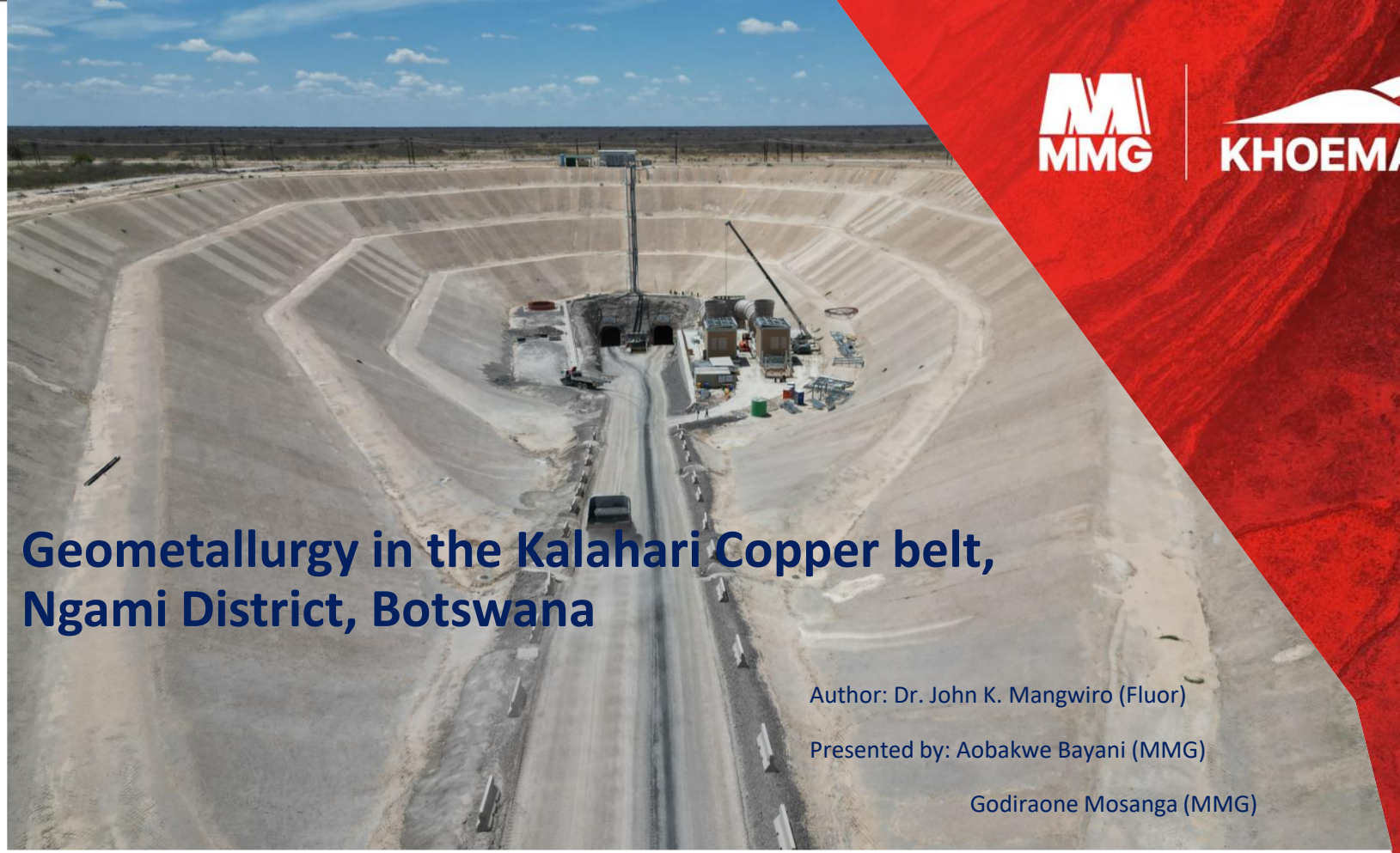

Geometallurgy in the Kalahari Copper belt, Ngami District, Botswana

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Presented by: Aobakwe Bayani (MMG)

Godiraone Mosanga (MMG)

Geometallurgy Conference 15 October 2025

Agenda

- Background
- Mineralogy and Metallurgical testwork
- Grade and Recovery prediction equations
- Gangue mineralogy Influence on Bond Ball Work index
- Conclusion and Future Work

Kalahari Copper Belt

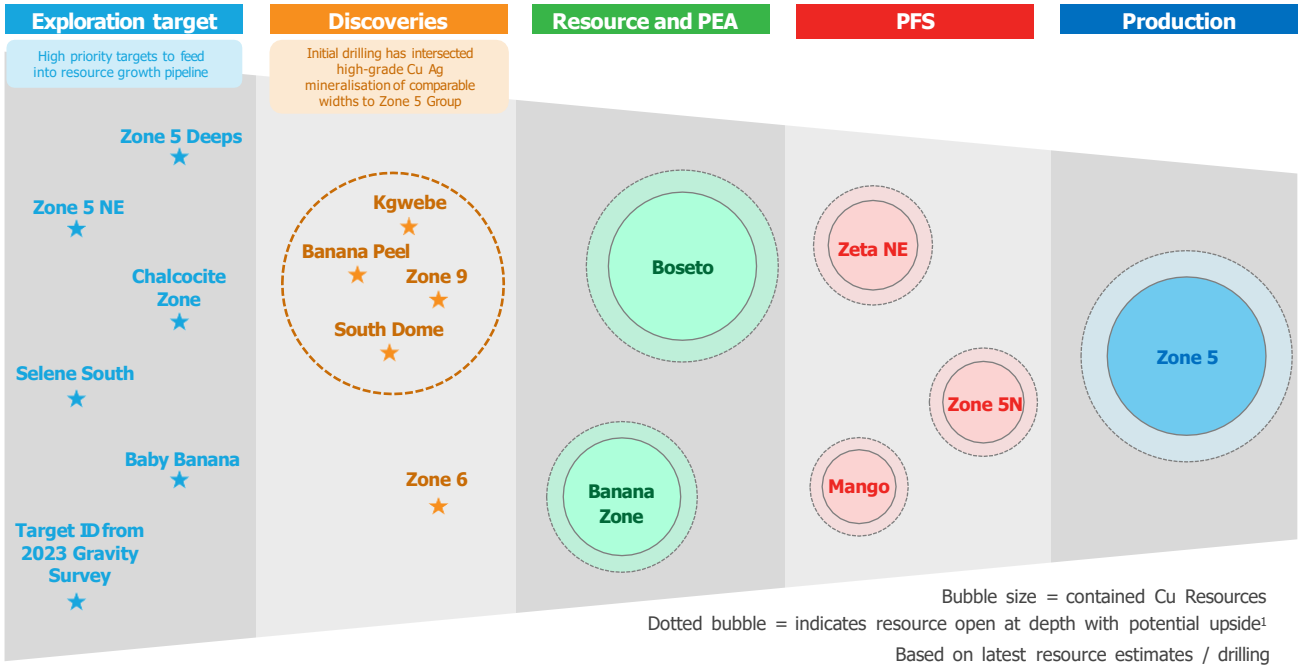
Kalahari Copper Belt

- Extends from Atlantic coast in Namibia through NE Botswana,
- >250km wide by >1,100km long,
- Stratabound, sediment & vein hosted Cu-Ag
- Folded and thrusted sequence of greenschist meta-volcanics & meta-sedimentary rocks

Zone 5 Deposit

- 4km strike and 1.2km depth
- Hosting 93mt @ 2.0% Cu, 21.3 g/t Ag

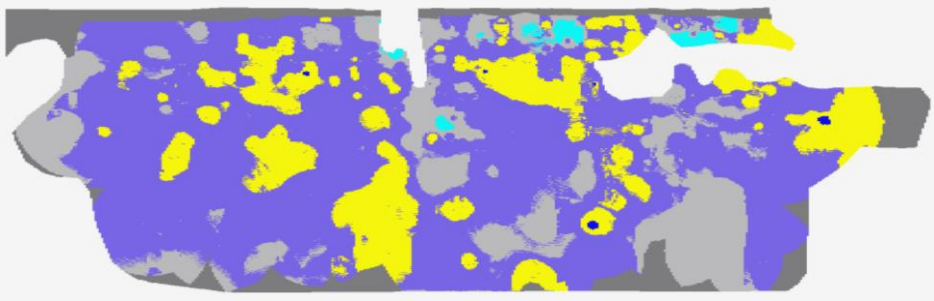
Current exploration and development pipeline in 4040km² land holding



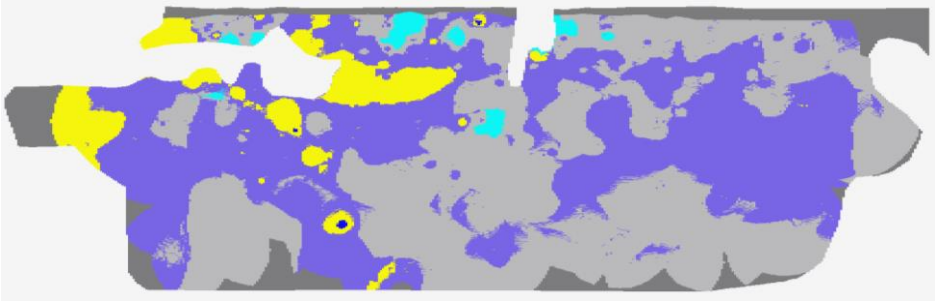
Bubble size = contained Cu Resources
Dotted bubble = indicates resource open at depth with potential upside[1]
Based on latest resource estimates / drilling

Zone 5 Mineral Distribution

Zone 5 Long Section Showing Dominant Mineralogy HW

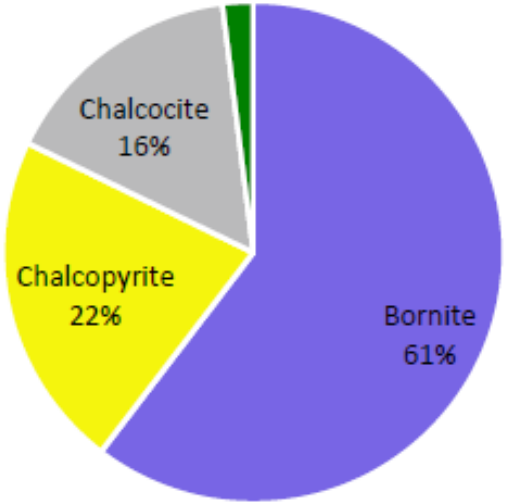


Zone 5 Long Section Showing Dominant Mineralogy FW



Mineral Type
Based on Cu:S

- Default
- Pyrite
- Chalcopyrite
- Bornite
- Chalcocite
- Silicate/Oxide



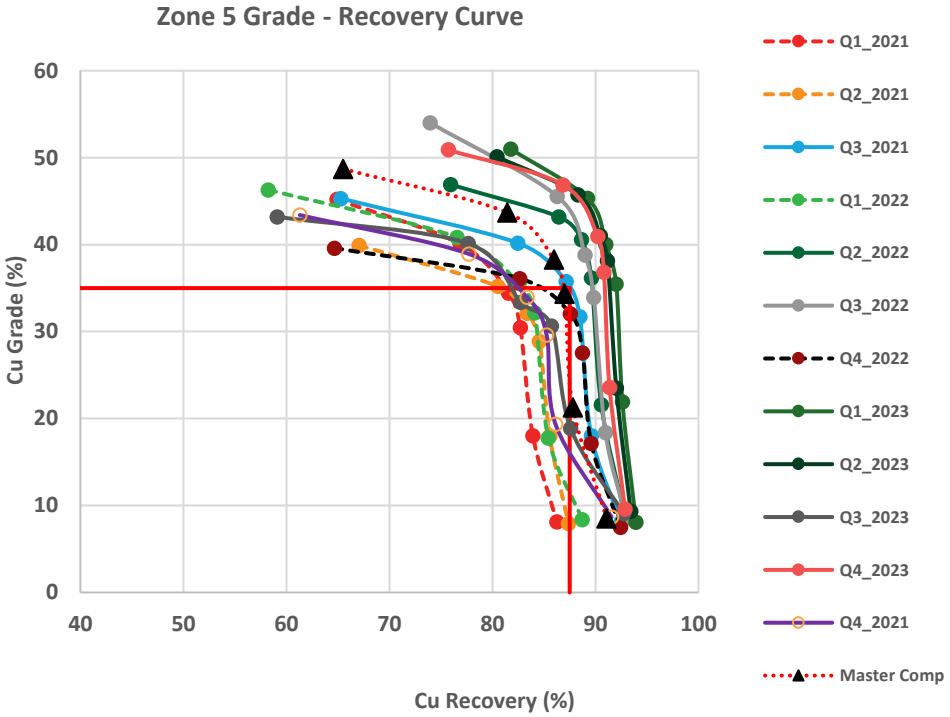
Mineralogical Composition

- **Primary Copper Sulphides**: Bornite, Chalcopyrite, Chalcocite
- **Accessory Minerals**: Galena, Sphalerite, Molybdenite, Arsenopyrite, Enargite, Tetrahedrite
- **Gangue Minerals**: Calcite, Quartz, Feldspars, Muscovite, Chlorite

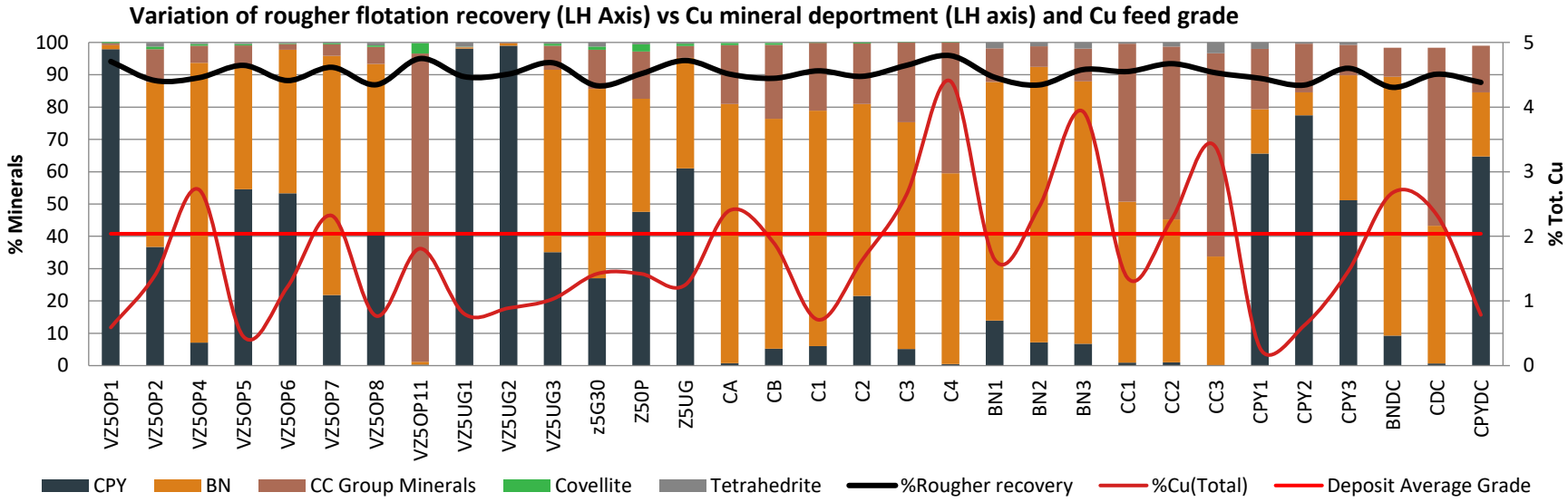
Metallurgical testwork

On acquisition of the Boseto plant by Khoemacau, metallurgical works to support expansion of the plant and modify the flowsheet for the processing the ore from Zone 5 was initiated:

- Mineralogical evaluation
- Detailed flotation testwork
- Variability
- Comminution

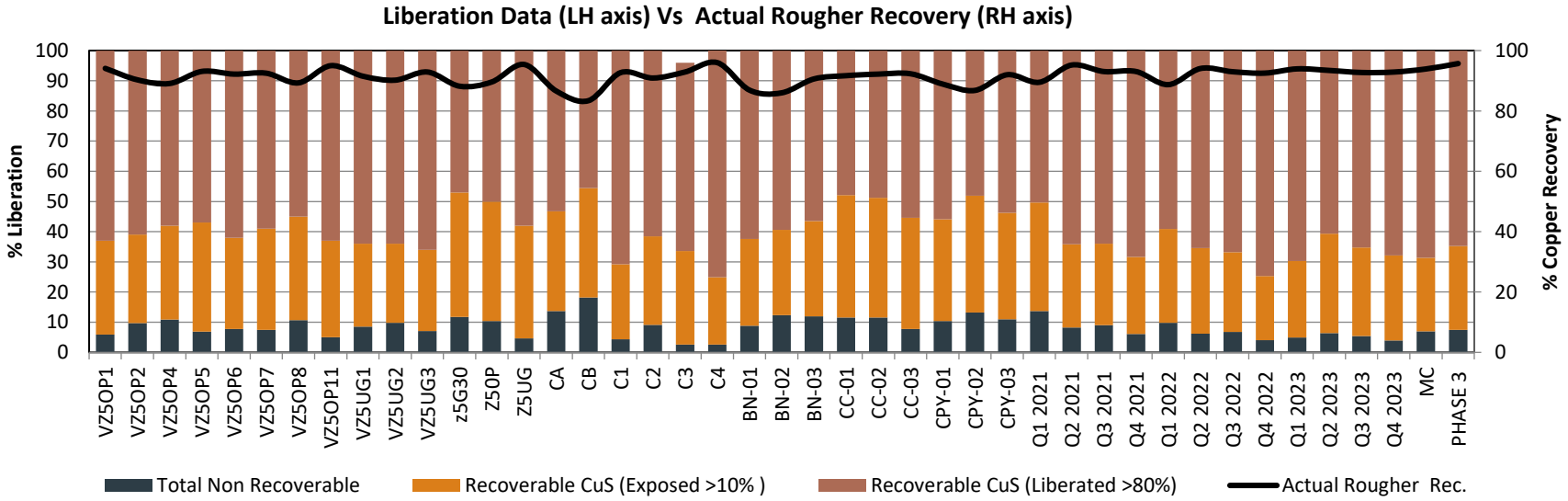


Impact of Mineralogy on recovery



- High variation of rougher flotation Cu recovery.
- Attributed to the varying amounts of chalcocite, bornite and chalcopyrite.

Impact of Liberation on recovery



- Samples with high amount of locked copper sulphides displayed low recoveries.
- Samples associated with high quartz contents we associated with poor liberation with finely disseminated copper sulphides

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Recovery Prediction Equations

- Initially modelled based on mineralogy.
- Cu:S ratio later used as a proxy for copper sulphide mineralogy
- Cu recovery equations generated using multiple linear regression

Copper Recovery Formulae

Cu:S Ratio			Recovery Formula	
From	To	Dominant Mineral	2020 August - Design	2022 May – Plant data
0.01	0.75	Chalcopyrite	86.12 + 0.56% Cu	86.22+0.76%Cu
0.75	1.5	Bornite	86.42 + 0.56% Cu	87.54+0.76%Cu
1.5	99	Chalcocite	88.85 + 0.56% Cu	85.89+0.76%Cu
		Observations	46	629
		R^2	0.97	0.96
		Standard error	3.3%	3.49%

Silver Recovery Estimate

Cu:S Ratio			Recovery Formula	
From	To	Dominant Mineral	2020 August - Design	2022 May- Plant data
0.01	0.75	Chalcopyrite	83.3	82.7
0.75	1.5	Bornite	83.1	82.3
1.5	99	Chalcocite	87.1	82.9
		Observations	46	581
		R^2	0.96	0.98
		Standard error	5.1%	5.9%

Con grade Prediction Equations and Application

- Modelled based on Cu:S ratio domains
- Cu Concentrate grade equations generated using multiple linear regression
- Ag equations based on copper mass pull

Concentrate Grade Prediction Equations

Cu:S Ratio From	Cu:S Ratio To	Equation	R^2	Standard Error %	Observations
0.01	1.0	49.4 * Cu:S - 3.2 * %Cu	0.93	4.6	22
1.00	2.0	24.0 * Cu:S + 4.8 * %Cu	0.94	5	24

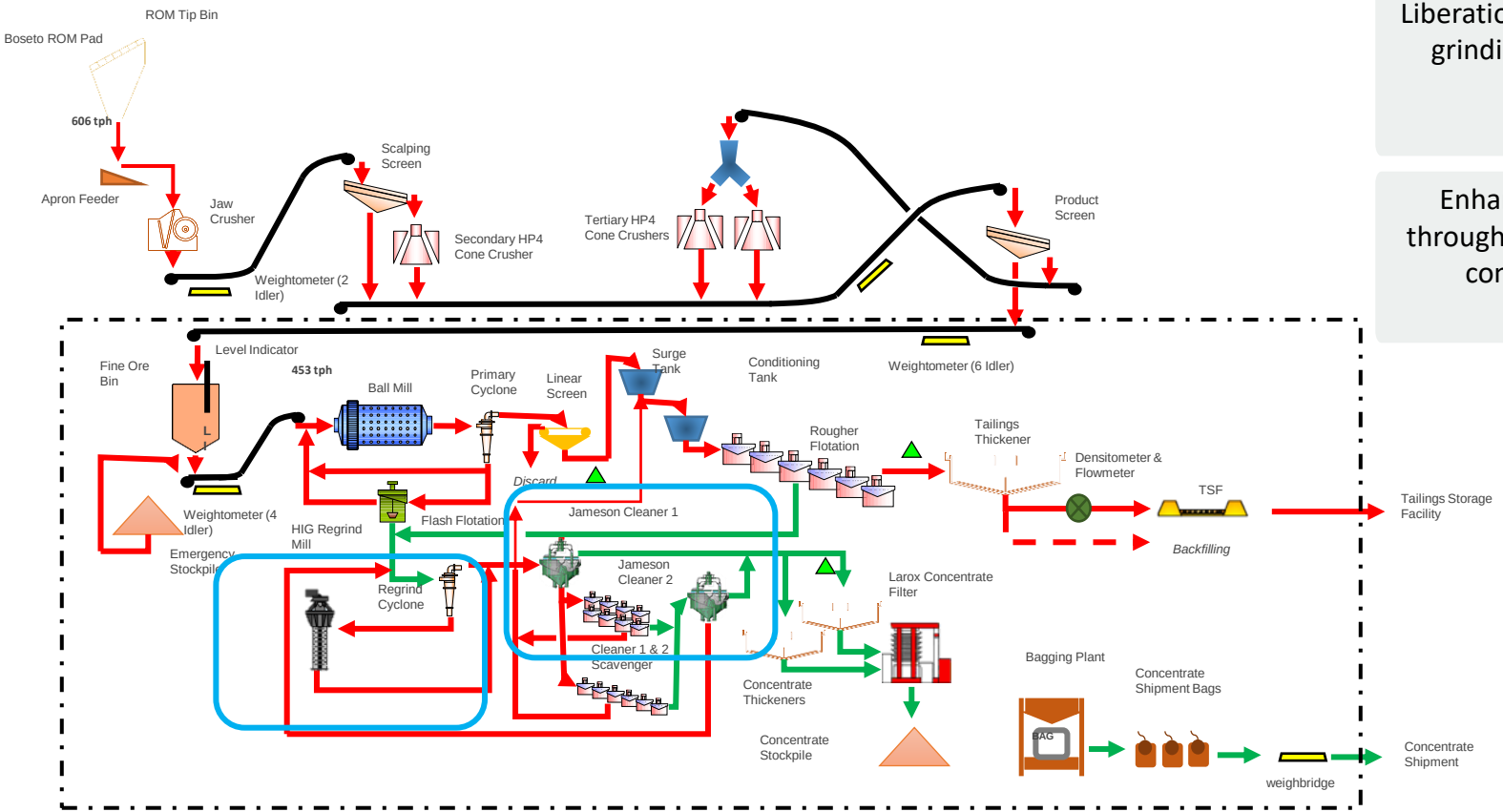
Zone 5 mineral Resource as at 31 December 2022

	Ore	Cu	Cu	Ag	Ag	Recoveries		Cu Con Grade
	(Mt)	(%)	(kt)	(g/t)	Koz	Cu	Ag	(%)
Measured	13.7	2.08	284	20.1	8,833	88.1	84.0	41.1
Indicated	27.2	1.92	523	19.2	16,772	87.8	83.7	39.8
Measured and Indicated	40.9	1.98	807	19.5	25,605	87.9	83.8	40.2
Inferred	52.0	2.08	1,081	22.7	37,939	88.0	83.8	41.1
Total	92.9	2.03	1,888	21.3	63,544	87.9	83.8	41.4

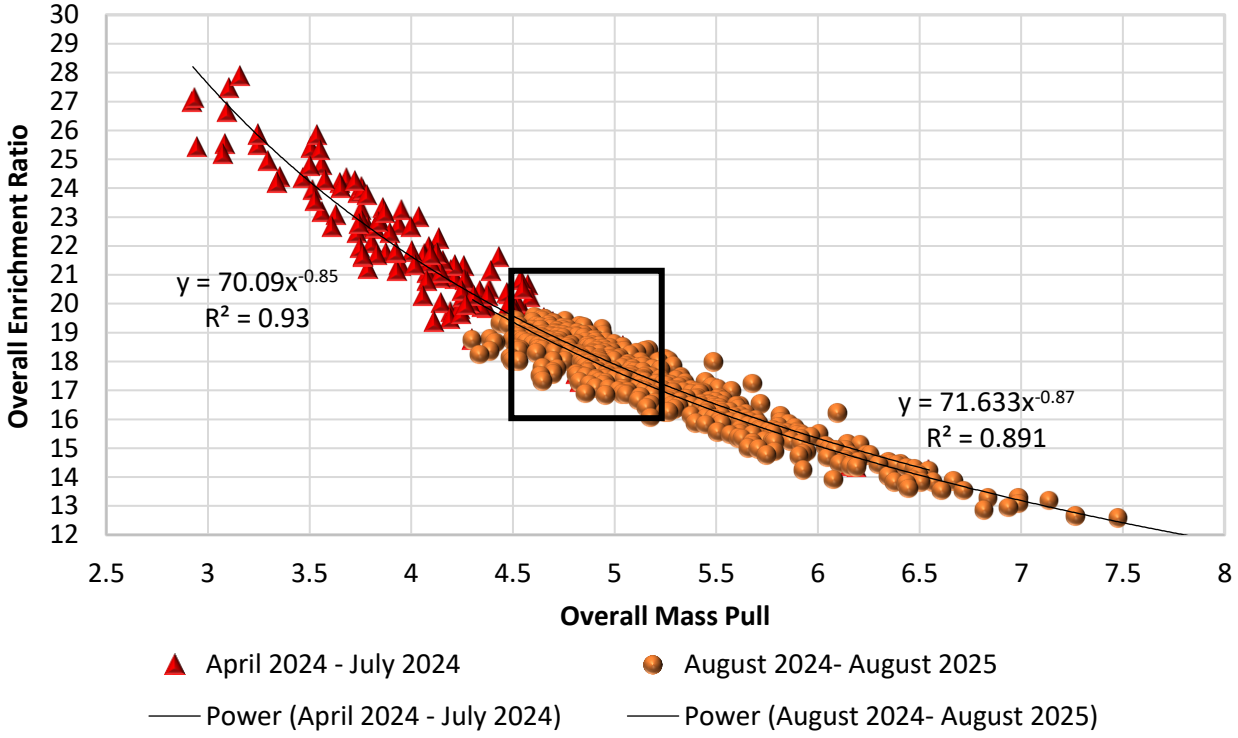
Boseto Process plant Flow Diagram

Liberation through fine grinding P_{80} 20µm

Enhance kinetics through high intensity conditioning



Operating philosophy illustration

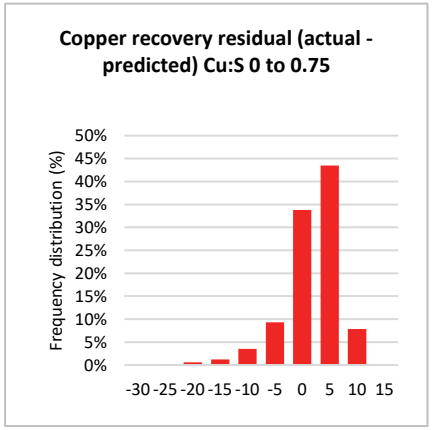


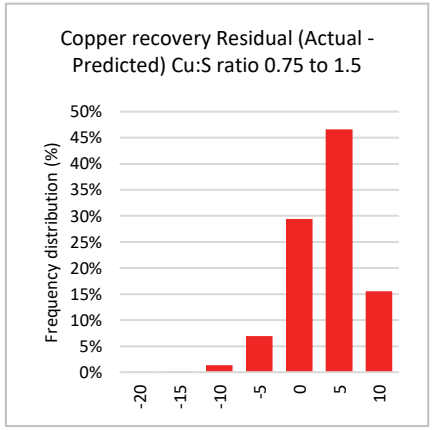
Reagents

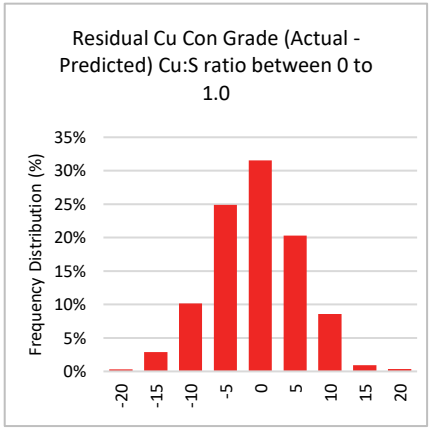
Energy

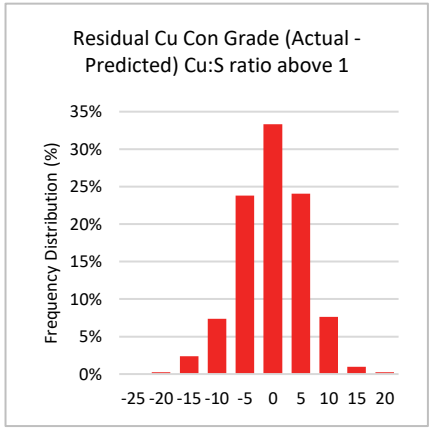
Recovery

Validations









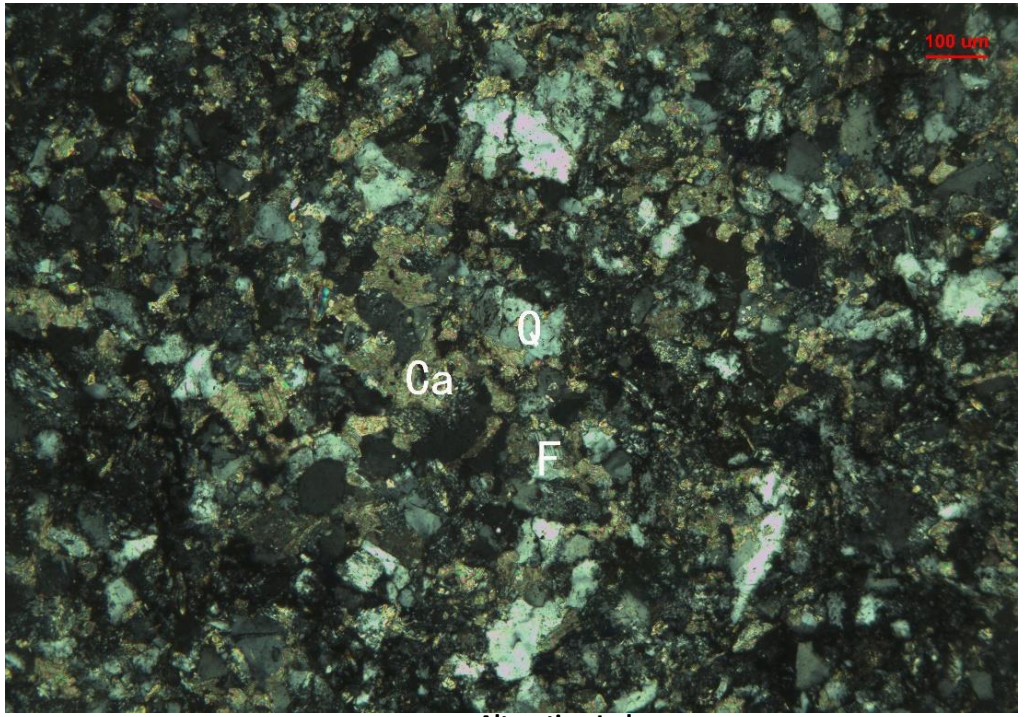
Samples Number	Cu:S ratio	Actual Cu recovery (%)	Predicted Cu Recovery (%)	Residual (%) (Actual - Predicted)	Standard error of estimate (%)
485	0 to 0.75	86.2	86.9	-0.7	5.1
1359	0.75 to 1.5	88.3	87.4	0.9	4.2
20	>1.5	88	90	-2	4.1

Samples Number	Cu:S ratio	Actual Cu Concentrate Grade (%)	Predicted Cu Concentrate Grade (%)	Residual (%) (Actual - Predicted)	Standard error of estimate (%)
1407	0 to 1.0	31.1	34.3	-3.1	7
420	>1	34	36.6	-2.7	6.4

Gangue Mineralogy Influence on BBWi

The gangue minerals in the Zone 5 orebody are predominantly **quartz**, **calcite**, and **feldspar**, followed by muscovite and chlorite.

- Quartz occurs mainly as granular or irregular aggregates, often closely intergrown with calcite and feldspar to form nodular clusters locally.
- Calcite predominantly exists as euhedral granular crystals, tightly interlocking to form massive aggregates, with partial intergrowth with quartz and feldspar.



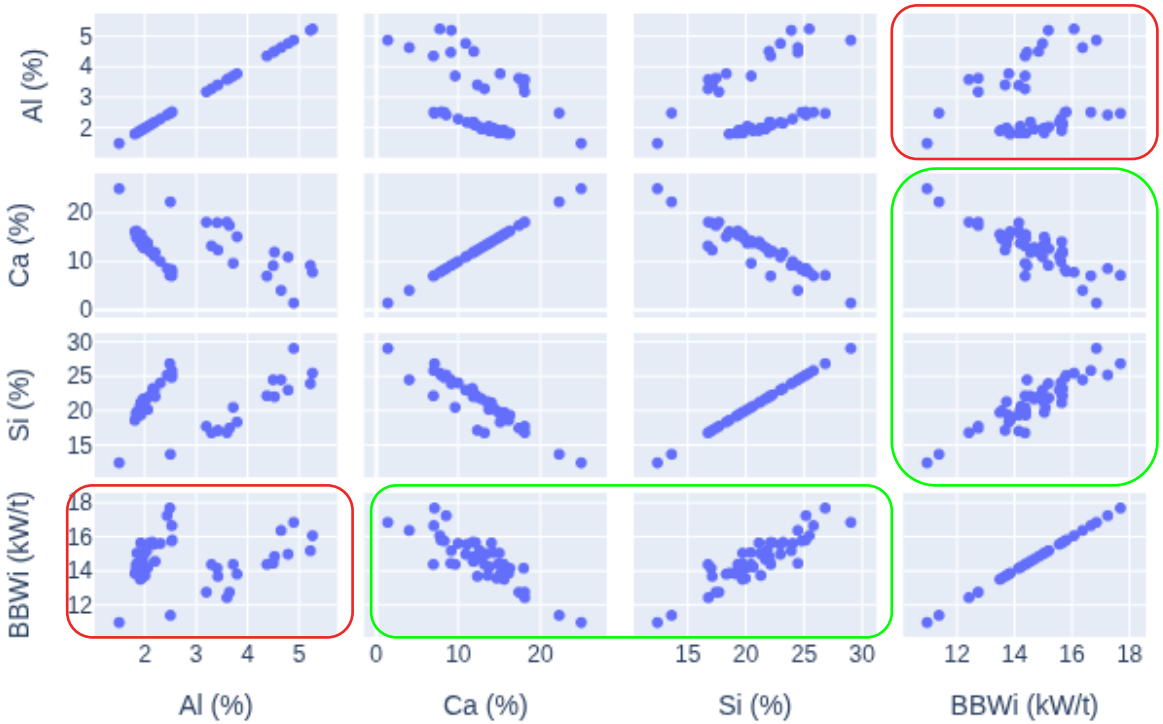
Optical microscope image (Zone 5 ore composite sample)

Alteration Index/Ratio

Alti [1]	Alti [2]	Alti [3]	Alti [4]
$\frac{\%Ca}{\%Ca + \%Al}$	$\frac{\%Ca}{\%Ca + \%Si}$	$\frac{\%Ca}{\%Ca + \%Si + \%Al}$	$\frac{\%Ca}{\%Si}$

Alteration Index

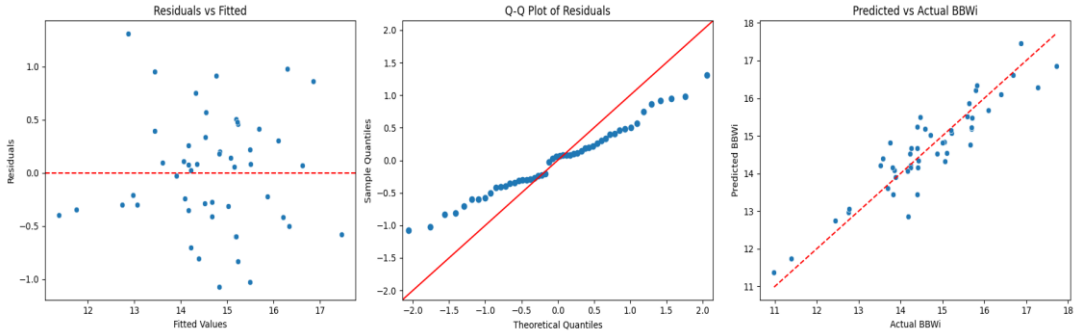
Elemental composition Influence on BBWi



BBWi Regression model

Regression Analysis

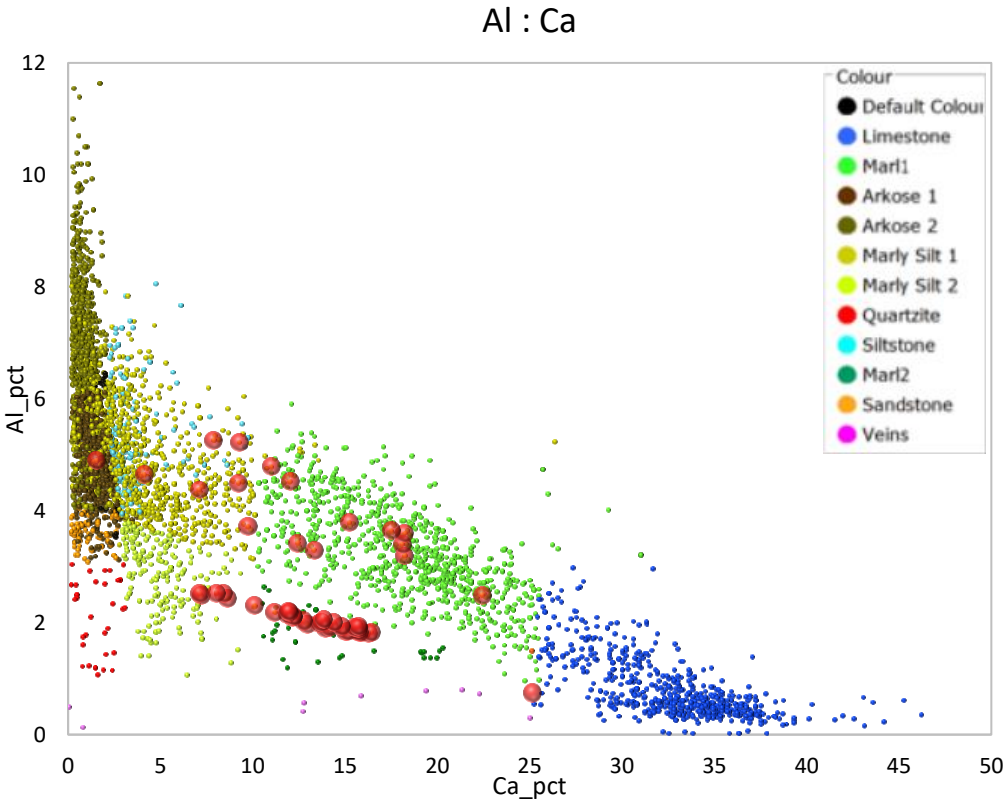
Multilinear regression was performed on current arising operational data, This link BBWi to Si, Al and Ca assays, providing a robust model for predicting ore hardness based on elemental composition.



Regression Statistics	
Multiple R	0.9136
R Square	0.8346
Adjusted R Square	0.8238
Standard Error	0.5561
Observations	50

BBWi (kW/t) = 11.99 - (0.27 x %Al) – (0.13 x %Ca) + (0.24 x %Si)

Zone 5 deposit Lithology



The superimposition of the BBWi samples on the Zone 5 lithology shows a good correlationship.

Conclusion & Future Upgrades

Database Expansion

The ore hardness dataset will be expanded to include deeper Zone 5 lithologies, providing a more comprehensive view of the deposit's variability.

Multivariable Integration

Future upgrades will incorporate Pb, Zn and Alteration Index as a proxy for liberation enhancing the precision of recovery and concentrate grade predictions.

Real-Time Integration

Integration of on-stream analyser will enable real-time adjustments, further optimize plant performance and reduce variability.

Error Reduction

Evaluate advanced data analytics and machine learning to improve predictions using plant data.

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Thank you

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