

Formulation and Plant Trial of a Mixed Collector Suite for Eland Platinum

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Summary



- Mixed Collector Theory
 - Reviewed across 50 years of publications
 - Consolidated and updated [Lotter and Bradshaw, 2009, 2010]
 - New improved model proposed
- Eland Platinum engaged this model
 - Baseline SIBX as single collector
 - New Mixed Collector Exp 820 tested
 - Demonstrated Performance Gains at Lab Scale
 - **2.1% PGE recovery gain**
 - Demonstrated Performance Gains at Plant Scale
 - **2.48% PGE recovery**
 - **16% relative concentrate grade**

Mixed Collectors – an Updated Platform

Sulphide Flotation:-

- Has used mixed collectors widely but seldom optimally
 - Historic practice has a variable track record
- Review in 2009 summarised 50 years of research
- Authors wanted to advance the practice to a more predictive form [Lotter and Bradshaw, 2009 and 2010]
 - New structure proposed
 - Eland Platinum engaged this theory in a project



The formulation and use of mixed collectors in sulphide flotation

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Mixed Collectors – the Benefits

Typical Outcomes:-

- Improved concentrate grade [15-25% relative]
 - [Glembotskii, 1958; Bradshaw, 1997; Lotter and Bradshaw, 2011]
- Improved overall performance / A better grade/recovery curve [generally 2-5% more paymetals recovery]
 - [Deng et al., 2010; Lotter and Bradshaw, 2011]

*Synergy from
Interactions*

Mixed Collectors – How..

Reported Mechanisms:-

- Improved flotation rate
 - [Plaskin, 1954; Adkins and Pearse, 1992]
- Improved coarse particle recovery
 - [Plaskin, 1954]
- Lower collector dosage requirement
 - [Plaskin, 1954; Bradshaw, 1997]
- Best results from an optimised ratio
 - [Critchley and Riaz, 1991; Valdiviezo and Oliveira, 1993; Mingione, 1984; Bradshaw, 1997; Lotter and Bradshaw, 2009; Deng, 2010]
- Less entrainment from improved froth structure
 - [Bradshaw et al., 1998]

Mixed Collectors – the Modern Structure

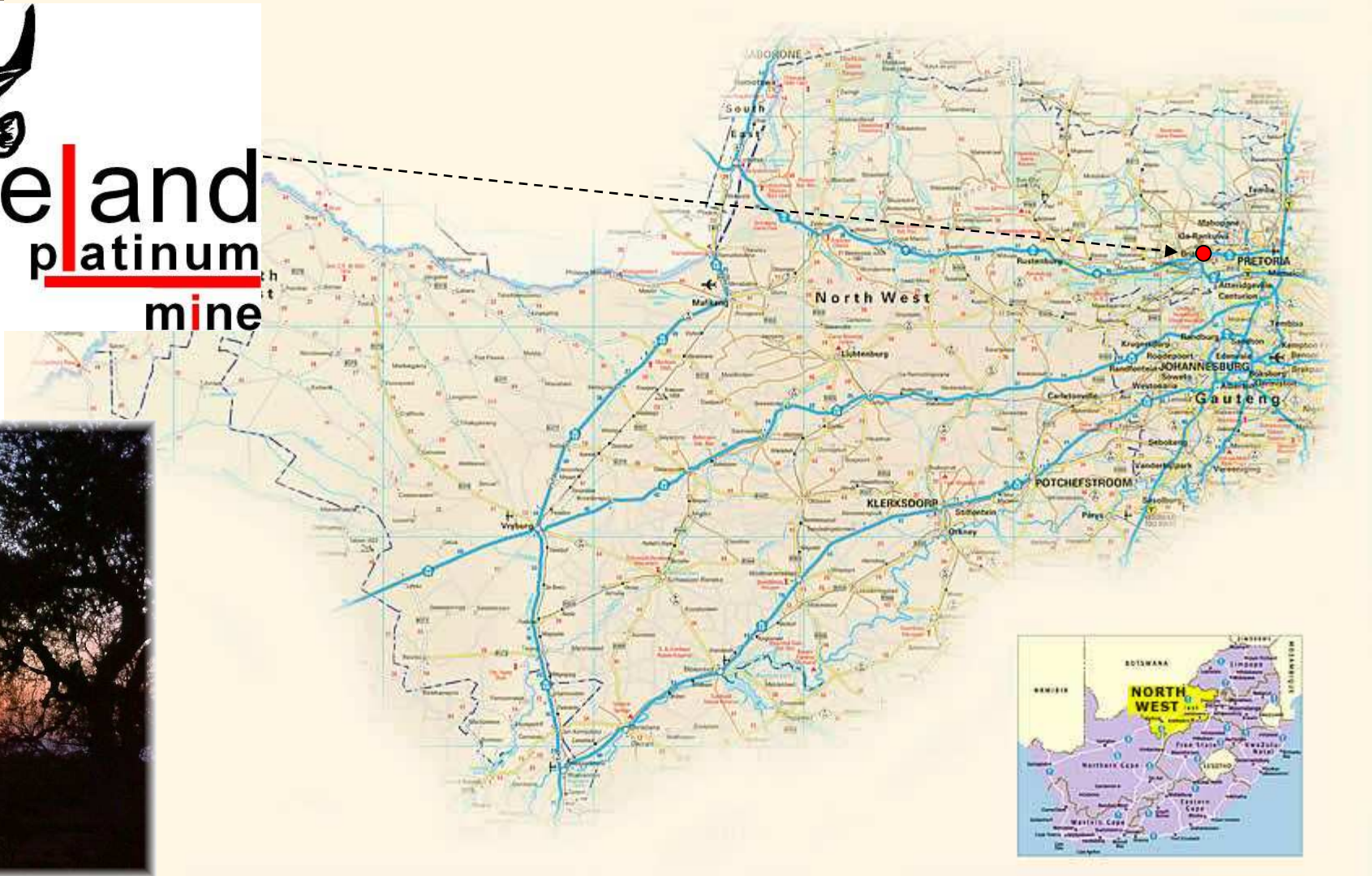
[Lotter and Bradshaw, 2009 and 2010]



Optimised mixed collectors best formulated by:-

- Mineralogy
 - What minerals are present, and what we want to float
- Electrochemistry
 - How these minerals react with collectors and and float
- Organic Chemistry
 - Best selection of functional groups, chain lengths and structures
- Reagent Sudoku
 - An expert system using 6-7 rules
- Factorial Design and Flotation Testing
 - Accurately identifies and quantifies main effects and interactions
- Plant Trial
 - Demonstrates the gains

Eland Platinum – the Opportunity



Eland Platinum – the Opportunity



- Commissioned Nov 2007
- Standard Design
- Commissioned on SNPX, changed to SIBX 2008

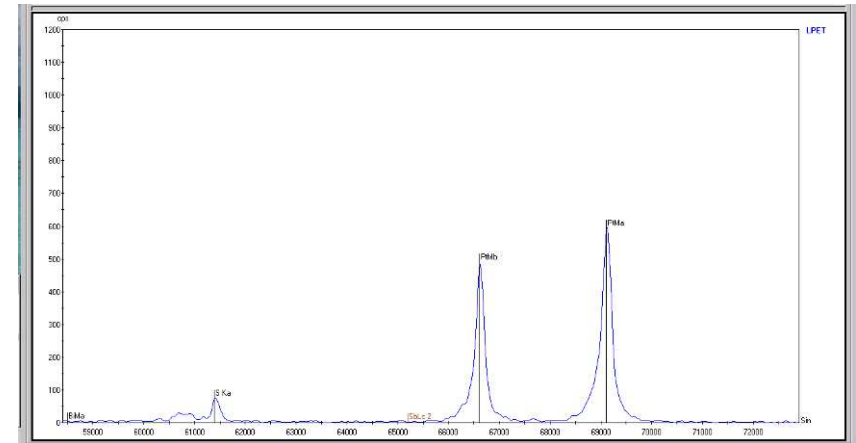


Geology

Understand the Orebody



Mineralogy - West Pit



EPMA - Characterise
Mineral Compositions



Mineral Compositions – West Pit

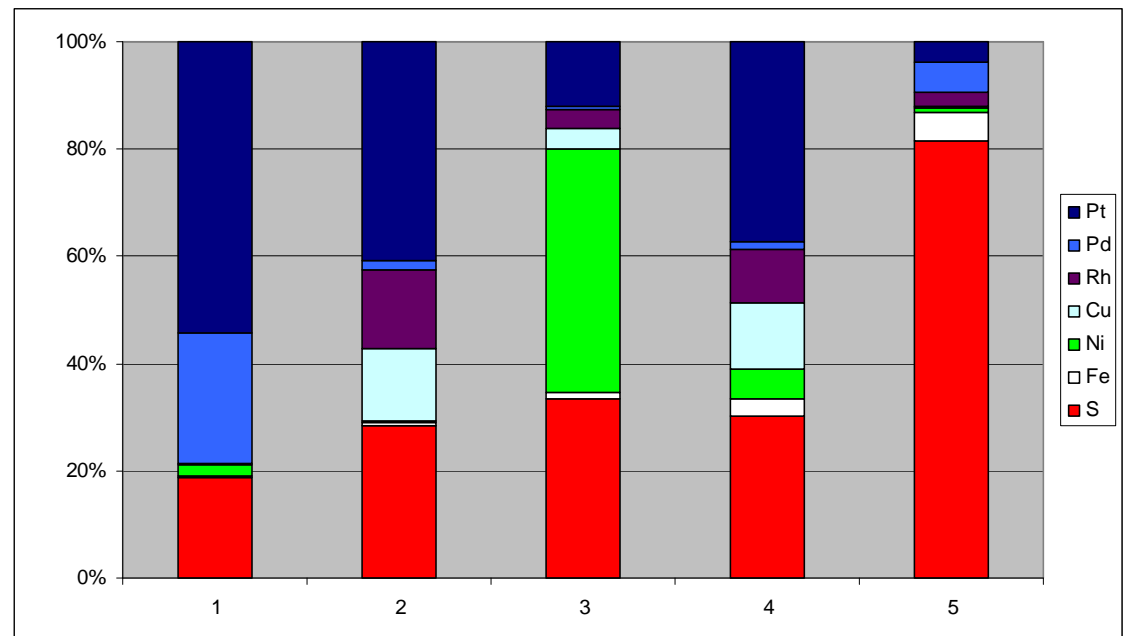


Composition of the Discrete PGMs varies widely

Electrochemical implications?

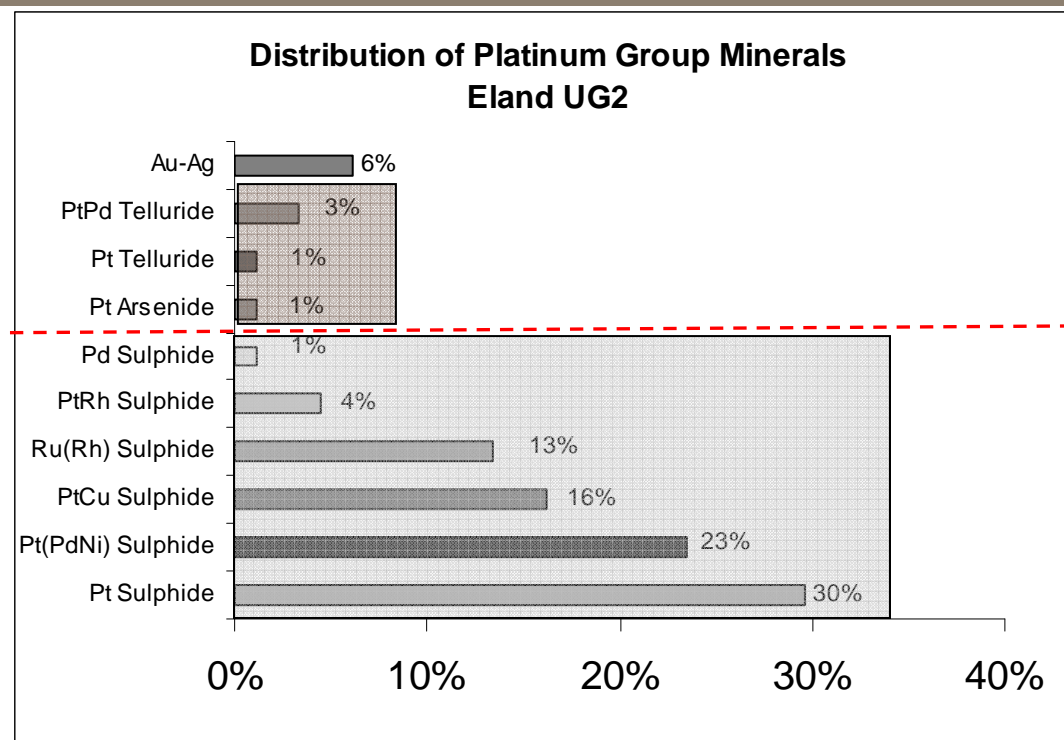
What reagent suite...?

Obviously a mixture...



Quantify Discrete PGMs

Discrete PGM Amphoterics

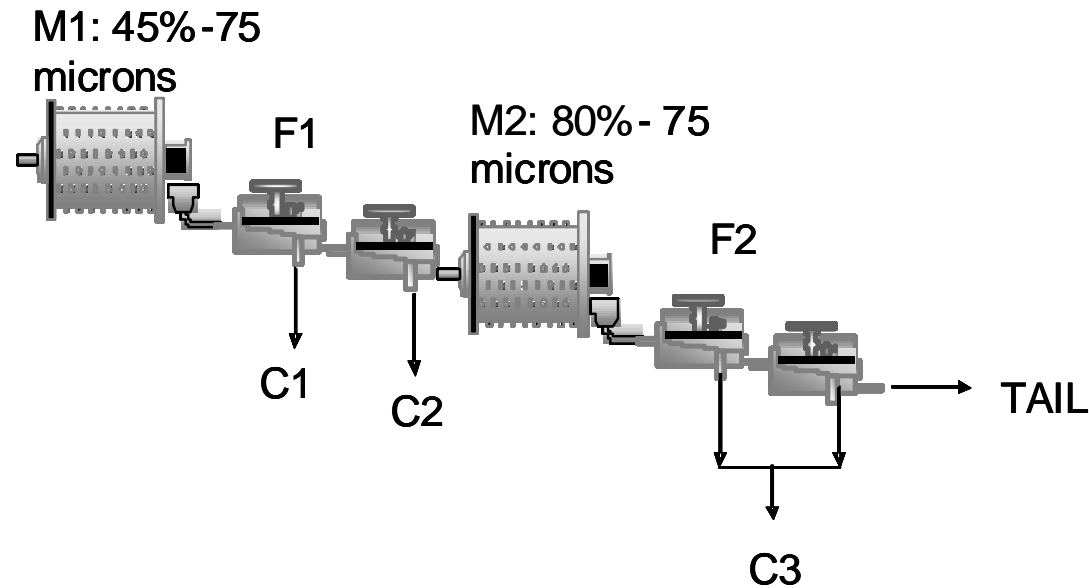


Discrete PGM Sulphides

Candidate Reagents

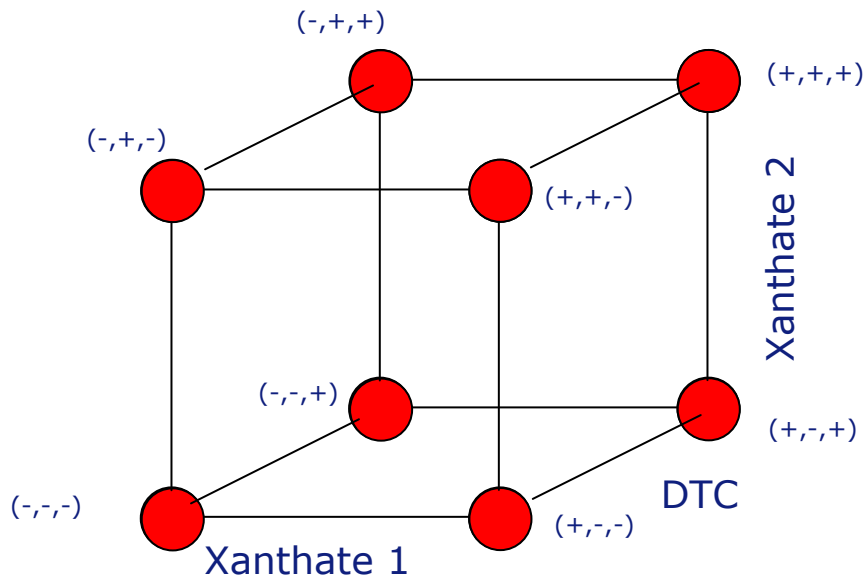
- Mineralogy
 - What minerals are present, and what we want to float:
 - Mostly discrete PGM sulphides, some PGM amphoteric, some electrum
 - Wide range of compositions
- Electrochemistry
 - Have to cover a range of potentials
 - More than one type of collector needed
- Reagent Sudoku
 - Selected two xanthates and a dithiocarbamate
 - Total collector dose at plant was 240 g/t milled
 - Factorial designed around this dose

Flotation Testing



Laboratory Scale Testing Used
an MF2 Format

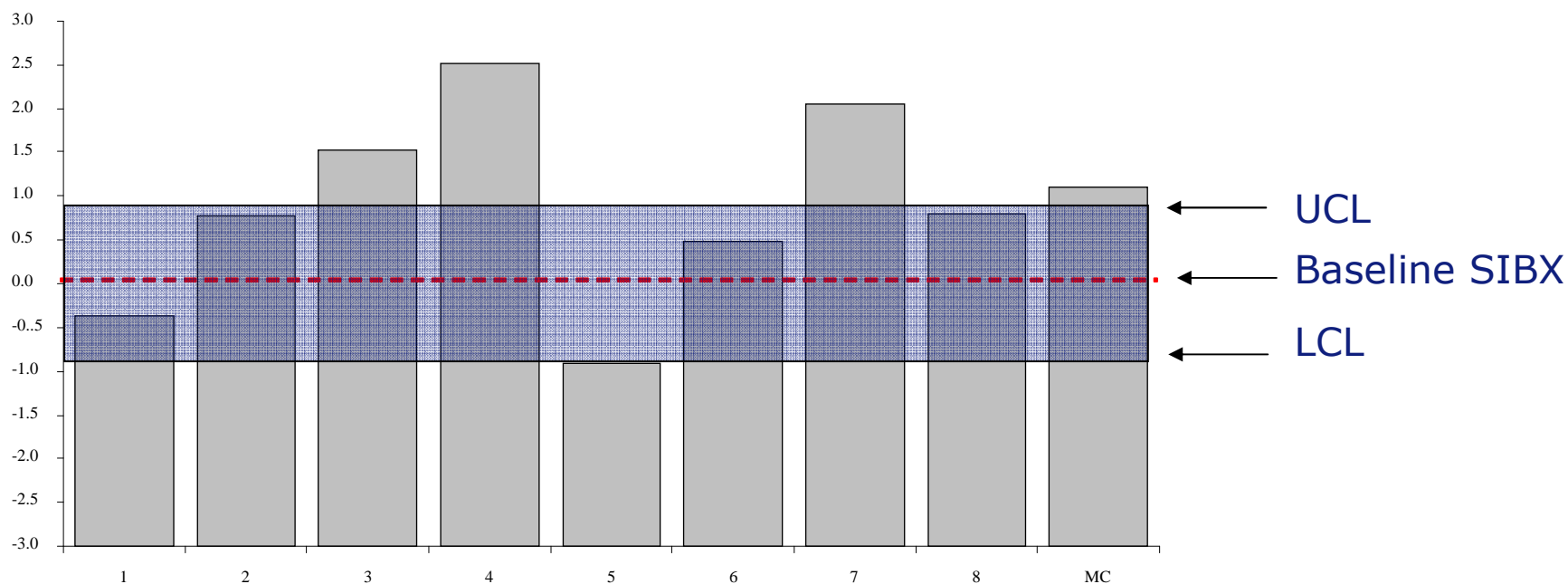
Flotation Testing – West Pit



Replicated Factorial at High Confidence



Flotation Test Results



Platinum Recovery Responds Well
(So Do Pd and Rh)

Flotation Test Results

- **Main Effects**
 - Xanthate 2 had significant main effects on Pt, Pd, Rh (1.15 to 2.89% recovery)
- **Interactions**
 - Xanthate 2/DTC had significant interaction (+0.69% Pd recovery)
- **Predicted Outcome**
 - Mixed Collector Formulation would increase 4E PGE recovery by +2.1%

Formulation of Mixed Collector Suite



- Three-component formulation called Exp 820
 - Xanthate 1
 - Xanthate 2
 - Dithiocarbamate
 - Formulated from modelling of factorial data
- Approached Senmin to manufacture trial batches

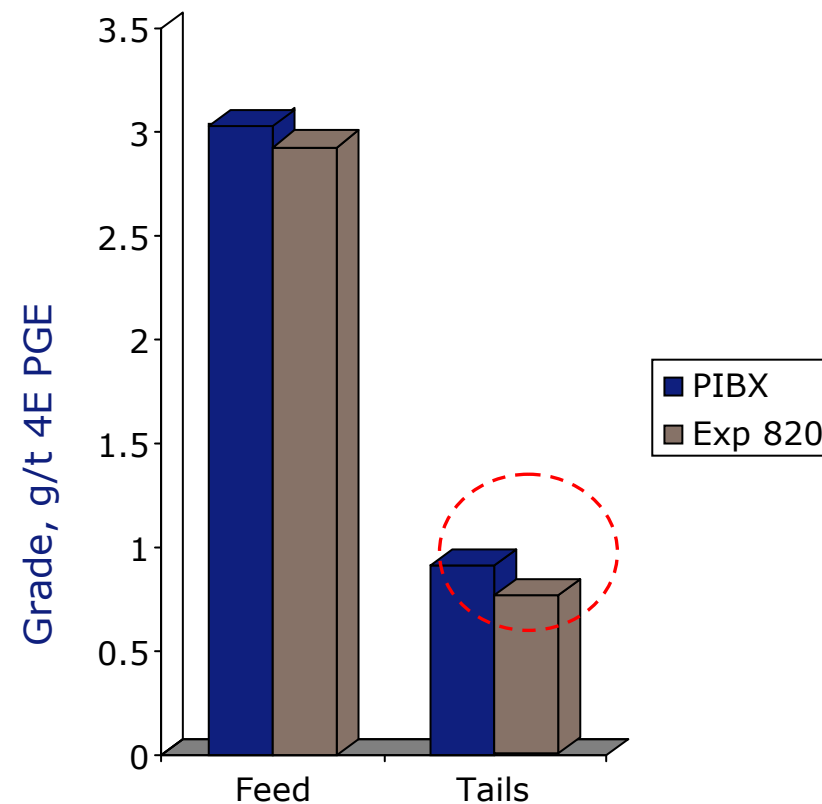
Plant Trials Q4.09

- Campaign Format
 - Eland Treats 5 Different Ore Types
 - West Pit Ore is One of These
 - On-Off Trial Had to Manage This
 - Require Standard and Mixed Collector Runs Each Month
 - Pooled Data Across Trial, First Test with ANOVA
- Changeover Rules
 - Changeover Day Plus Next 2 Days Disqualified
- Conclusions to Be Made on West Pit Ore Only
- One-Week “Sighter” Trial First

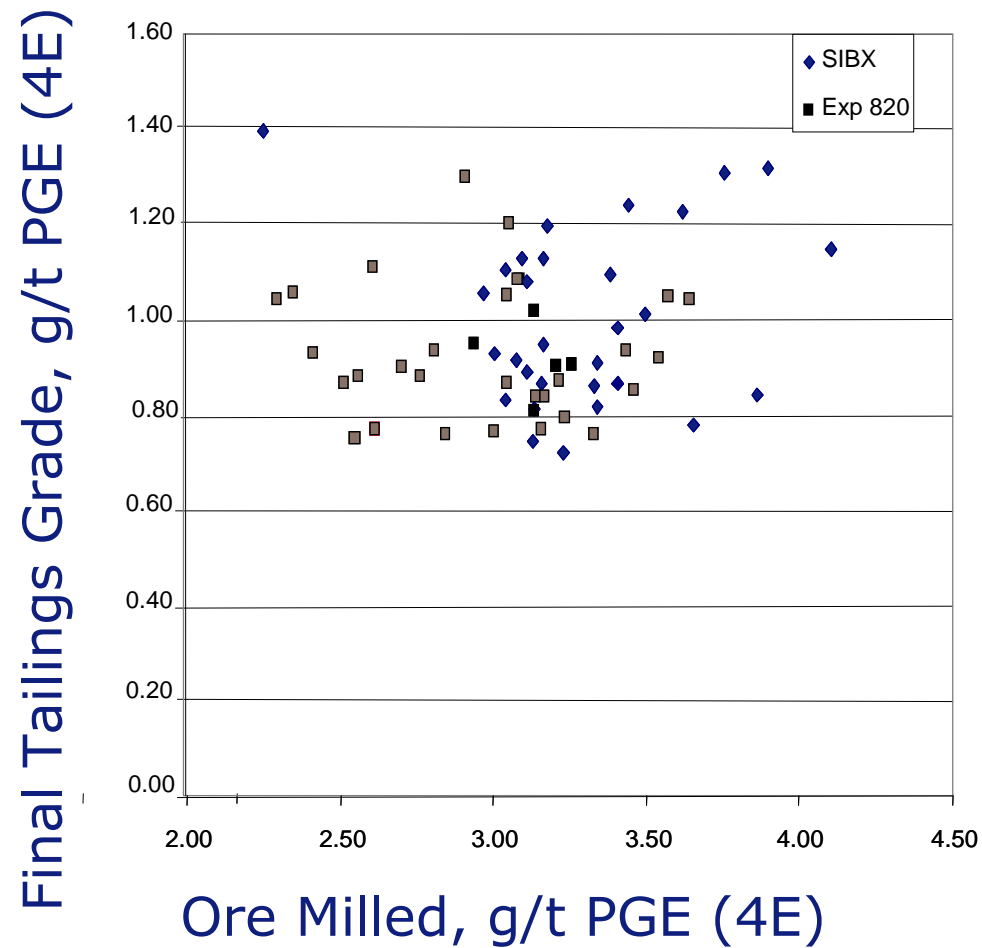
Sighter Trial – July 2009

- One-Week “Sighter” Trial on West Pit Ore
- Feed Grades
 - PIBX 3.04
 - Exp 820 2.93
- Tails Grades
 - PIBX 0.91
 - Exp 820 0.76
- Concentrate Grades
 - PIBX 156.4
 - Exp 820 131.9

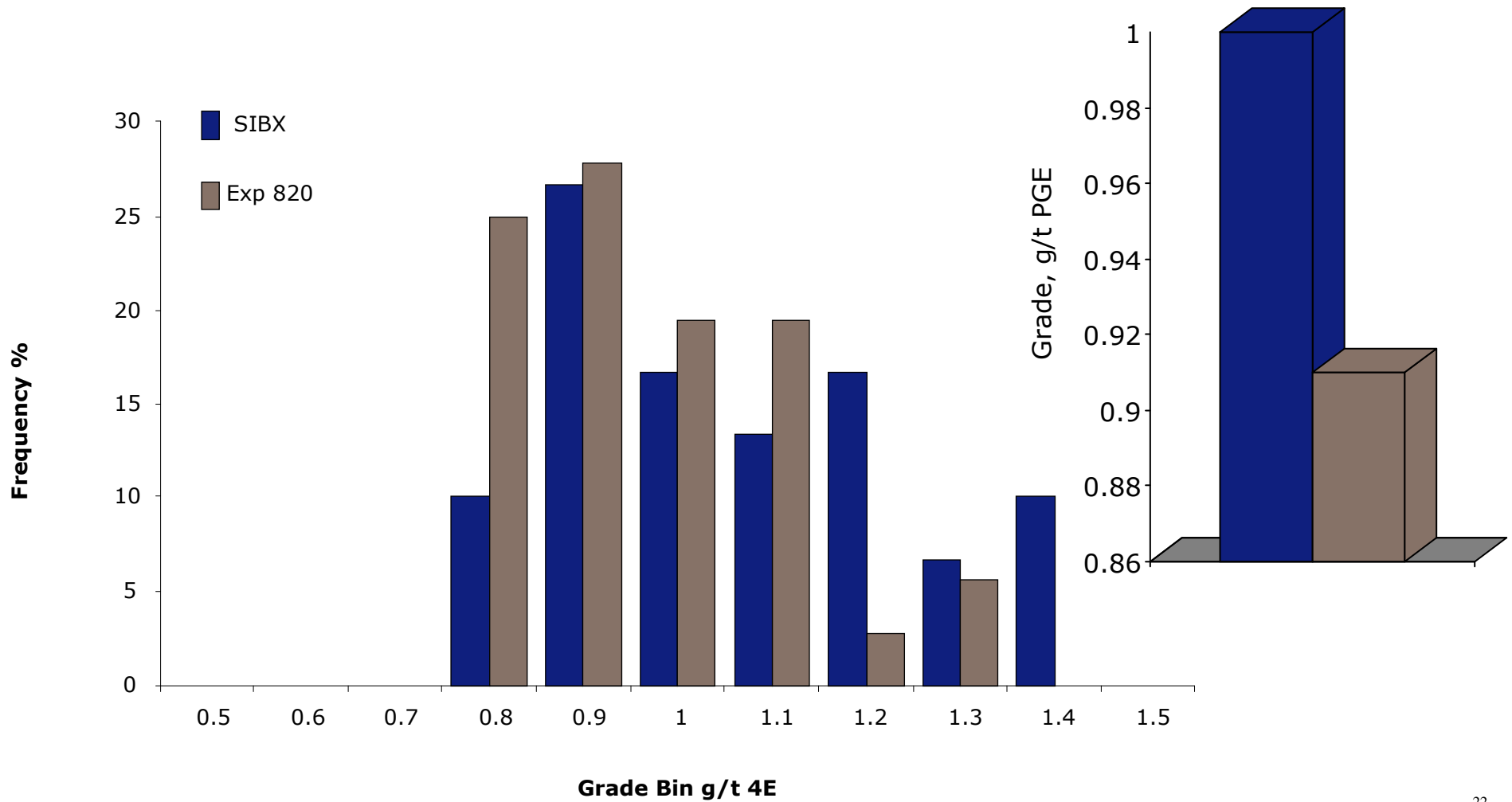
Needed to change frother



Final Tailings

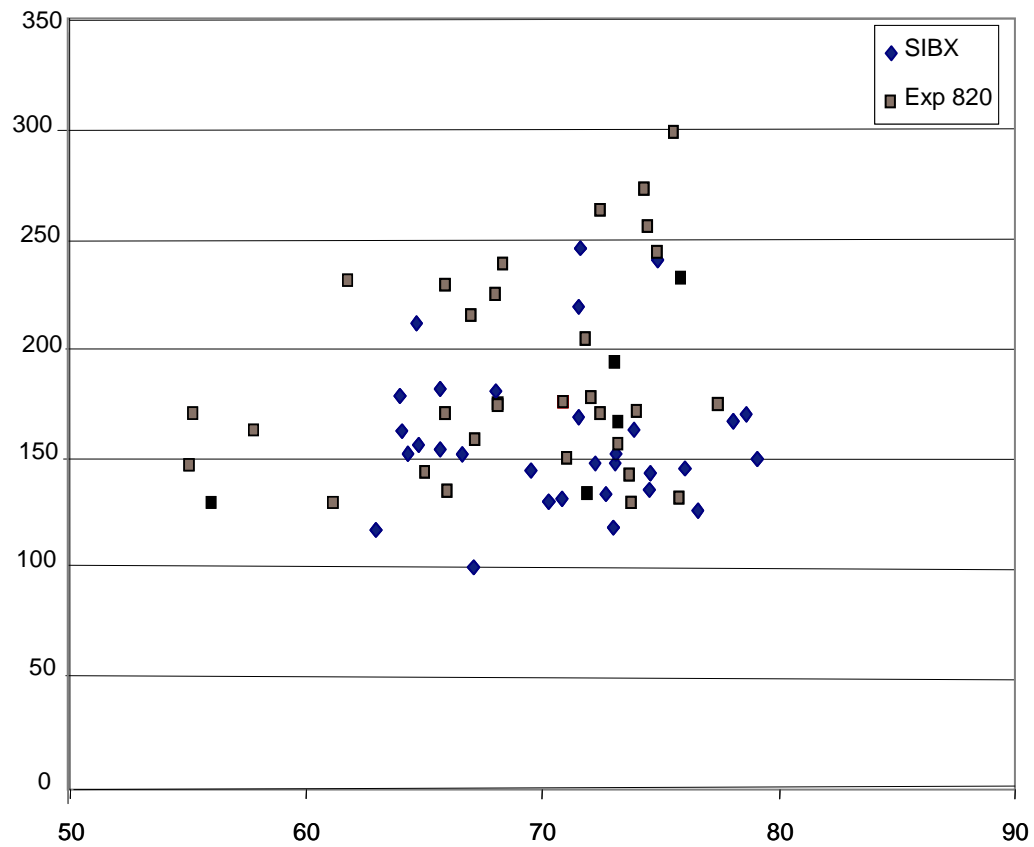


Final Tailings



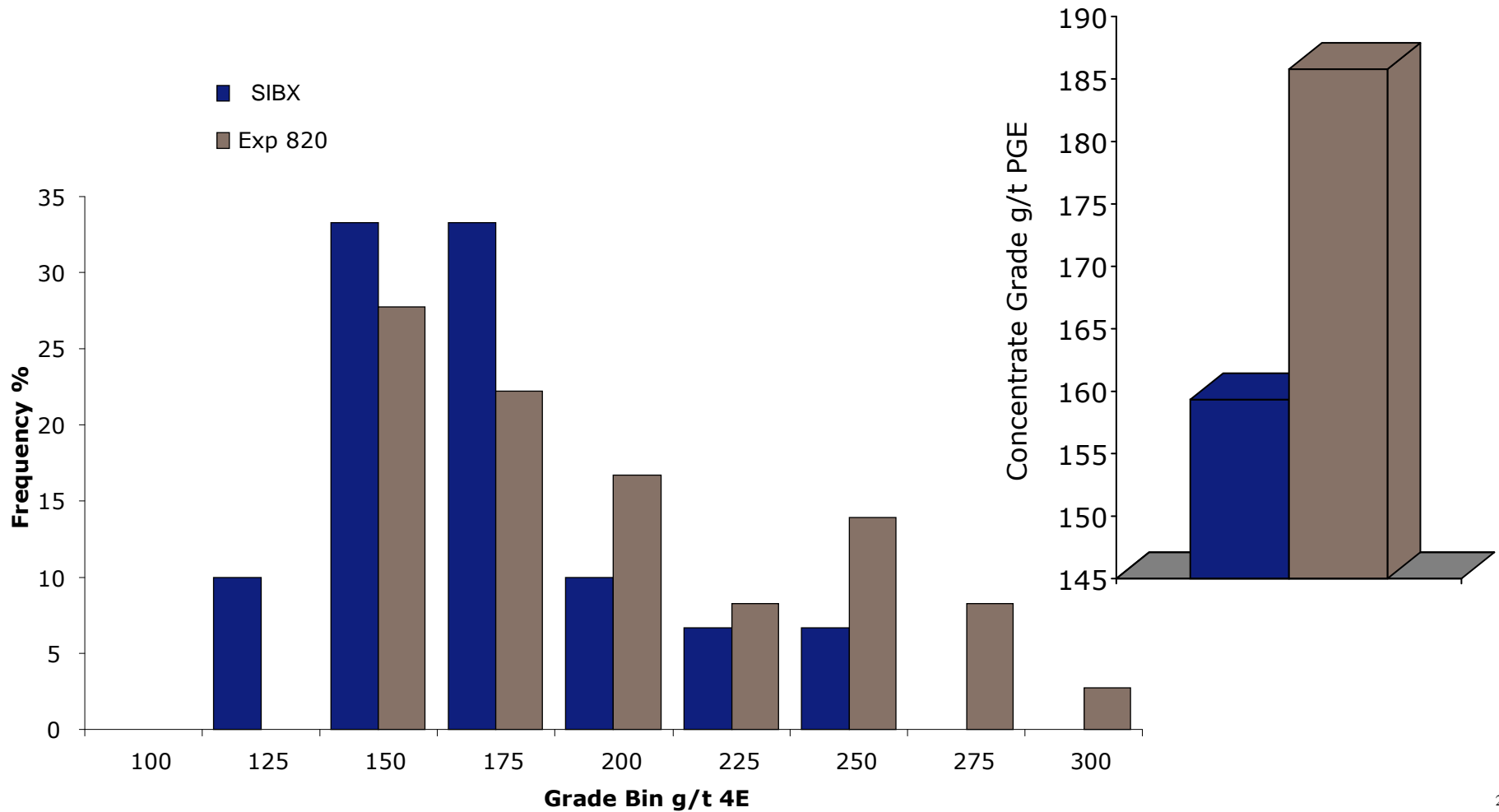
Final Concentrate

Final Concentrate Grade, g/t PGE (4E)



Recovery, % PGE (4E)

Final Concentrate



Outcomes at Eland – West Pit

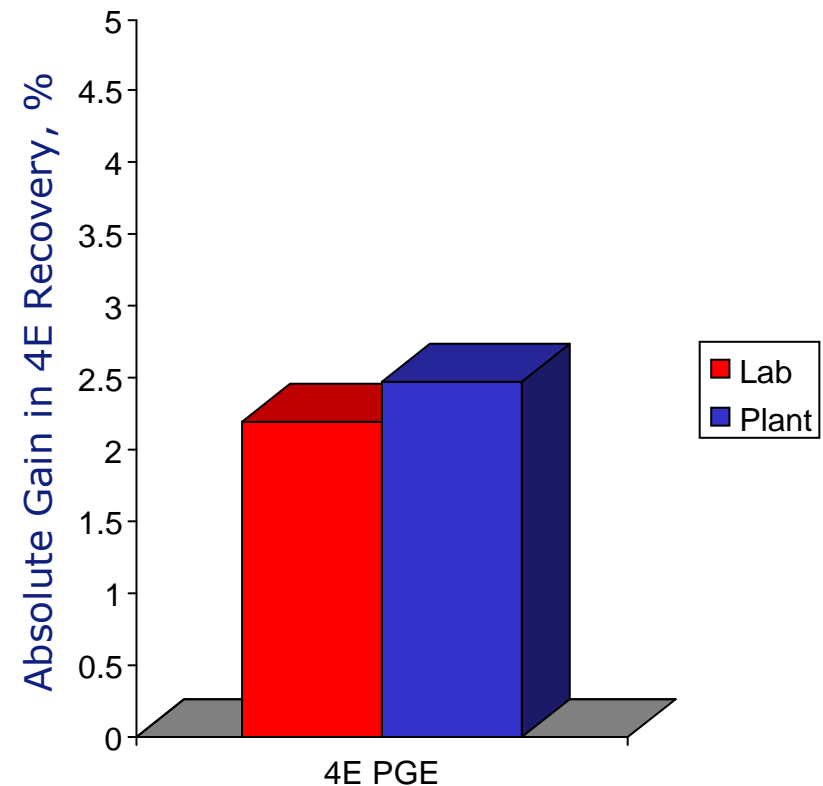
Successful Plant Trials

Demonstrate the Value

Mixed Collector Project at Eland
Platinum Gains 2.48% PGE
Recovery and 16.6% Higher
Concentrate Grade

Differences Demonstrated at
> 90% confidence level

Accurate Scale-up from Lab
Work



Conclusions

- **Mixed Collector Theory Validated**
 - Mineralogy powerfully informs reagent selection
 - Laboratory scale testwork accurately predicted plant response
- **Prototype Mixed Collector Exp 820 Successfully Formulated**
 - Clear Grade and Recovery Gains Demonstrated
- **Further Work Anticipated**
 - What advances can be made from here...?

Acknowledgements

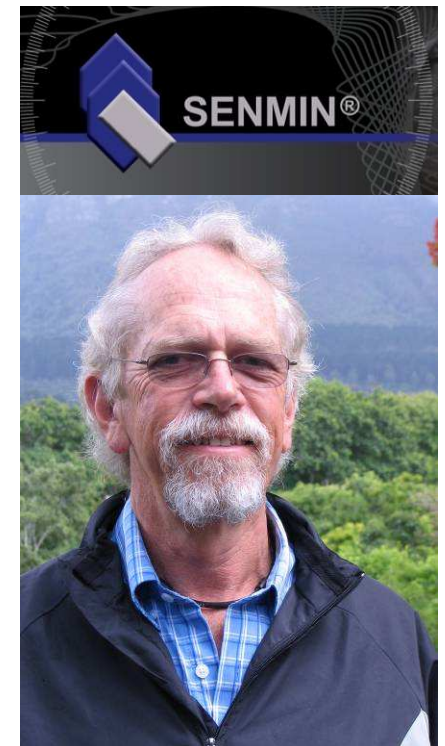


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