Mineral Processing Research in Support of an Industrial Critical Mineral Facility in Pennsylvania

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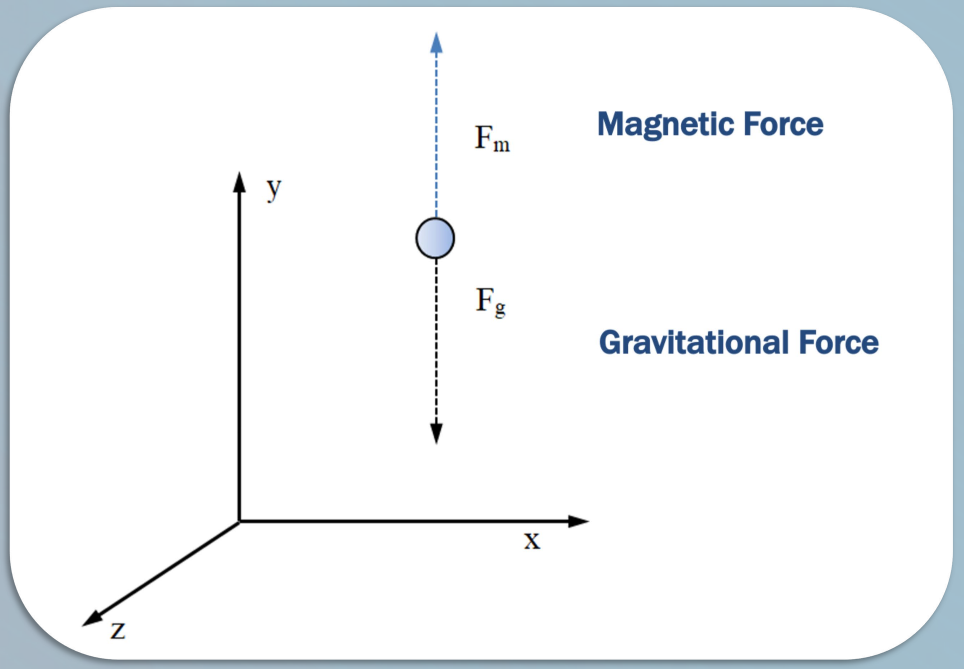
INTRODUCTION

The Mercer Underclay in Pennsylvania is being researched as a source of critical minerals such as Alumina (Aluminum Smelter Feedstock),

Lithium (for Lithium-Ion Batteries), and Rare Earths (for Rare Earth Magnets).

Materia USA is developing production facilities in Pennsylvania for recovery of salable critical mineral commodities from the mercer underclay. Mineral processing includes separating individual minerals by gravity separation, magnetic separation, electrostatic separation, and flotation.

Previous work has been done on the mercer underclay magnetic separation produced a concentrate enriched in Goethite and Tourmaline (Lithium Mineral) and an Anatase, (TiO2)-enriched product



Magnetic Separation (Cross-Belt Separator). Where Magnetic Force > Gravitational Force, the Mineral Particle is separated into the Magnetic Product

RESEARCH OBJECTIVES

The goal is to research the results of the mineral processing for plant design by getting equipment in production mode, this includes:

a. Grinding samples for mineral processing tests

b. Evaluating grinding behavior of mercer clay lithotypes

c. Integration with valid XRF results for real analyses while running mineral processing tests (i.e. **Understanding the XRF**)

Objective Questions

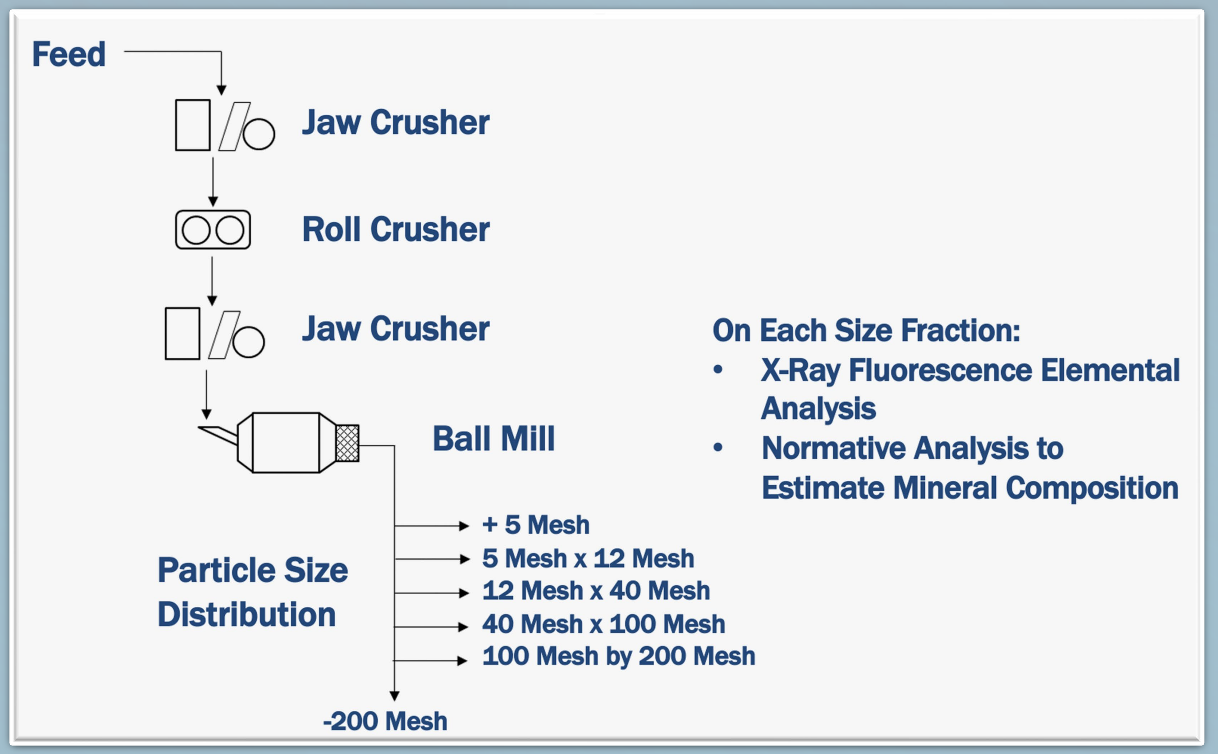
XRF test: Which particles are magnetic?

XRF reproductivity: How do the spread between minimum % and maximum % of the averages of multiple analysis vary with particle size? Do we need to do additional sample preparation on mill products (or products of other mineral processing tests)?

Equipment & Methods

1. Nodule Clay- 1 Hour, 21 kg Media Charge (1.4 cm Balls), 4 kg Feed Charge
2. Semi-flint Clay- 20 Minutes, 21 kg Media Charge (1.4 cm Balls), 4 kg Feed Charge
3. Feed and Products for Both Tests Screened at 5, 12, 40, 100 and 200 Mesh
4. Multiple XRF tests on each size fraction was done to test reproducibility of the XRF
5. New Normative Analysis Technique was developed to estimate mineral composition

Equipment & Method



Flowsheet Representation

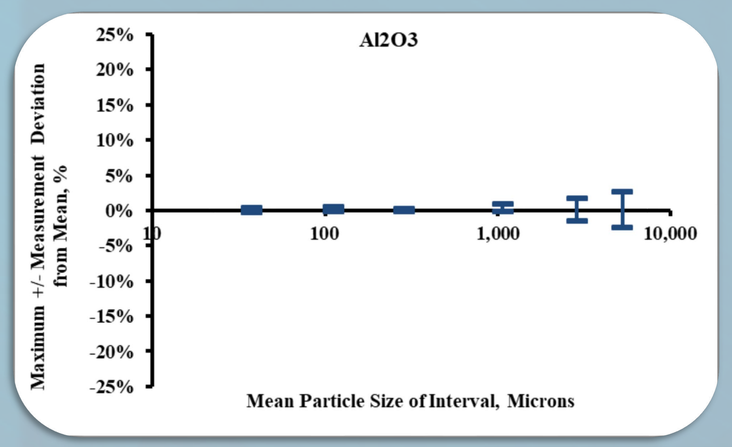
Run	1	2	3	4	5	6	7	8	9	10	11
Al_2O_3	43.3%	41.1%	39.7%	39.4%	39.4%	39.2%	39.2%	39.2%	39.2%	39.2%	39.2%
SiO_2	56.7%	50.8%	48.1%	47.5%	47.5%	47.3%	47.3%	47.3%	47.2%	47.2%	47.2%
Fe_2O_3		8.1%	8.4%	8.4%	8.4%	8.5%	8.4%	8.4%	8.4%	8.4%	8.4%
TiO_2			3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%
K_2O				0.9%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
MgO					0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Na_2O					0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CaO					0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S						0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
P						0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Cl						0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Zr							0.1%	0.1%	0.1%	0.1%	0.1%
Ba								0.0%	0.0%	0.0%	0.0%
Cu, Br, Sn, Sc, Cr									0.0%	0.1%	0.1%
Mn, Co, Ni, Ce, Y, Hf										0.0%	0.0%
Rb, W, Ta											0.0%
Total	100.0%	100.0%	99.9%	100.0%	100.0%	100.1%	100.0%	100.0%	99.9%	99.9%	99.9%

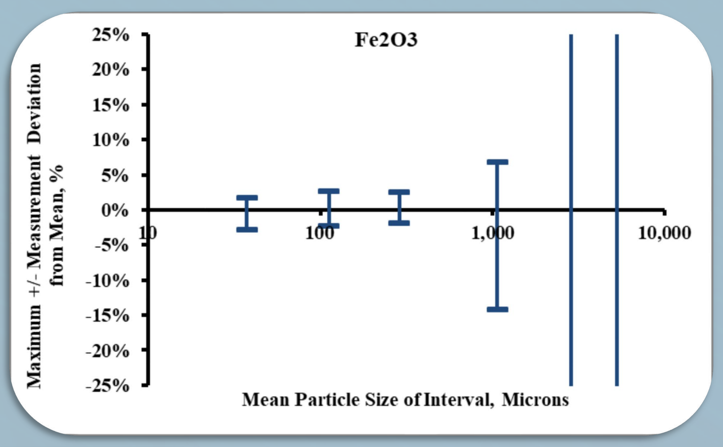
The XRF:
11 Runs processing the same test, each run had elements added beyond the previous run. We found that they add up to 100% in each case. Underclays are Clay-Rich, the XRF needs to be asked to look for major Oxides rather than elements

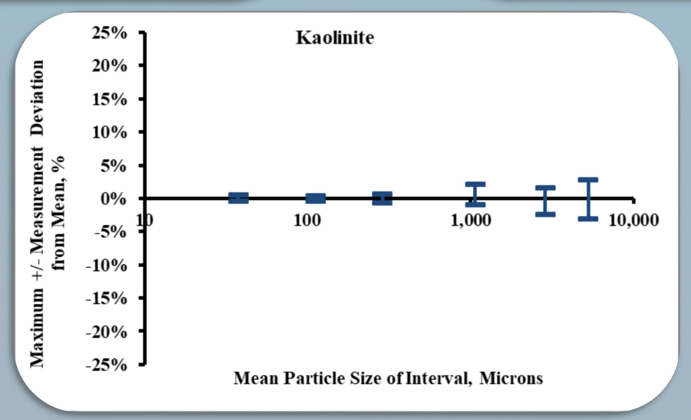
Normative Analysis:
In order to estimate mineral composition, a technique was developed involves converting some oxides into the mercer clay that corresponds to each oxide. For example: Fe_2O_3 analysis was used to calculate Goethite and TiO_2 to calculate Anatase composition

Data Set	1b	2b	3b	4b	5b
Material	Nodules	Nodules	Nodules	Nodules	Nodules
Type	Mill Product	Mill Product	Mill Product	Mill Product	Mill Product
Topsize	100 Mesh	100 Mesh	100 Mesh	100 Mesh	100 Mesh
Bottom Size	200 Mesh	200 Mesh	200 Mesh	200 Mesh	200 Mesh
Measured					
Wt% TiO_2	3.57%	3.50%	3.51%	3.40%	3.52%
Wt% Fe_2O_3	7.31%	7.19%	7.09%	6.96%	7.09%
Wt% MgO	0.00%	0.00%	0.00%	0.00%	0.00%
Wt% K_2O	0.58%	0.64%	0.67%	0.62%	0.70%
Wt% Al_2O_3	40.40%	40.40%	40.50%	40.70%	40.50%
Wt% SiO_2	47.80%	47.90%	47.90%	48.00%	47.80%
Wt% CaO	0.00%	0.00%	0.00%	0.00%	0.00%
Wt% Na_2O	0.00%	0.00%	0.00%	0.00%	0.00%
Calculated					
Wt% Anatase	3.57%	3.50%	3.51%	3.40%	3.52%
Wt% Goethite	7.31%	7.19%	7.09%	6.96%	7.09%
Wt% Kaolinite	85.86%	85.79%	85.64%	86.07%	85.36%
Wt% Illite	2.48%	2.73%	2.87%	2.63%	2.97%
Wt% Chlorite	0.00%	0.00%	0.00%	0.00%	0.00%
Wt% Quartz	0.00%	0.00%	0.00%	0.00%	0.00%
Wt% Diaspore	0.08%	0.02%	0.14%	0.23%	0.23%
Total	99.30%	99.23%	99.25%	99.29%	99.17%
CIA	98.47%	98.31%	98.23%	98.39%	98.17%

Results







CONCLUSIONS and Future Research

- Sample preparation is needed on mill products especially the ones that have significant particle size effect before taking them to the XRF.
- The new Normative analysis technique gives an estimation of the mineral composition from the XRF results
- The technique determines if we are confident about the test results and if we can use them

Further work involving this research could include:

- Laboratory magnetic separator tests
- Calculation of the force balance around particles that have mixtures of minerals

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