Develop and test an integrated Acid Mine Drainage treatment and REE/CM extraction plant

USDOE Project DE FE00 31834

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PARTICIPANTS

Research team

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- Jim Constant, Plant Manager
- David Hoffman, Chemist
- Harry Finklea, PhD: Chemistry
- Lance Lin, PhD, CEE
- John Quaranta, PhD, CEE

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Aaron Noble, PhD, Mineral Process Engineering

- Tom Larochelle

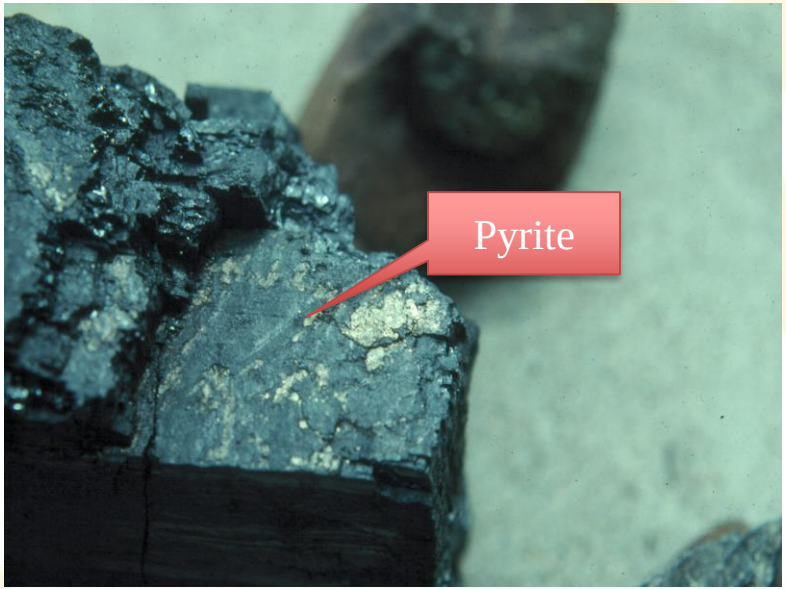
External partners

- West Virginia Dept. of Environmental Protection
- Rockwell Automation Inc.
- TenCate Corporation

ACID MINE DRAINAGE: AMD

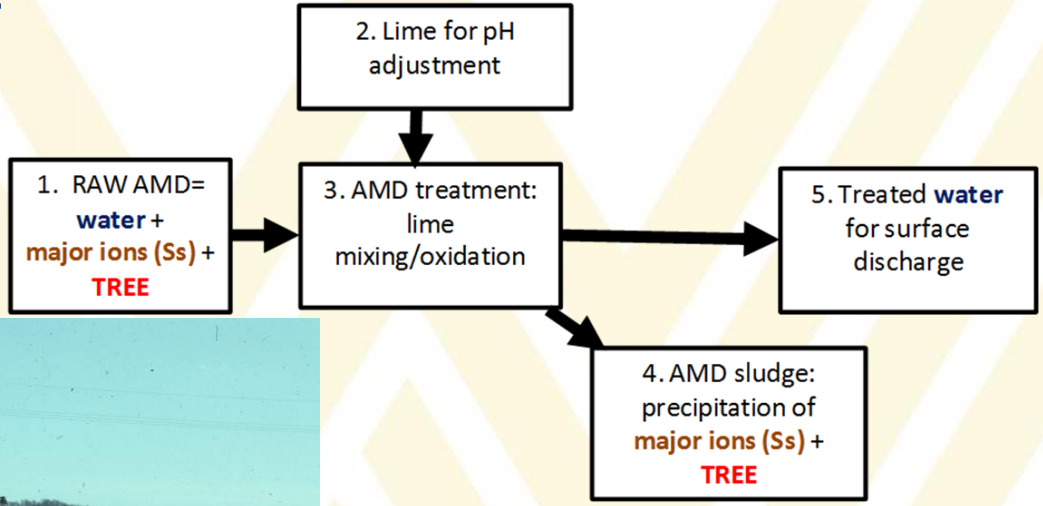
1. H_2SO_4 LEACHES REE FROM SHALE
2. REE PRECIPITATE WITH $FE(OH)_3$

$$Pyrite + O_2 + H_2O = Fe^{2+} + H_2SO_4$$

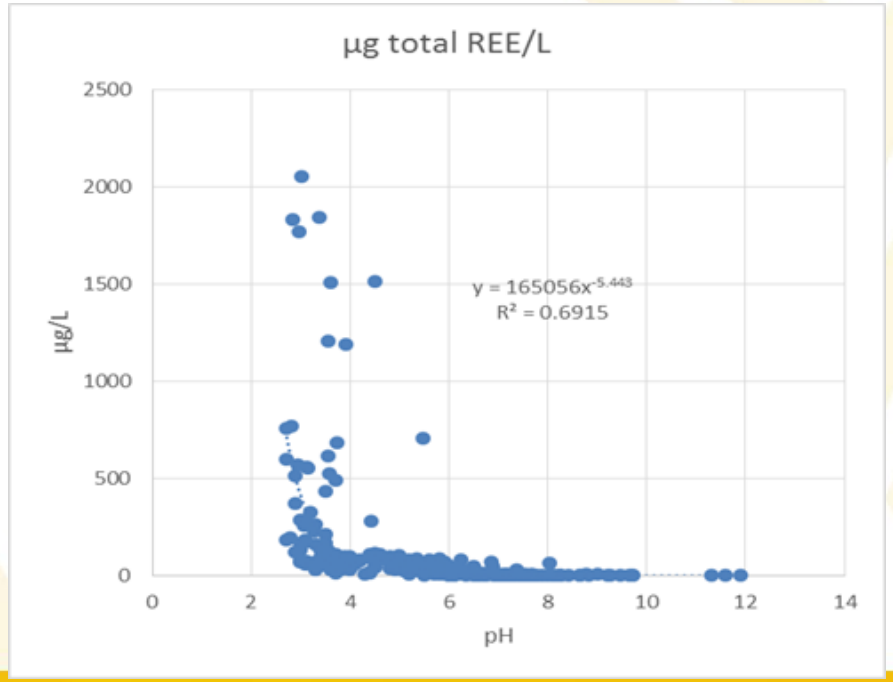


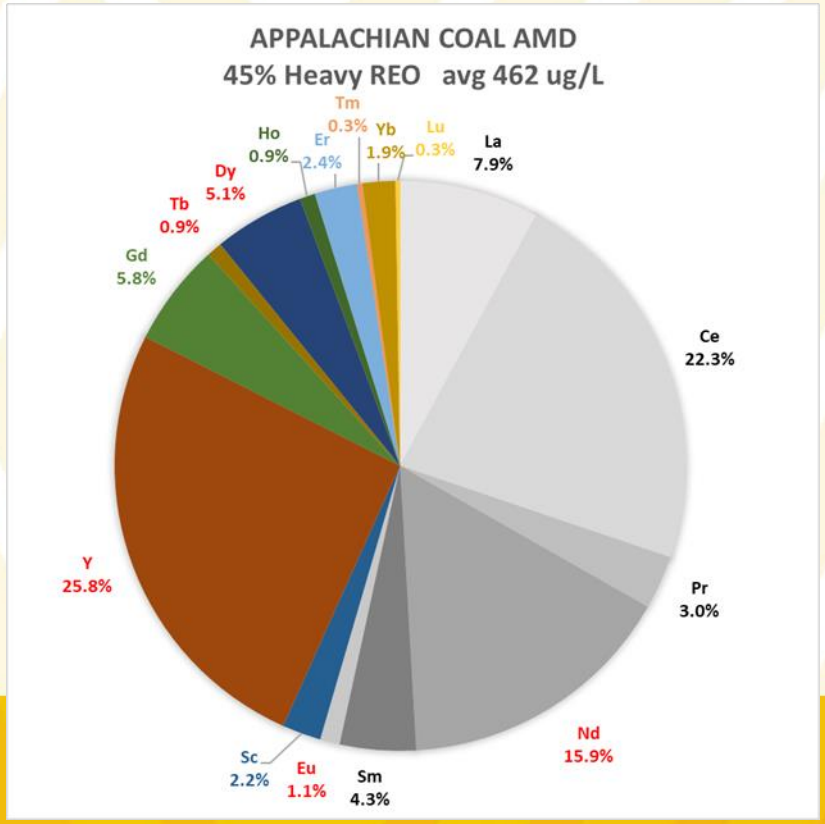
$$Fe^{2+} + O_2 + OH^- = Fe(OH)_3$$

AMD TREATMENT



Acid mine drainage:
pH < 5, elemental distribution is consistent

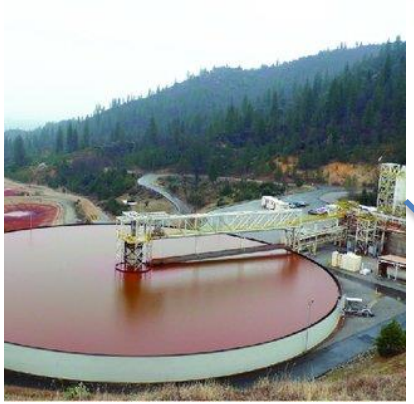




Scaleup to at source REE recovery

- Mobile extraction unit operated at WVDEP's Omega AMD treatment plant
- Field concentrates averaged 0.5% TREE
- Feedstock was supplied to SX plant at WVU

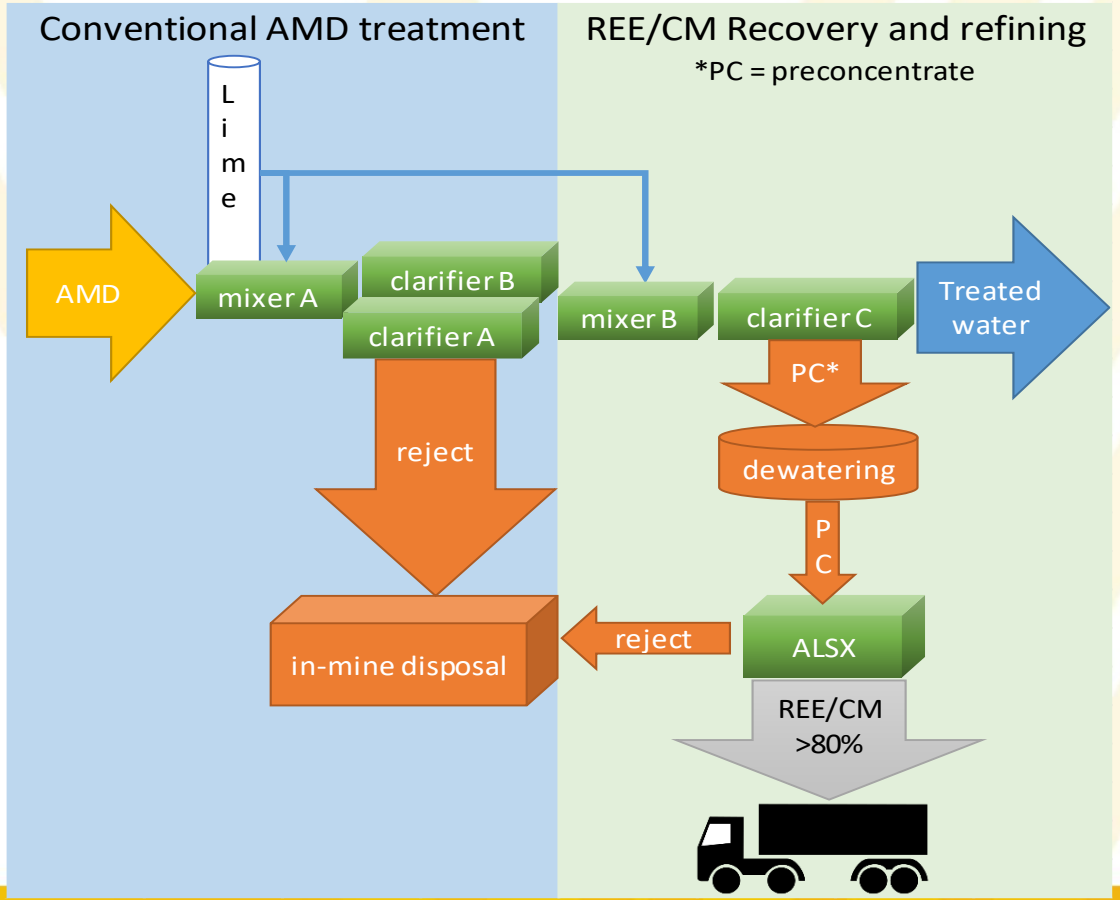
Conceptual supply chain: Concentrates move to central processing facilities



Potential source districts

A: Northern/Central APP
B: Southern APP/Illinois basin
C: Southern Rockies metal belt
D: Sierra metal belt
E: Northern Rockies metal belt
F: Iron range

Recovery strategy 1: Integrated AMD/REE/CM plant



ETD67: Mt. Storm Pilot Plant

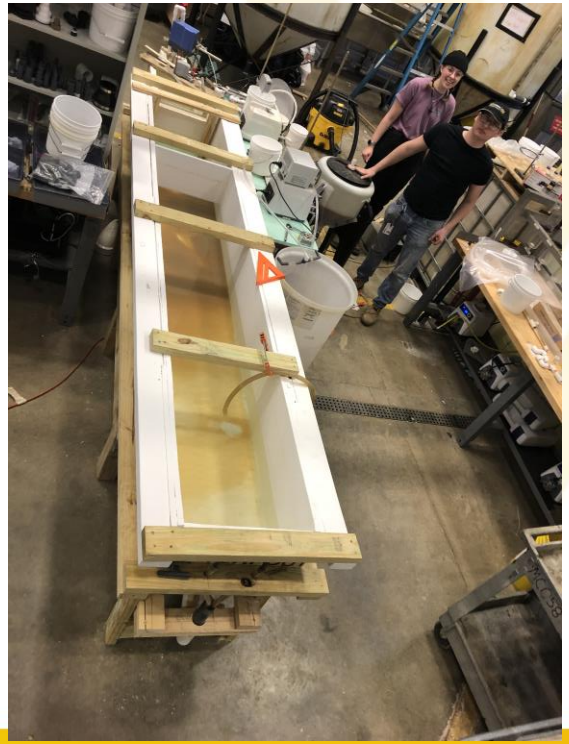
AMD treatment: Up to 1,000 gpm,
Production rate ~ 1 tpy each:
TREE, Cobalt, Nickel.

Recent Developments: Upstream Processing

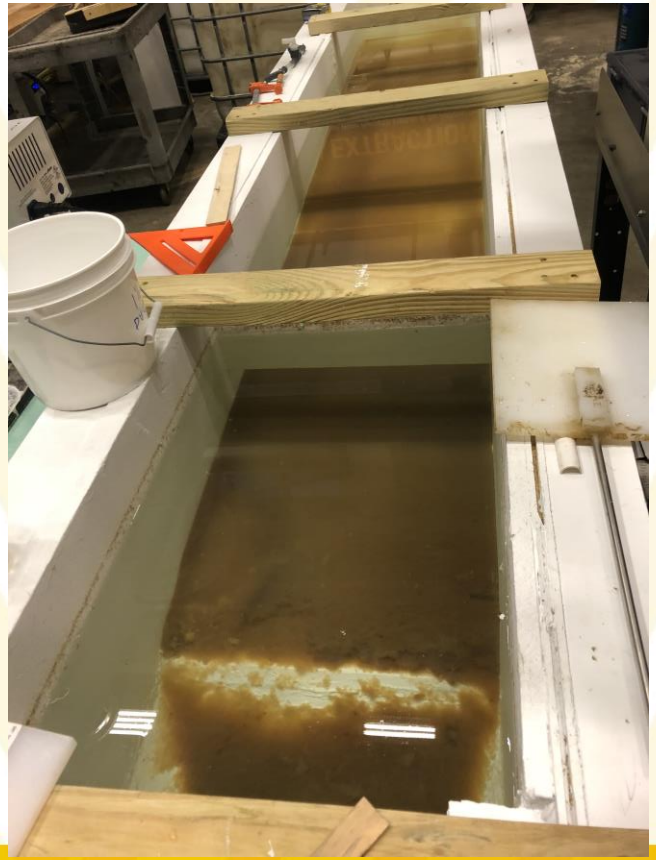
- HPC: Hydraulic pre-concentrate
  - Grade improvement
  - Dewatering for transport
- High volume production/recovery in the lab
  - 1:10 scale clarifier
  - Processed 10,000 gal of site A34 AMD
- PLS: Pregnant leach solution-feedstock to solvent extraction
  - Grade improvement
  - Removal of deleterious gangue
- A34 Plant construction
  - Building delivery by end of August 2021
  - Commission by early Fall 2021

Scaleup to the A34 plant

1:10 scale clarifier in the lab



Floc reporting to clarifier sump



Recovery Strategy 2. Remote sites

1. Generate pre-concentrate (brown floc)
2. Passively dewater to 85% solids (brick)
3. Transport to a central processing facility
4. Convert it to high-grade PLS (green), then MREO

Pre-conc. TREE: 0.5%

0.1% solids

Brick TREE: 0.5-5.0%

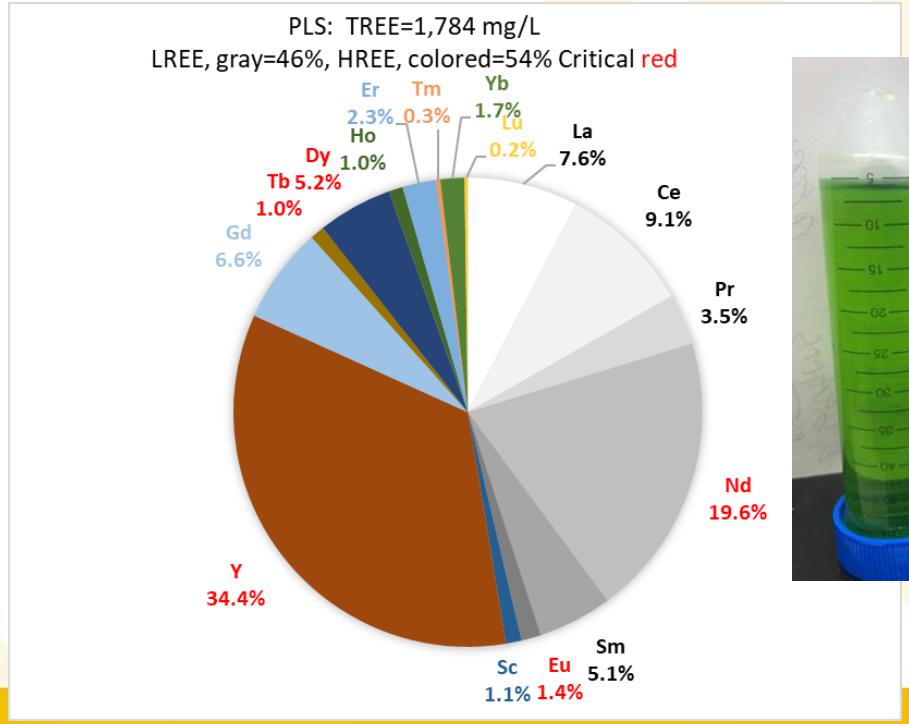
Hi grade PLS

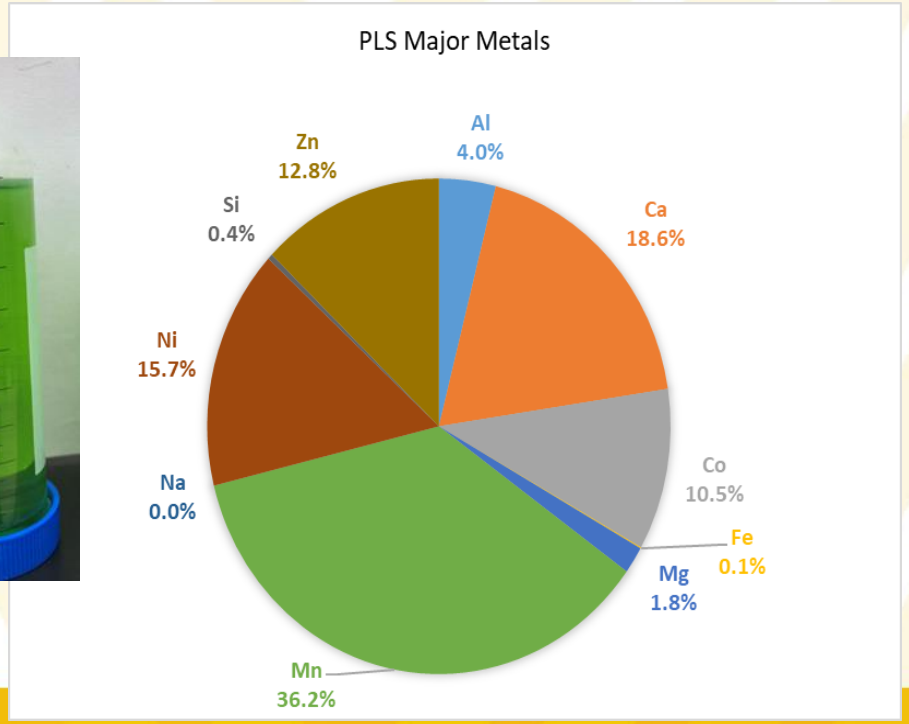
PLS TREE: 100-1,800 mg/L

MREO

MREO TREE: 90-99%

Recent PLS production: 1,784 mg TREE/L, 54% HREE almost no Al, Si

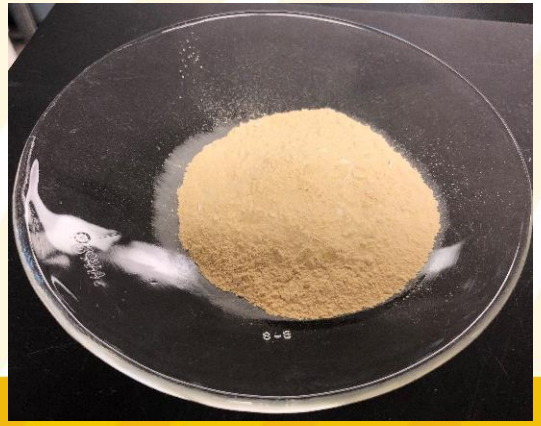




Acid Mine Drainage as an REE/CM Feedstock

1. Opportunity: Low cost, already permitted sites, environmentally beneficial
2. Resource Assessment: Northern/Central Appalachian Coal
    1. AMD: 800 tpy
    2. AMD treatment sludge: 350 t in-place
3. Our Pilot Plant:
    1. Bench scale pilot Installed 2018
    2. Field scale pilot under construction, Building delivery August 2021
        1. Production rate: ~1 tpy each: TREE, Cobalt, Nickel.
        2. 27 tpy Manganese: maybe, economic assessment underway
4. Potential Market Size:
    1. U.S. market: 20,000 t REE/year
    2. U.S. defense industry: 1,000 t REE/year
5. Resulting Technology
    1. 1 U.S. patent issued
    2. 1 Active provisional patent
6. Greatest Achievement from Pilot:
    1. Continuous process flowsheet
    2. High grade MREO product
7. Greatest Challenge: Develop domestic supply chain

REE Product: 99% purity



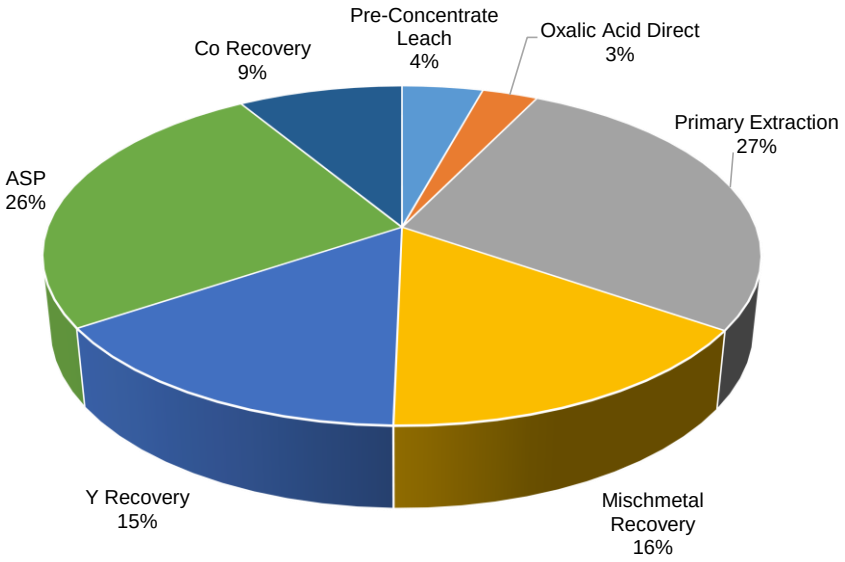
Estimated MREO production rate at A34 Similar levels of

a. cobalt, nickel
b. 27x manganese

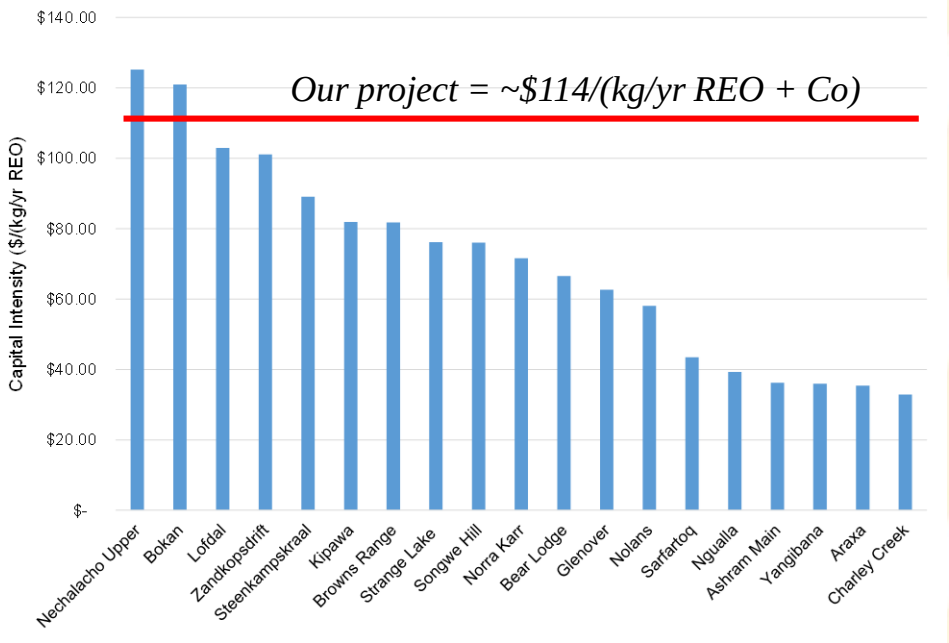
Original prediction		
Q AMD	500	gpm
Q AMD	1892.5	L/m
TREE	1	mg/L
TREE yield	2.7	kg/day
	992.1	kg MREO/year

Current prediction		
Q AMD	500	gpm
Q AMD	1893	L/m
HPC	709	kg/day
HPC grade	0.5%	TREE
TREE yield	3.5	kg MREO/day
TREE yield	1,293.1	kg MREO/year

Conceptual Study – Capital Cost Estimate*



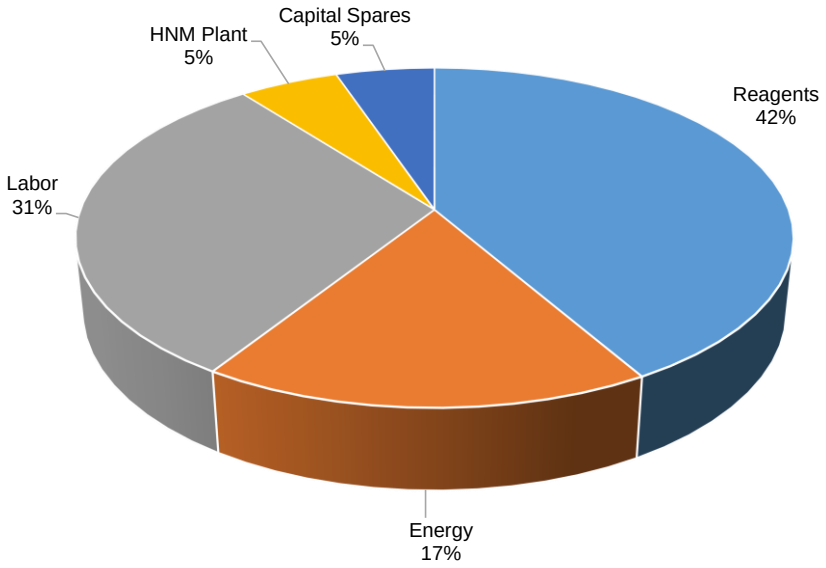
* The comparison project economics are based on old, much higher REE prices. Our analysis uses current, much lower values. Still, our economics are favorable.

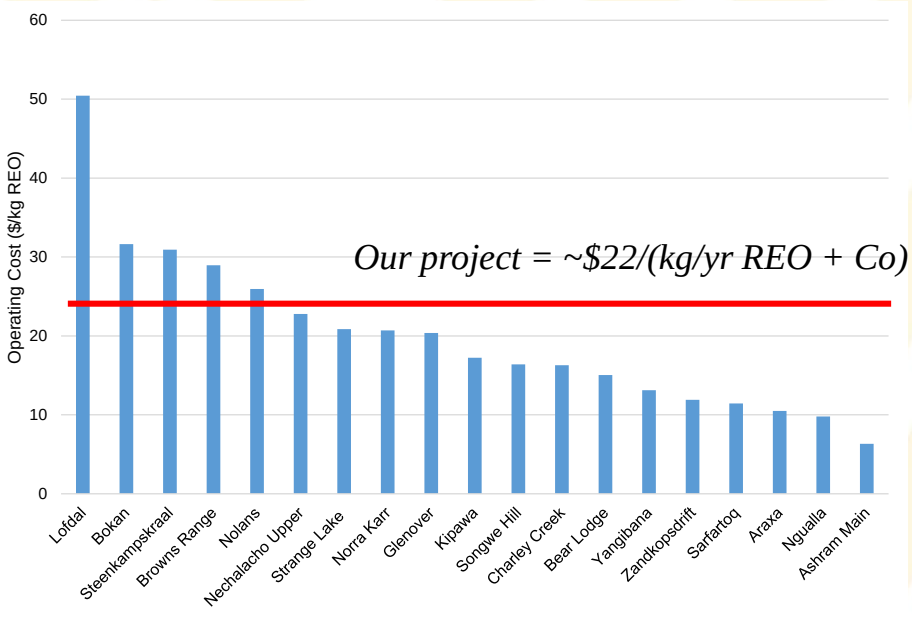


Capital Cost Comparison for Complete Facility

Conceptual study conducted as a part of: ContractNumber_89243320CFE000059

Conceptual Study – Operating Cost Estimate*





Operating Cost Comparison for Complete Facility

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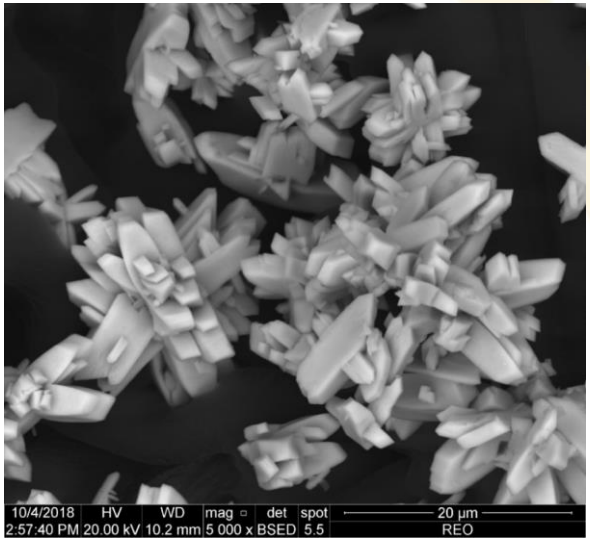

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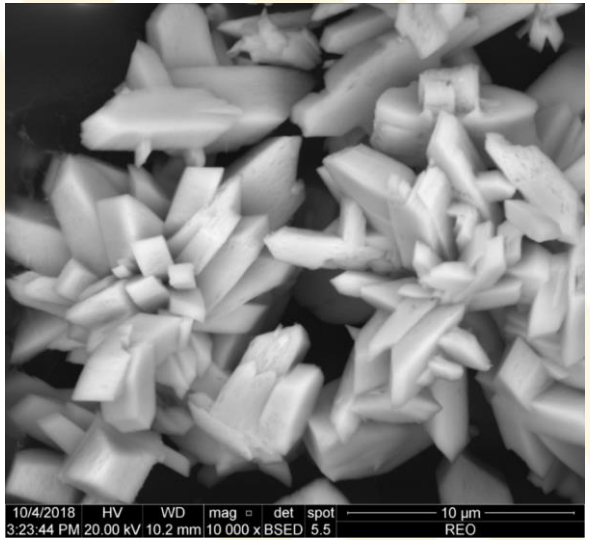
Questions?



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