

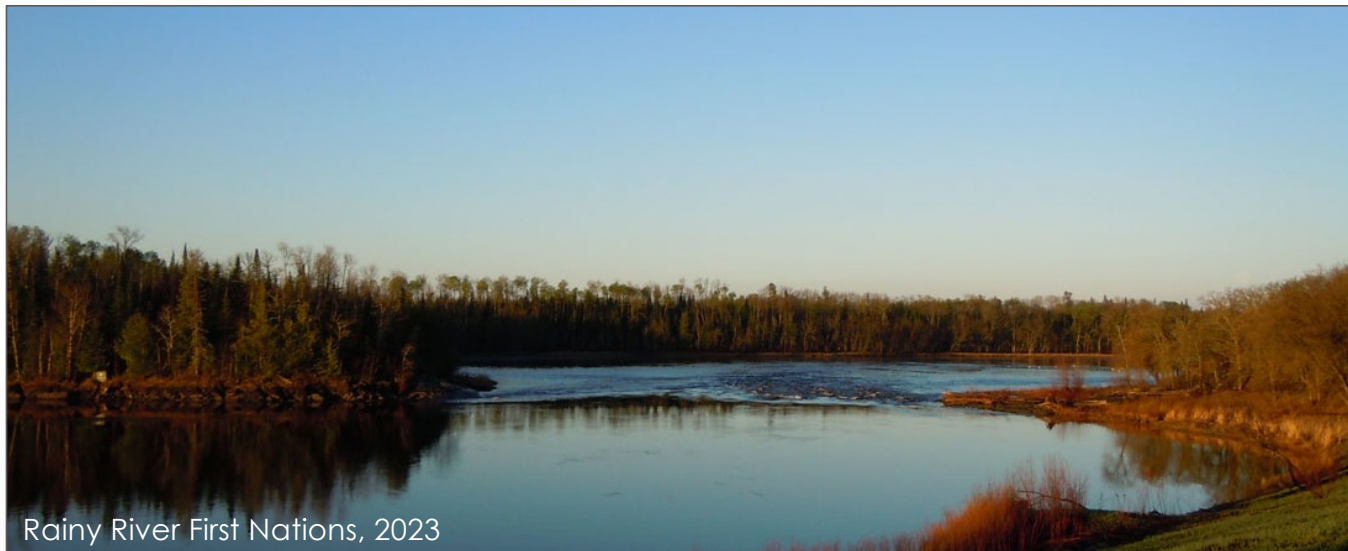
Blast Fractionation of Sulfides and Carbonates – Implications for Operational Classification of Mine Rock

BC MEND ML/ARD Annual Workshop
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Land Acknowledgment

- We would like to start off by taking this opportunity to acknowledge that the land on which this project was conducted is Treaty 3 territory, the traditional lands of the Anishinaabe Nations and home to Métis communities



Rainy River First Nations, 2023

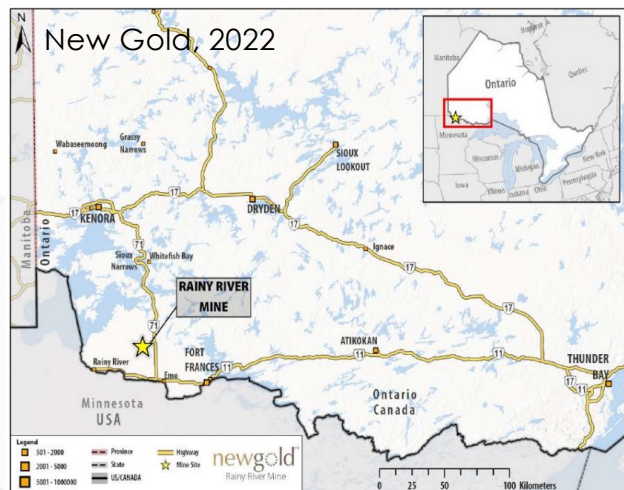
Outline

- Rainy River (New Gold Inc.) mine site overview
- Blast fractionation study objectives and field program
- Analysis of sulfide and carbonate fractionation
- Implications and opportunities for geochemical classification criteria



Rainy River Gold Mine

- Gold mine 65 km NW of Fort Frances, Ontario
- Milling throughput of ~23,500 tonnes/day
- Series of volcanic, sedimentary, and intrusive rock successions
 - Major lithologies: dacite, intermediate felsic, mafic, and diabase dike
- PAG mine rock is segregated and placed in the East Mine Rock Stockpile (EMRS)
- NAG mine rock used for construction fill or placed in the West Mine Rock Stockpile (WMRS)



Mine Rock Segregation

- Blast hole samples are measured for Total Sulfur and Total Carbon at the on-site LECO laboratory
- Neutralization potential (NP) and acid potential (AP) are calculated based on empirical correlations to calculate the neutralization potential ratio (NPR)
- Rainy River mine rock classification criteria:

- PAG Mine Rock: $\text{NPR} = \frac{\text{NP}}{\text{AP}} < 2$

- PAG Mine Rock Sub-Classifications

PAG1: NP < 12.5 kg CaCO₃/tonne
PAG2: NP < 19 kg CaCO₃/tonne
PAG3: NP > 19 kg CaCO₃/tonne

- NAG Mine Rock: $\text{NPR} \geq 2$

Blast Fractionation Study

- Geochemical classification is based on whole, unblasted rock
- Do sulfides and carbonates partition to different size fractions in blasted rock?
- Is the “effective” NPR of blasted rock different from the whole rock NPR?
- Because the fines in the blasted rock are the most reactive:
 - If sulfides fractionate to the fines, **NAG rock** may behave as **PAG rock**
 - If carbonates fractionate to the fines, **PAG rock** could be used as **NAG rock**
- **Objective: Evaluate the potential for sulfides or carbonates to partition to finer fractions in blasted mine rock**



Sampling Plan

Rock Type	Classification	Samples Targeted	Samples Collected
Dacite	PAG1	1	1
	PAG2/3	3	3
Intermediate	PAG2/3	2	2
	NAG	2	2
Mafic	PAG2/3	2	1
	NAG	2	1
Diabase	NAG	2	2
Total		14	12

- Sampling program targeted all major lithologies, PAG, and NAG rock
- Approximately 100 to 200 kg of freshly blasted mine rock collected directly from the open pit
- Total carbon, total sulfur, and mineralogy completed on bulk sample and individual size fractions in duplicate

Field Sampling



- Identified freshly blasted mine blocks of the desired lithology and PAG/NAG classification

- Loader sampled blasted rock from active face and placed blasted mine rock on tarp to minimize contamination



Geochemical Blast Fractionation

Field Sampling

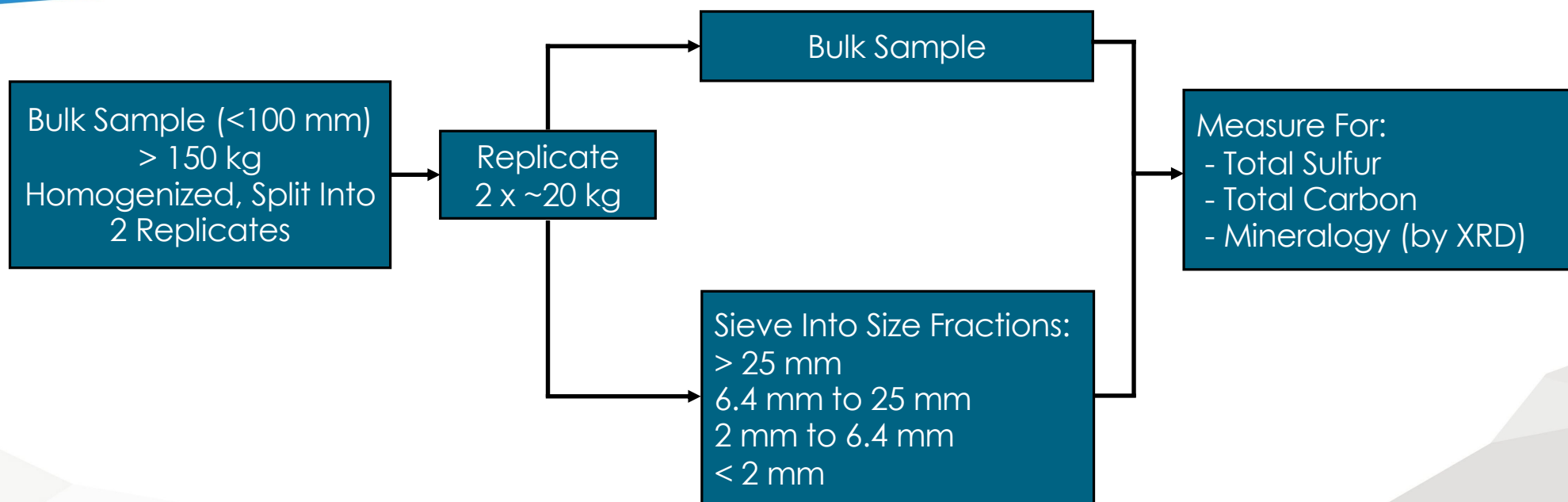


- Removed rocks > 100 mm by hand
- Sampled rock into pails with shovels
 - Attempted to get an EVEN PSD instead of a REPRESENTATIVE PSD
 - Ensured enough of each size fraction available for laboratory testing



Geochemical Blast Fractionation

Laboratory Handling



- Pails of each sample homogenized, split in two replicates
- One replicate used as the bulk sample, other replicate sieved into four size fractions
- Geochemical analysis conducted on bulk sample and each size fraction

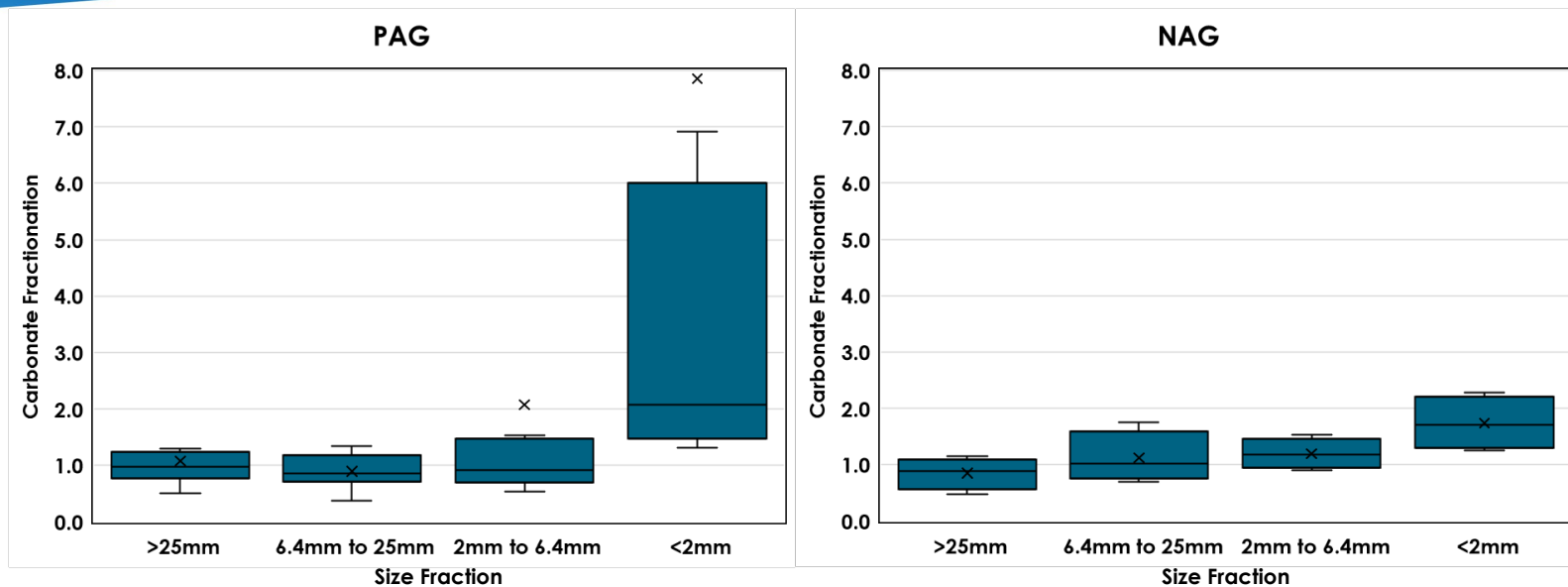
Blast Fractionation Study Results

- For the purposes of this study, fractionation is defined as the ratio of a parameter in a specific size fraction to the bulk sample
- For example:

$$\text{NP Fractionation to } < 2 \text{ mm Size Fraction} = \frac{\text{NP in } < 2 \text{ mm Size Fraction}}{\text{NP in Bulk Sample}}$$

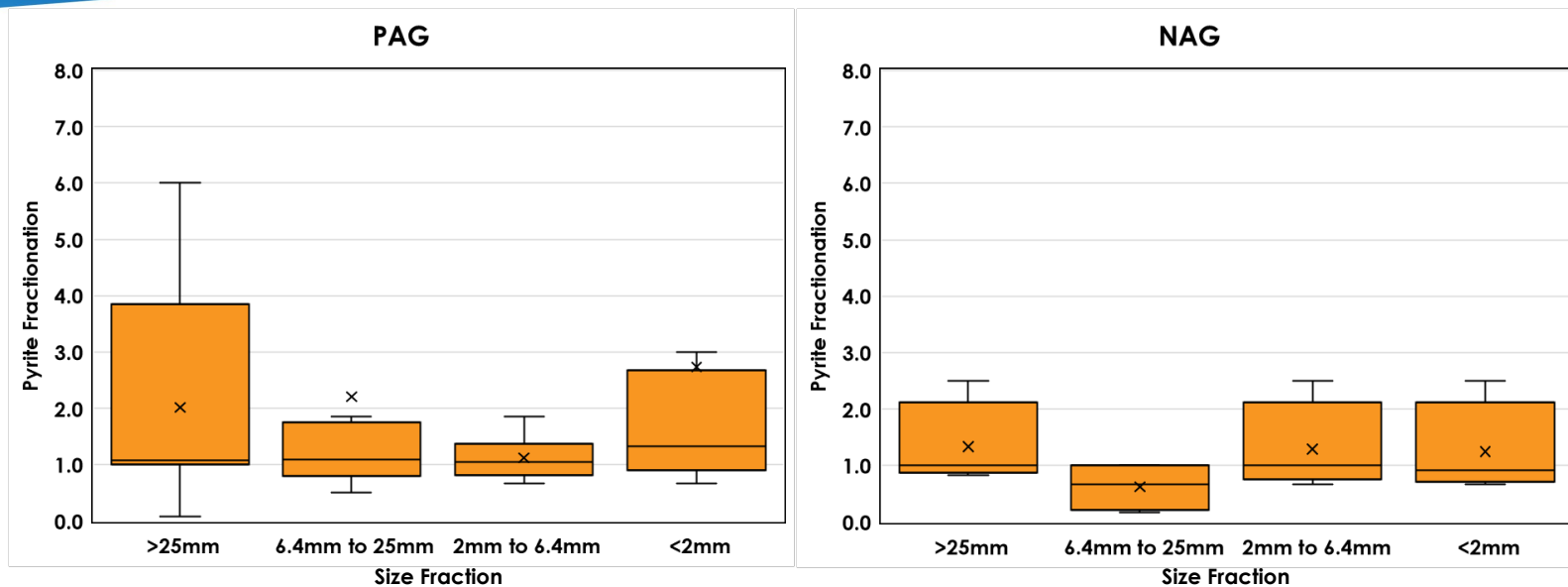
- Fractionation > 1 suggests there is more NP in the < 2 mm size fraction
- Fractionation < 1 suggests there is less NP in the < 2 mm size fraction

Mineral Fractionation – Carbonates



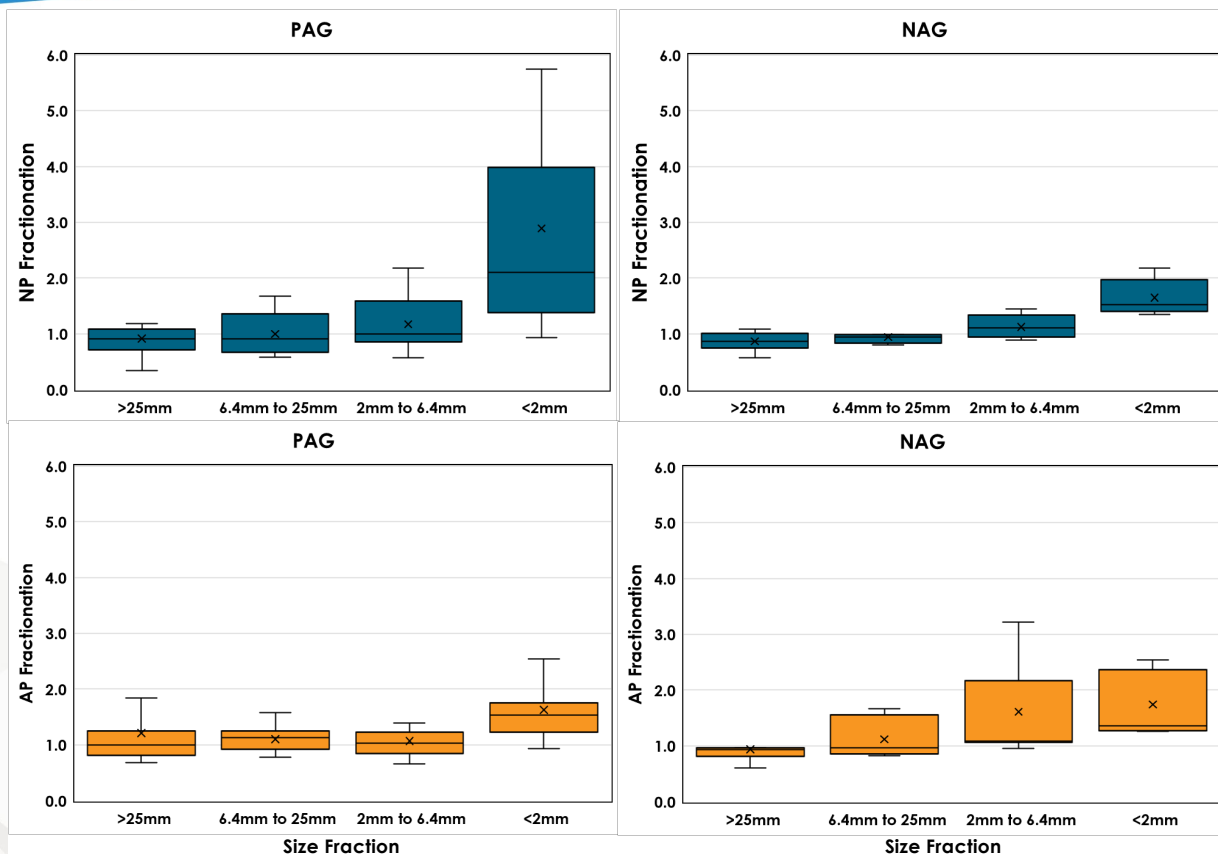
- Calcite is the dominant carbonate mineral in all rock types, with moderate amounts of dolomite
- 0.9 to 5 wt.% calcite + dolomite in PAG samples
- Carbonate fractionation is greatest in PAG samples, but appears to occur in NAG samples as well
- Fractionation is most evident in the -2 mm fraction

Mineral Fractionation – Pyrite



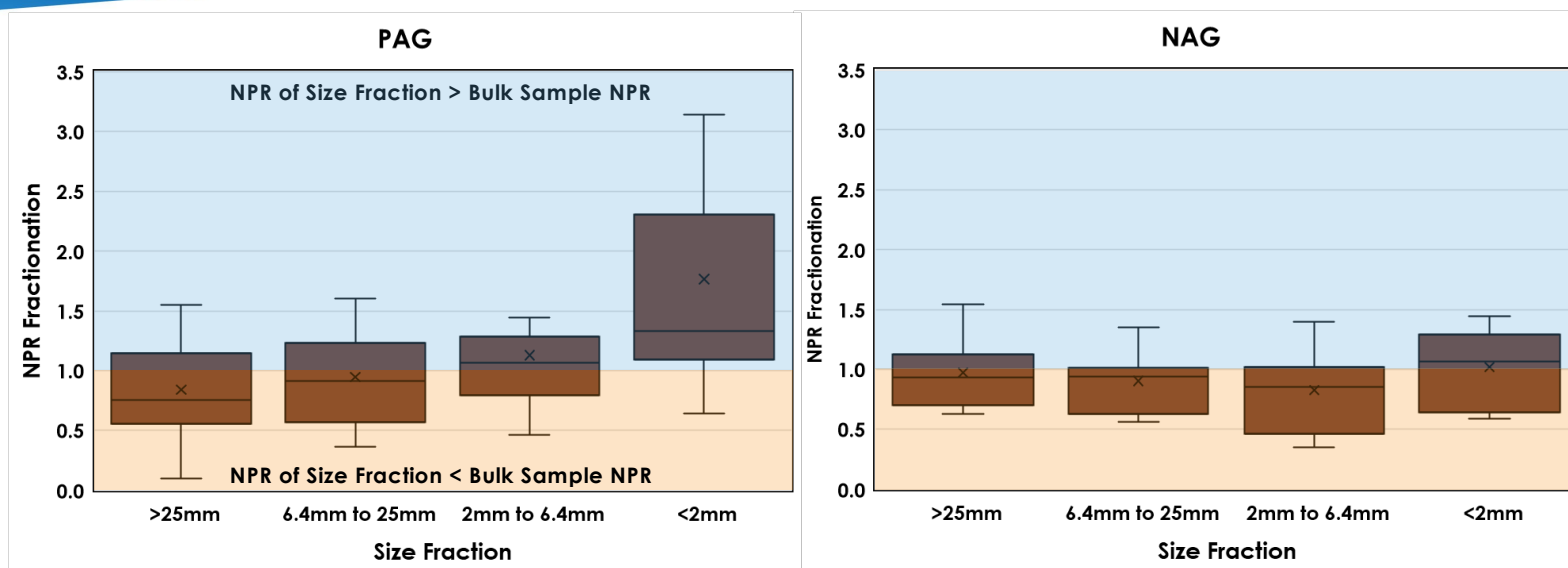
- Pyrite is the dominant sulfide mineral in all rock types
- 0.2 to 2 wt.% pyrite in PAG samples
- Pyrite fractionation is greater in PAG samples, and no clear trend by size fraction

NP and AP Fractionation



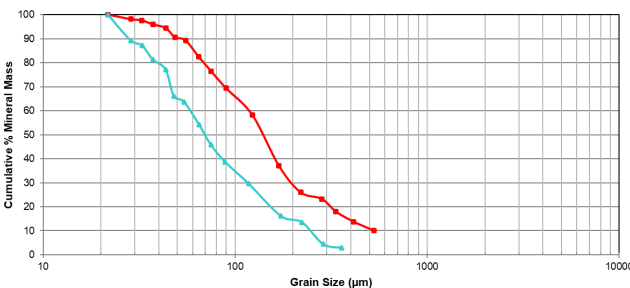
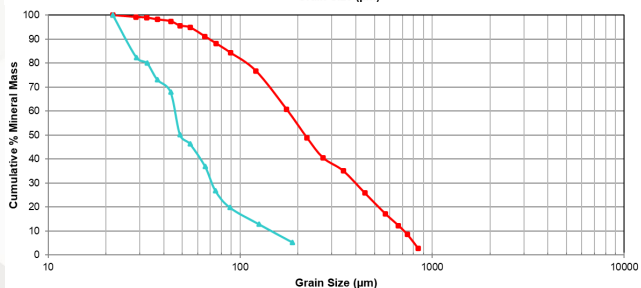
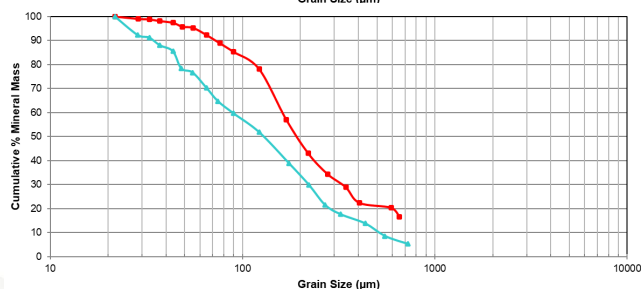
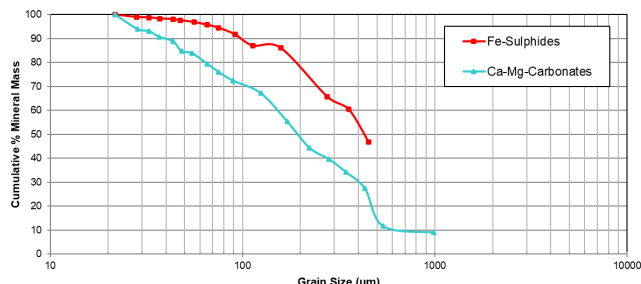
- Total sulfur and carbon used to calculate AP and NP
- AP and NP results generally consistent with mineralogy
- Greatest fractionation occurs with NP in PAG rock
 - **Higher NP in the -2 mm fraction**
- AP and NP fractionate in similar amounts in NAG rock

NPR Fractionation



- The median NPR of the finest fraction (< 2 mm) in the PAG samples is ~1.3x the NPR of the bulk sample
- Coarser fractions are more acid generating in PAG samples, but less reactive
- Fractionation in NAG rock is more uniform across particle sizes

Mineral Grain Size



- Previous QEMSCAN analysis – pyrite grains consistently larger than carbonate grains
- Carbonates generally disseminated through rock matrix (Pelletier, 2016)
- Sulfides generally present in veins (Pelletier, 2016)
- Consistent with observation of more NP in finer fractions

Geochemical Implications

- The < 2 mm size fractions represents the most reactive material (MEND, 2009)
- More NP is available in the blasted finer fractions of PAG material than what is measured in bulk material
- There is functionally more NAG rock if the fractionation of NP to more reactive size fractions is accounted for
- Opportunity to update the classification criteria based on mineral fractionation

PAG/NAG Classification Re-Evaluation

	PAG Samples
NP Fractionation Median	2.10
AP Fractionation Median	1.53
NPR Fractionation Factor	1.37

$$\text{NPR Fractionation Factor} = \frac{\text{Median NP Fractionation (< 2 mm)}}{\text{Median AP Fractionation (< 2 mm)}}$$

$$\text{Adjusted NPR} = \text{NPR} \times (\text{NPR Fractionation Factor}) = \text{NPR} \times 1.37$$

- Applying the NPR fractionation factor to mine rock produced since 2021, 9% of PAG mine rock would be reclassified as NAG

Conclusions

- Blast fractionation of carbonates and sulfides occurs in Rainy River mine rock
 - Carbonates partition to the finer fractions more than sulfides
- Based on the relative amount of NP in the finer-fractions vs. AP, the current NPR calculation could be updated to account for this fractionation
- Takeaways for other mines:
 - Once a mine is operational, consider the potential for mineral fractionation as part of ARD monitoring programs
 - Evaluate the implications for ARD risk and PAG/NAG classification criteria that were developed prior before mining began

Acknowledgments and References

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References

MEND. 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. Report 1.20.1. Prepared by W.A. Price of CANMET.

New Gold Inc. 2022. NI 43-101 Technical Report for the Rainy River Mine, Ontario Canada.

New Gold Inc. 2023. New Gold 2022 Annual Compliance Report.

Okane, 2022. 1003-020-007. Blast Fractionation of Acid and Neutralization Potential in Rainy River Mine Rock.

Pelletier, M. 2016. The Rainy River Gold Deposit, Wabigoon Subprovince, Western Ontario: Style, Geometry, Timing and Structural Controls on Ore Distribution and Grades

Rainy River First Nations. 2023. www.rainyriverfirstnations.com. Accessed December 1, 2023.

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