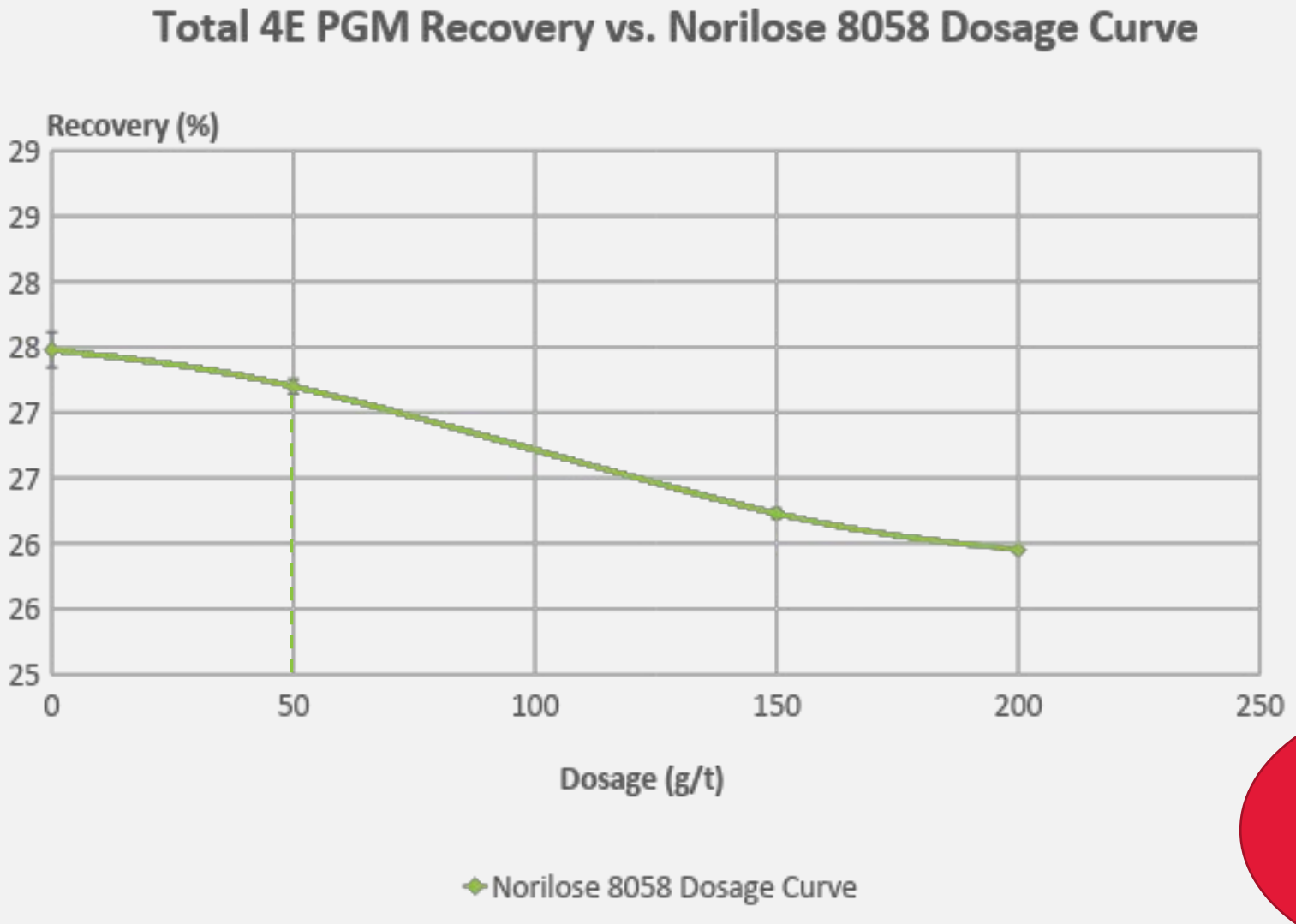


Collector – Frother Synergy

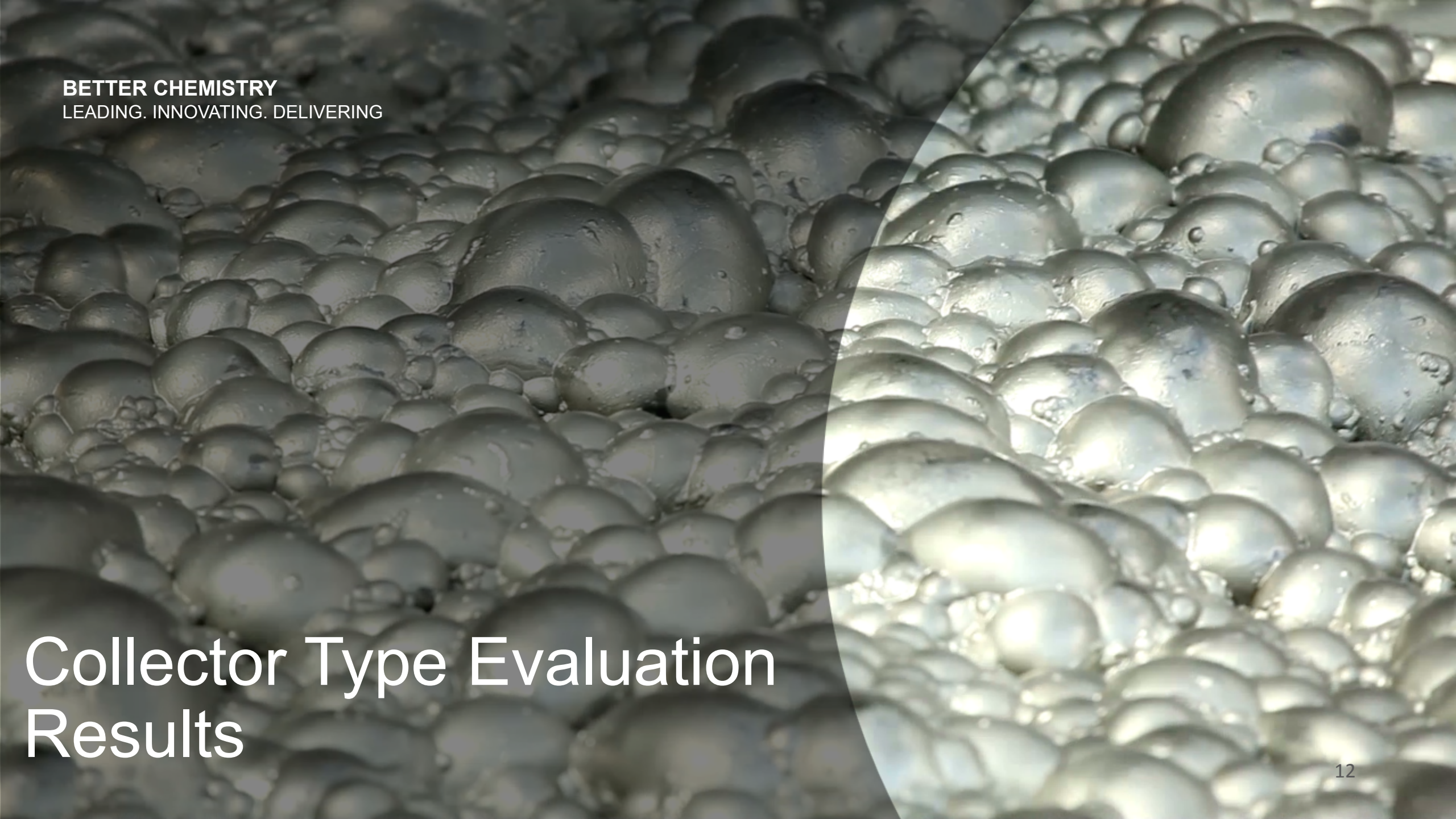


Depressant Dosage Curve Results

DEPRESSANT DOSAGE CURVE



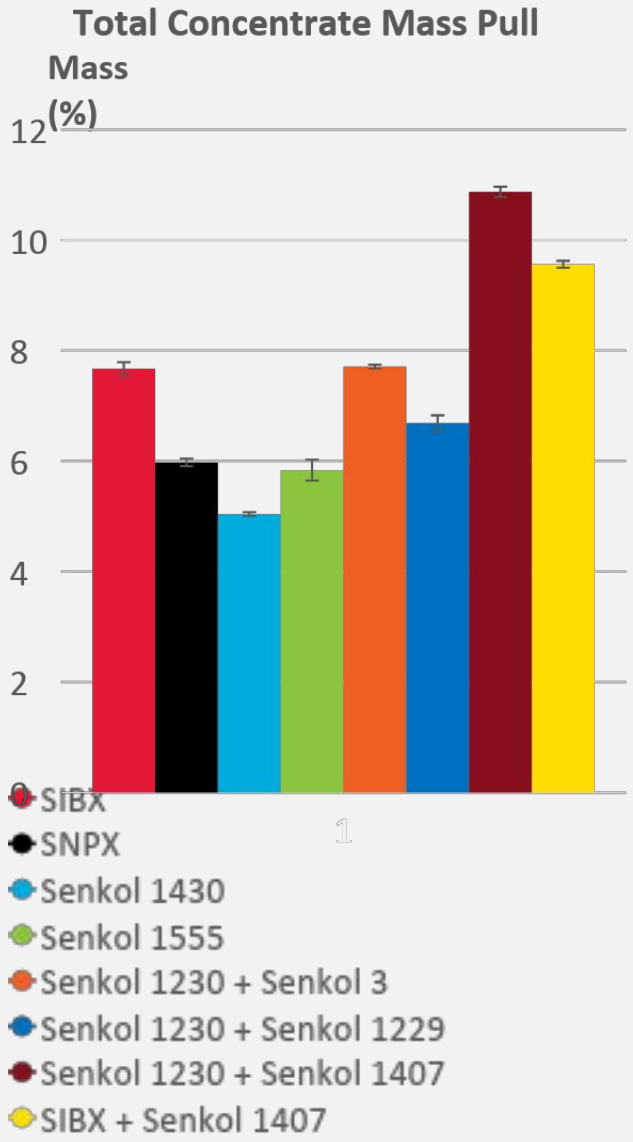
50 g/t is the optimal Norilose 8058 dosage

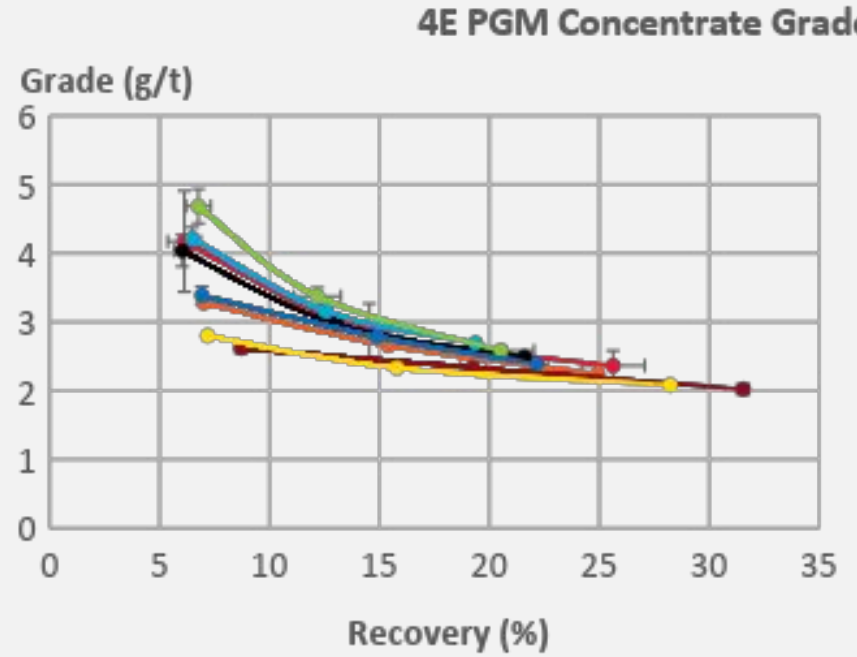


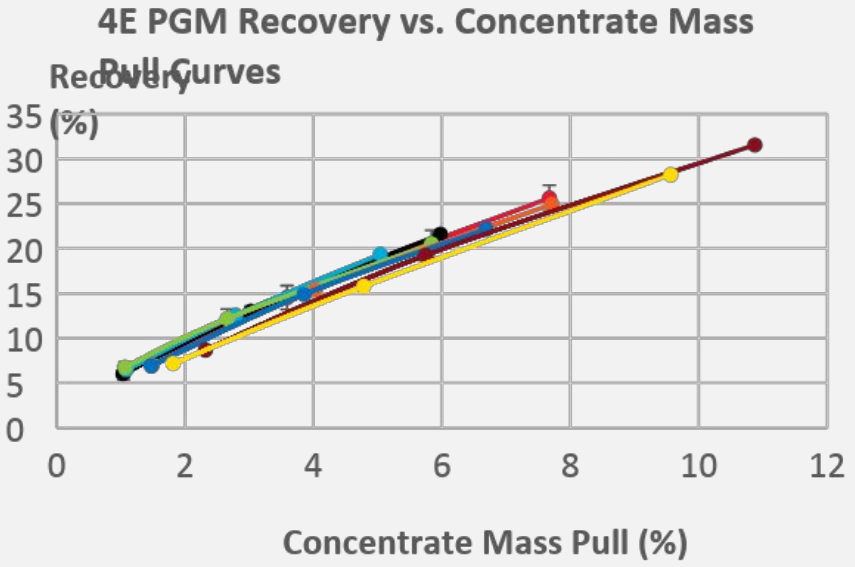
Collector Type Evaluation Results

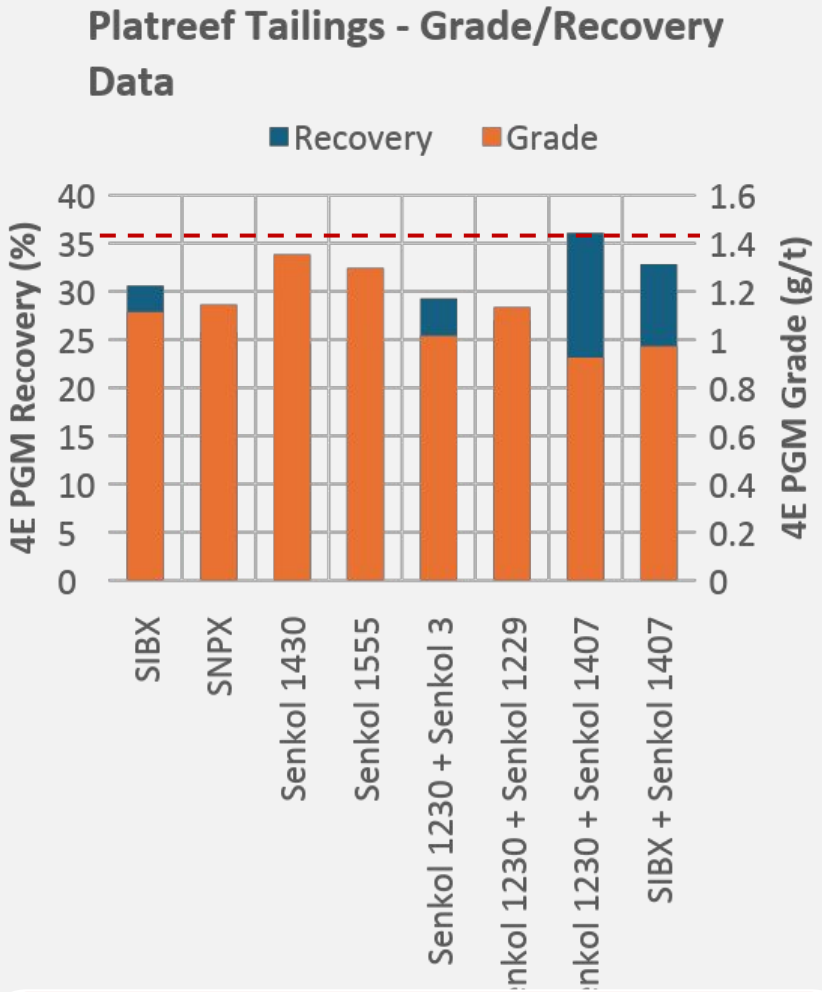
COLLECTOR EVALUATION – PLATREEF TAILINGS

Head Grade
0.68g/t 4E PGM, 0.02% Cu, 0.09% Ni





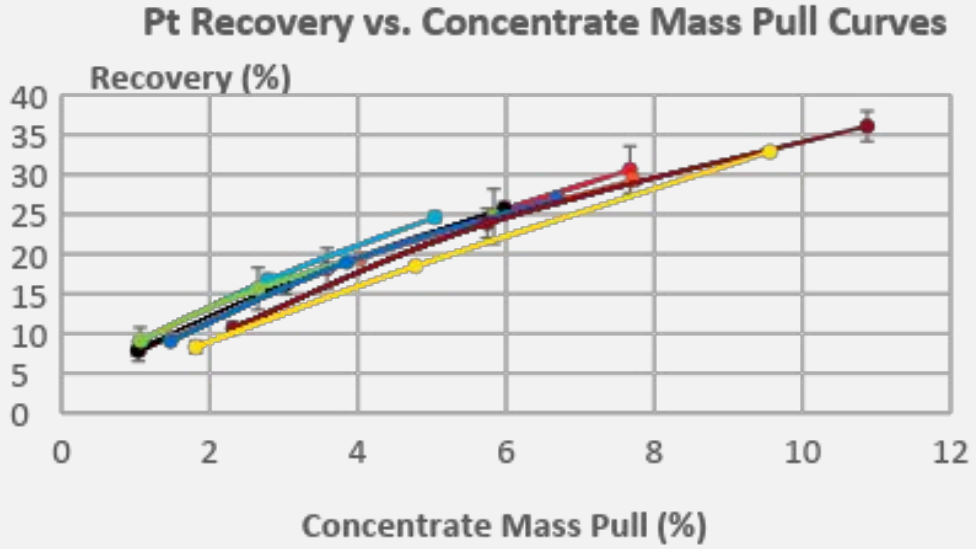


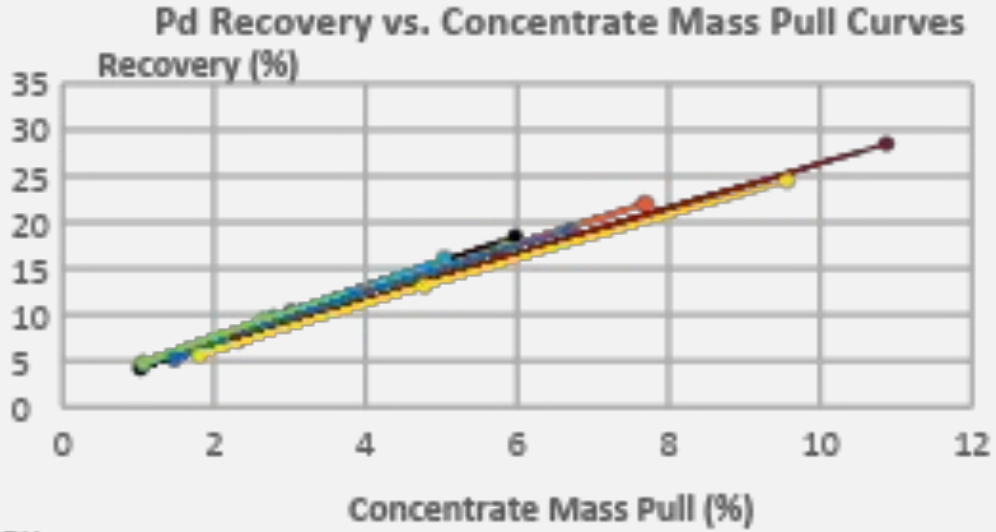


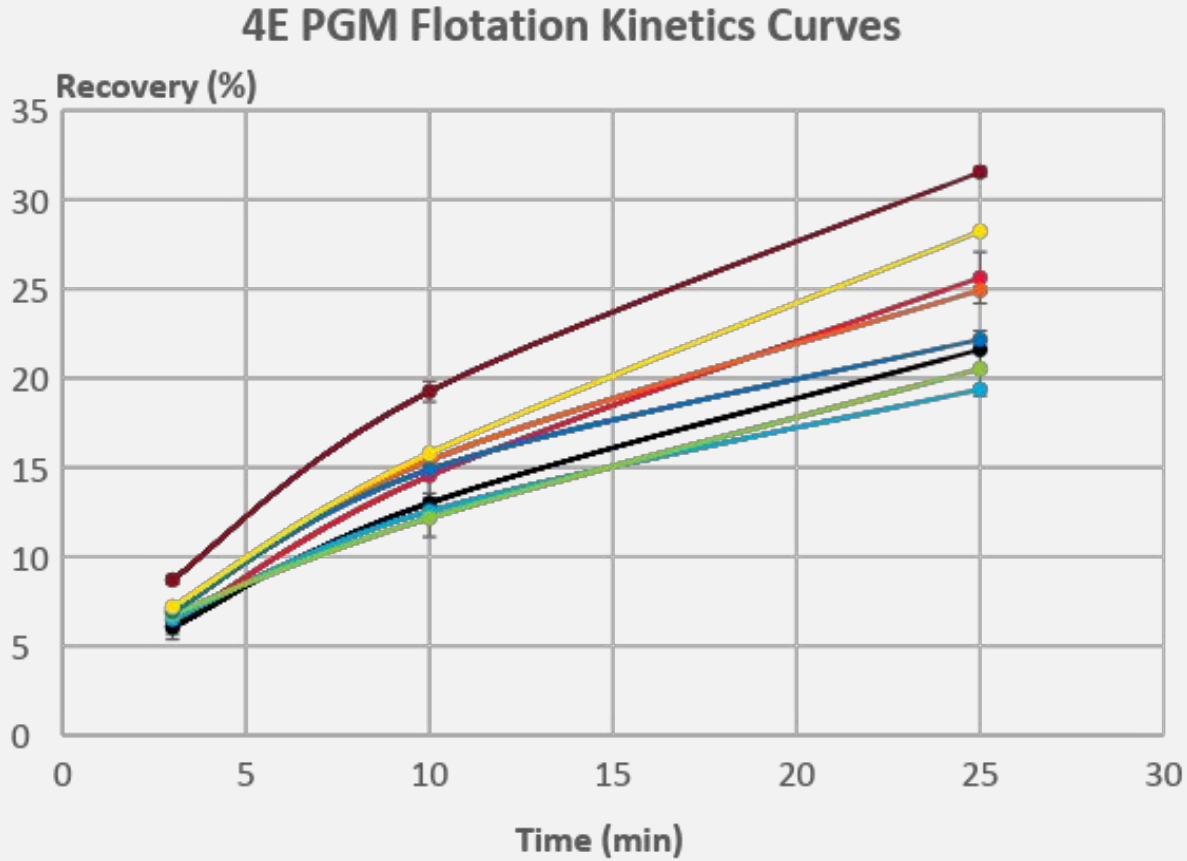
Mineralogy data suggests ultra fine grinding would be necessary - ~ 26% overall liberation for PGM & BMS

COLLECTOR EVALUATION – PLATREEF TAILINGS

Results – Senkol 1430 gave a slightly higher Pt recovery per corresponding concentrate mass pull

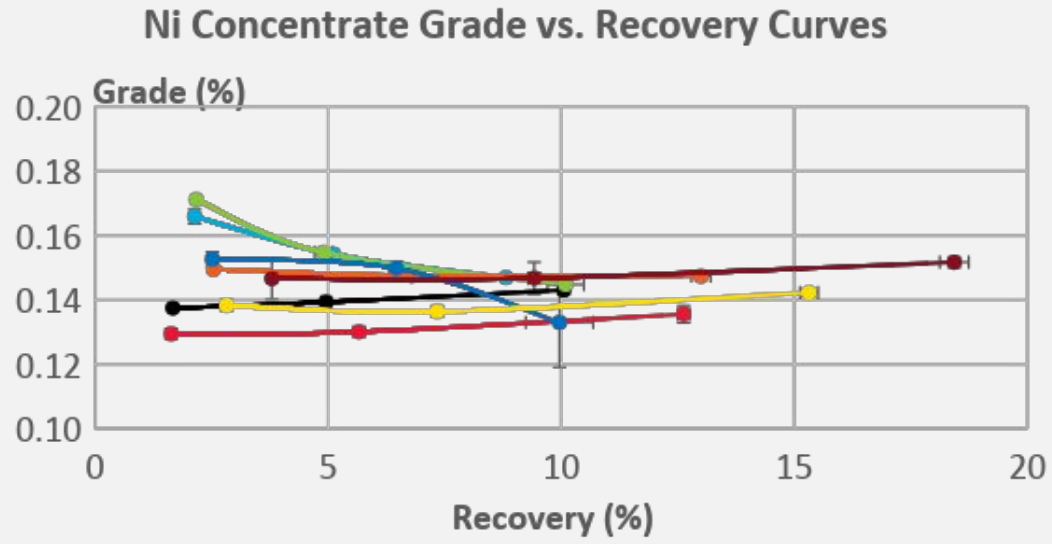


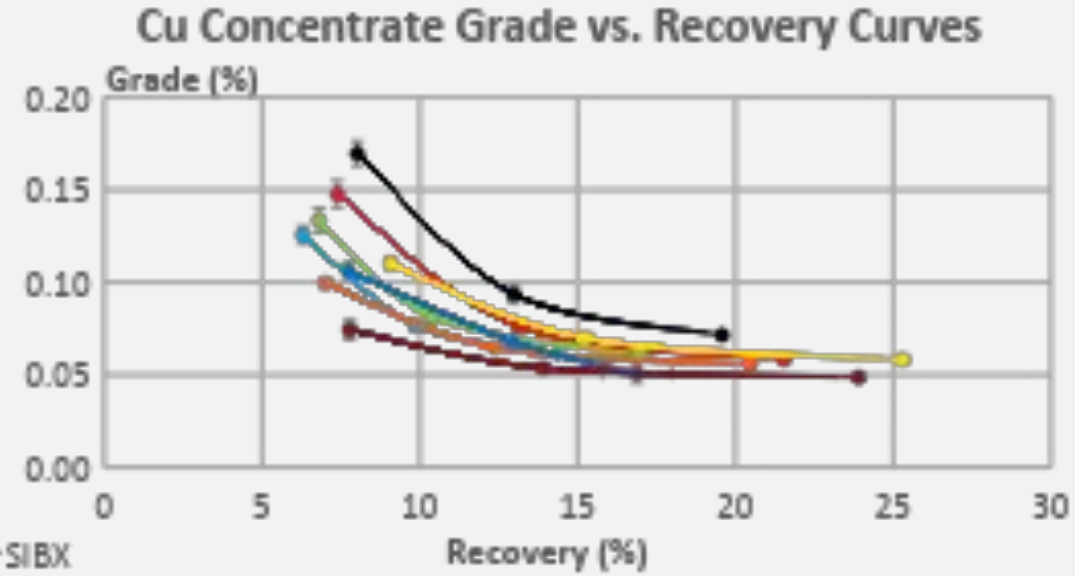


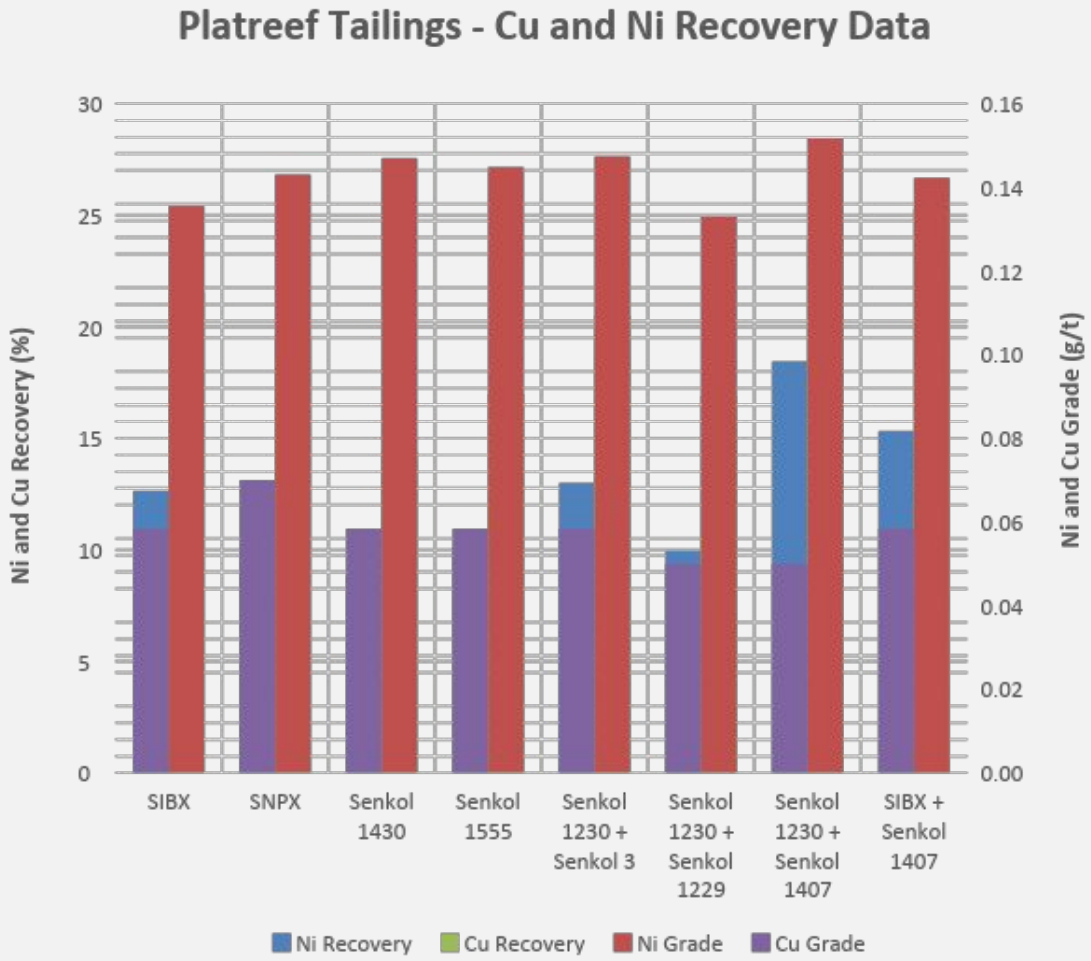


SIBX
SNPX
Senkol 1430
Senkol 1430+Senkol 1207

COLLECTOR EVALUATION – PLATREEF TAILINGS





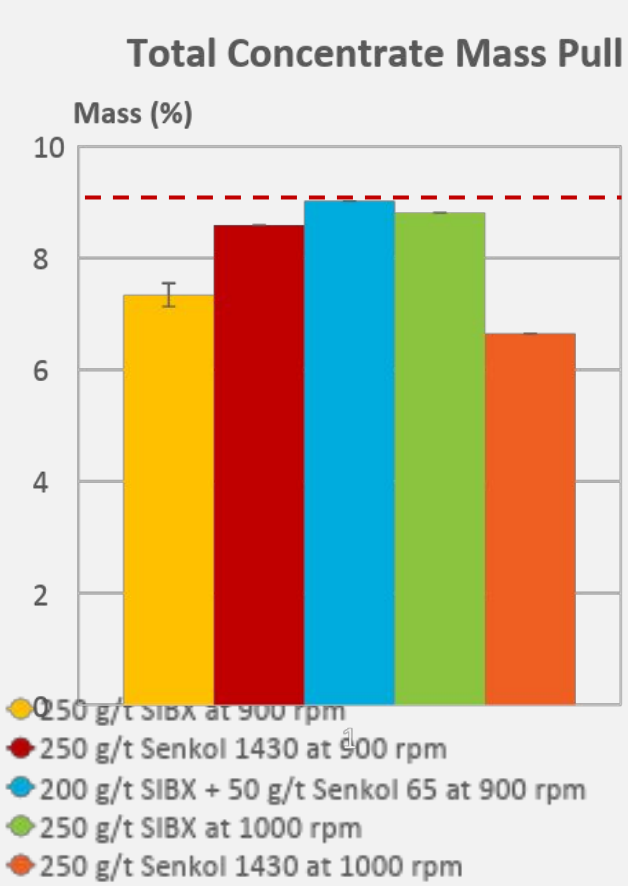


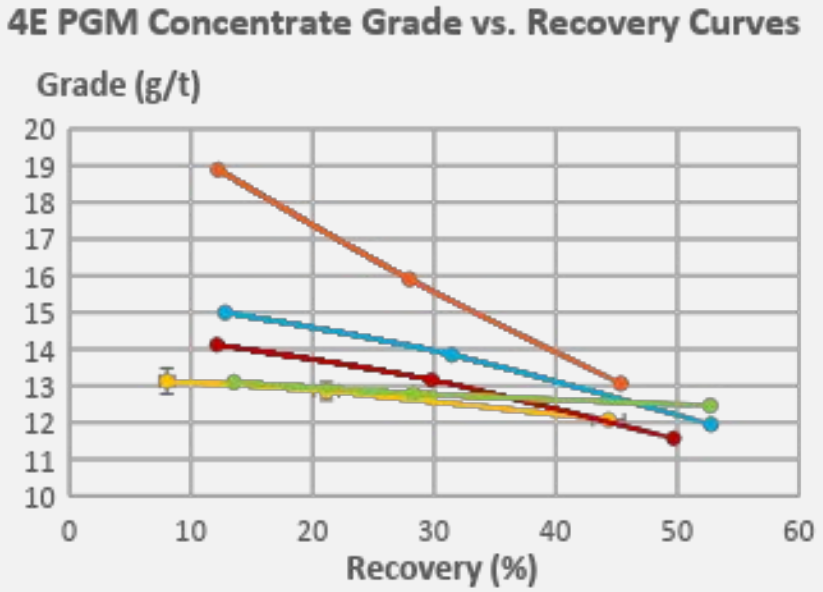
Senkol 1230 + Senkol 1407 gave a higher overall 4E PGM recovery

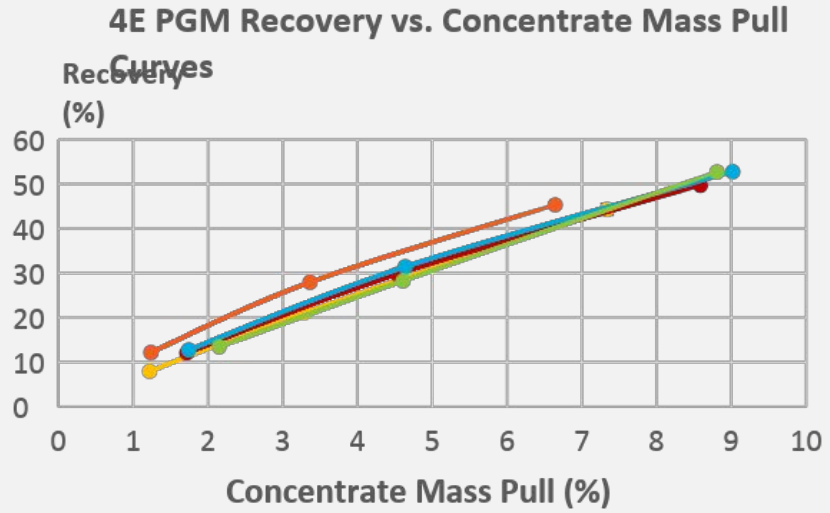
COLLECTOR EVALUATION – UG2 CHROMITE TAILINGS

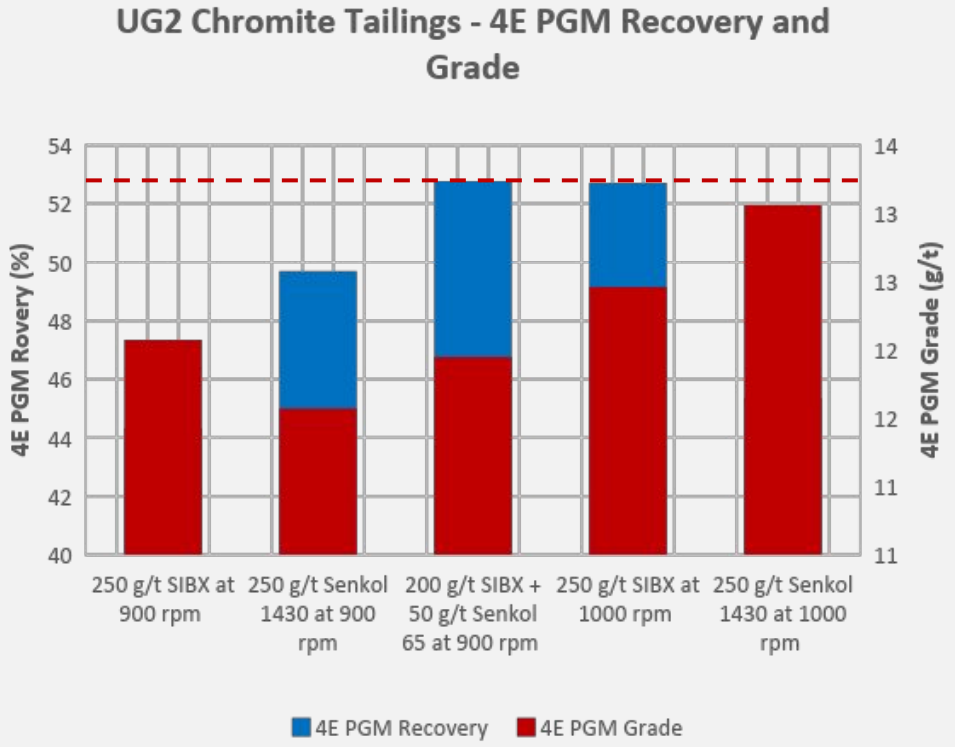
Head Grade 2.5 - 4g/t 4E PGM

Rougher expected 75-80% 4E PGM Recovery, Mass Pull target >/=14%









Results – Senkol 1430 initially gave a significantly higher 4E PGM concentrate grade, and overall 4E PGM recovery per corresponding concentrate mass pull

CONCLUSIONS - COLLECTOR DOSAGE CURVE

❖ Frother Performance Comparison

Senfroth 516 demonstrated a **superior flotation response** compared to **standard Frother A**, resulting in a **higher cumulative recovery of 4E PGM**

Collector-Frother Synergy - Lower collector (SIBX) dosage with **Senfroth 516**

❖ Implication

This indicates that **frother selection** plays a critical role in optimizing flotation performance and maximizing PGM recovery

❖ Recommendation

Consider **Senfroth 516** as a preferred frother in future flotation circuit designs or process optimizations

CONCLUSIONS – PLATREEF TAILINGS

Recovery Efficiency Insight

The total **4E PGM and Ni recoveries** were partially influenced by the **concentrate mass pull**

Mineralogy indicated the **ultra fine grinding** would be necessary

Implication

This highlights a **process-driven recovery mechanism**, suggesting that **optimizing concentrate mass pull in conjunction with flotation reagents** are important factors to be optimised, however the mineralogy is the overriding factor

Strategic Focus

Future metallurgical improvements should prioritize **mass pull control** and flotation reagent optimisation to enhance recovery outcomes at acceptable concentrate grades

CONCLUSIONS – CHROMITE TAILINGS

Recovery Efficiency Insight

Energy input played a role in the 4E PGM recovery for the Chromite tailings and highlights that it is necessary to achieve a balance

Impeller Speed	*Effect on PGM Recovery*	*Effect on Chromite Entrainment*
Low	Poor bubble-particle contact	Low entrainment and thus low recovery
Moderate	Optimal recovery and selectivity	Balanced entrainment
High	High turbulence, possible detachment	Increased chromite entrainment

Selectivity vs. Recovery Trade-off

Higher impeller speed boosts PGM recovery - But increases **chromite entrainment**

Lower speed improves concentrate grade - But may reduce **PGM recovery**

Optimal speed balances recovery and selectivity

STRATEGIC INSIGHTS FOR ENHANCING PGM RECOVERY AND SUSTAINABILITY

Unlocking Value from Process Optimization, Frother Selection, and Secondary Resource Recovery

Strategic Imperative

The global push for **net-zero emissions** and the **irreplaceable role of PGEs** in key technologies underscore the urgency of expanding recovery efforts beyond primary sources

Opportunity in Waste Streams

Flotation tailings, **legacy dormant tailings**, and **mineral waste rock dumps** represent **untapped resources** that can immediately support the critical mineral supply chain

Call to Action

Integrating **secondary recovery strategies** into existing operations is essential to meet sustainability goals and secure future PGE availability

Acknowledgements

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