

OCCURRENCE AND DISTRIBUTION OF RARE EARTH ELEMENTS IN ACID MINE DRAINAGE PRECIPITATES: RESULTS OF A REGIONAL SURVEY

USDOE PROJECT DE FE00 26444

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AMDTF

26 mar 19



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USDOE/NETL PROJECTS

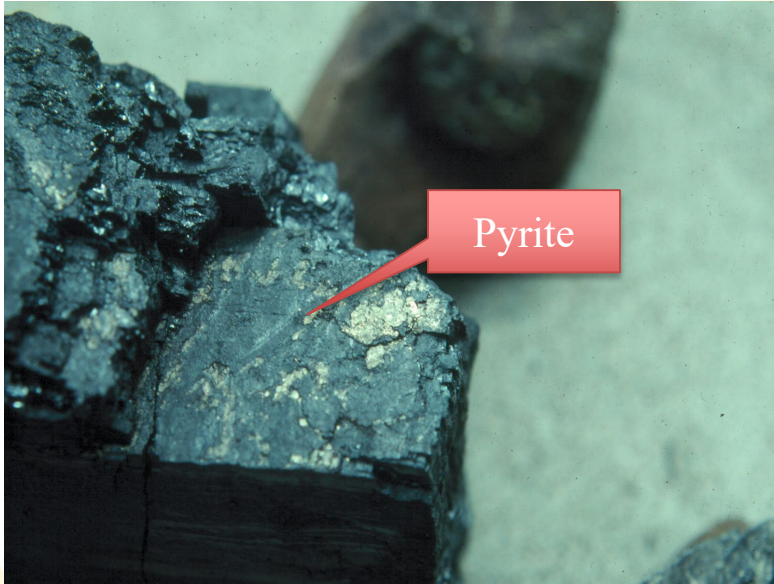


- SOL 9067: Prove significant supply to the domestic REE market
 - Characterize and quantify the reserve base
- FOA 1202: Feedstock TREE > 300 mg/kg
 - Concentrate TREE > 2%
 - Small scale demonstration
- FOA 1718: At Source TREE recovery from AMD
 - Concentrate TREE > 90%

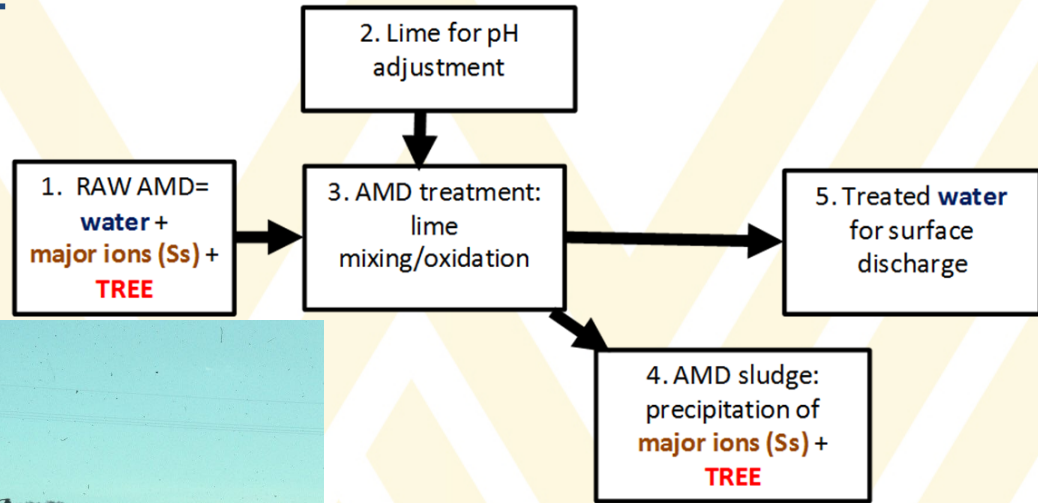


ACID MINE DRAINAGE: AMD

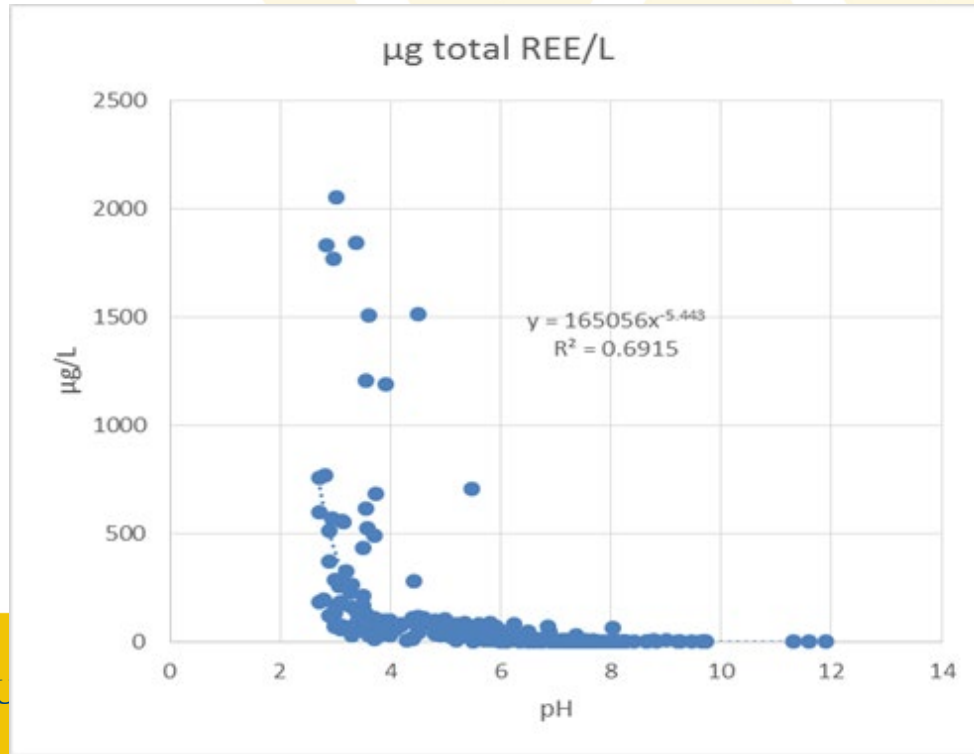
1. H_2SO_4 LEACHES REE FROM SHALE
2. REE PRECIPITATE WITH $\text{Fe}(\text{OH})_3$



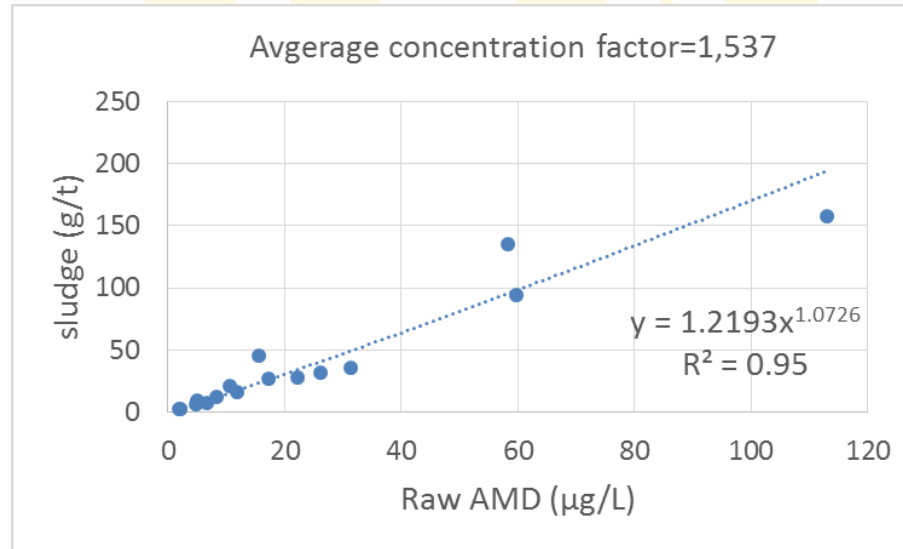
AMD TREATMENT



ACID MINE DRAINAGE: TREE CONCENTRATION VS. RAW WATER PH



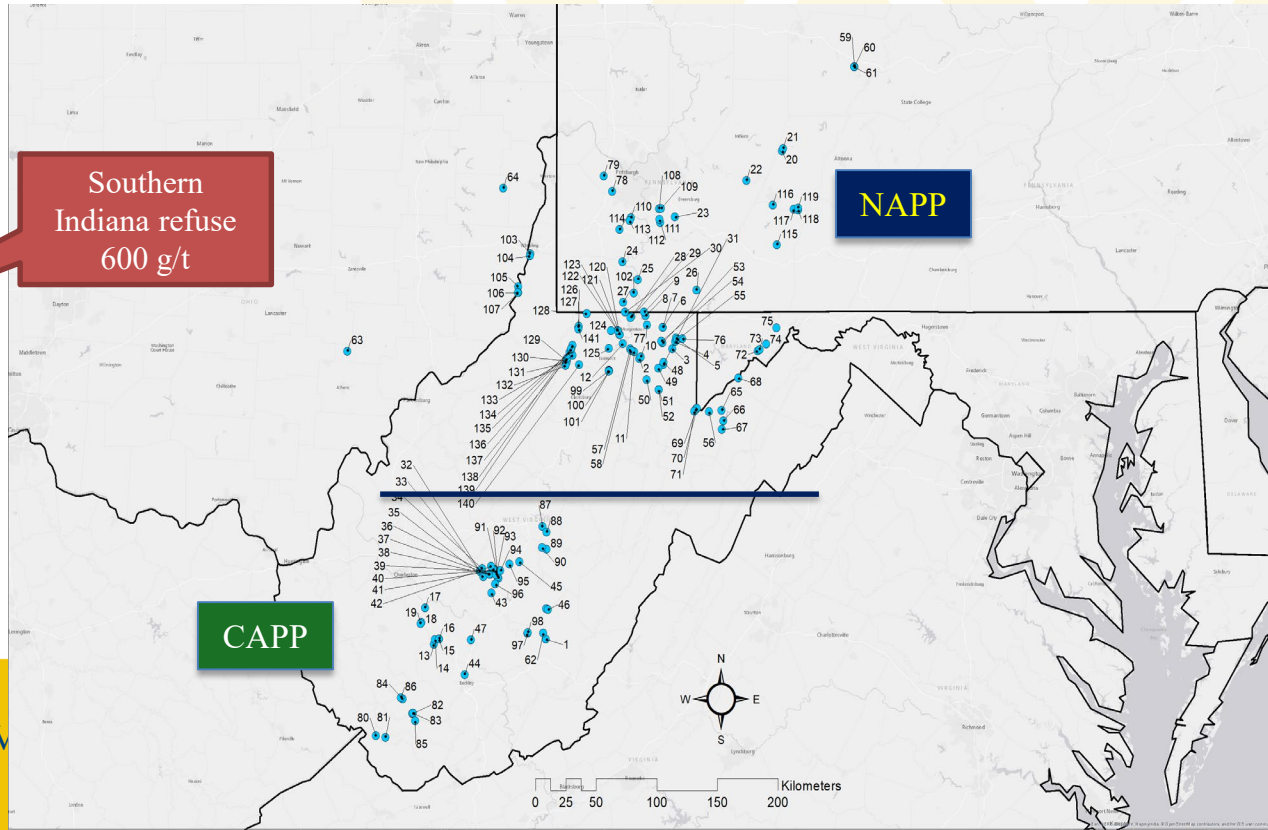
REE PRESENT IN LOW CONCENTRATIONS IN AMD. STRONGLY CONCENTRATED IN SLUDGE



Excellent correlation between REE concentrations in raw water and sludge



Regional AMD sampling program DE FE 0026444



West V

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AMD treatment concentrates REE from aqueous to solid phase to about 700 g/t

REE in NAPP vs. CAPP whole coal

Pittsburgh Seam

mg TREE/kg

max 146.3

mean 34.6

min 7.3

st. dev. 22.0

NAPP

Eagle Seam

mg TREE/kg

max 225.7

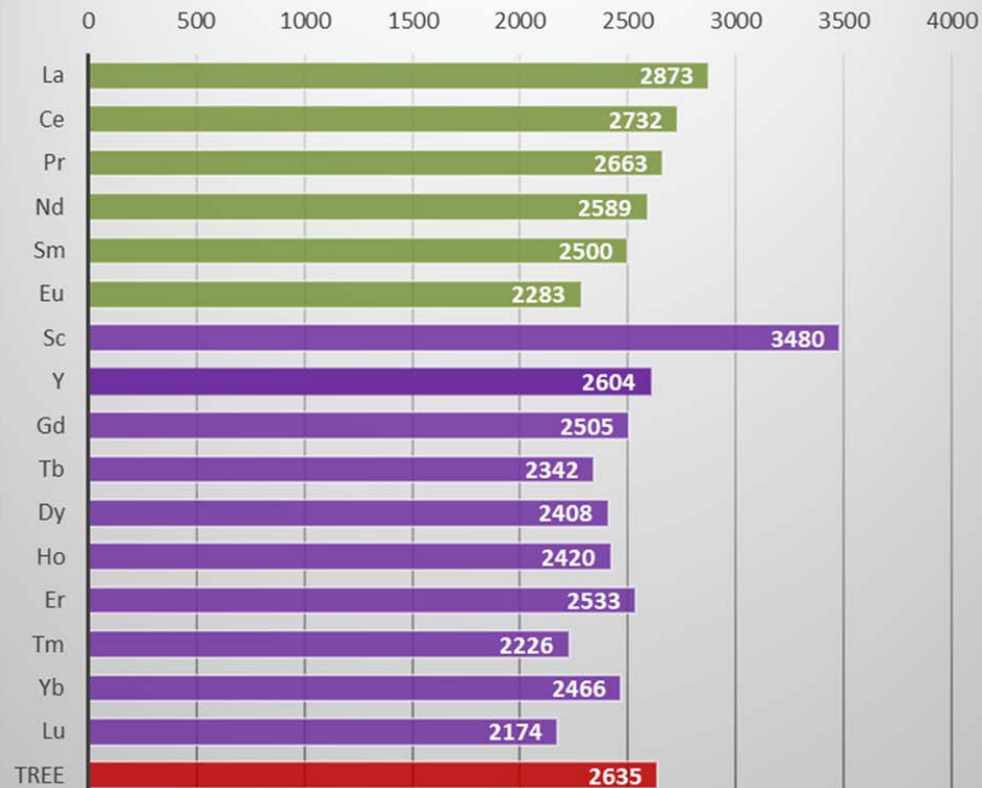
mean 49.5

min 9.3

st. dev. 42.2

CAPP

Concentration factor



RESOURCE CHARACTERIZATION, VALUATION

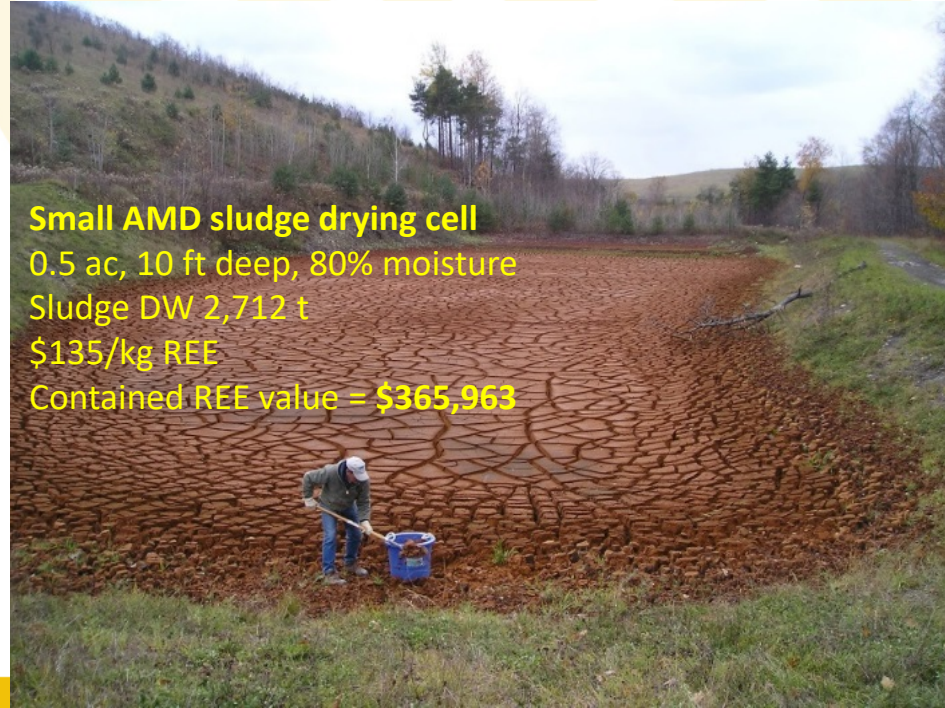
Metal value: \$555/kg each REE Processed to pure metal
Oxide value:

Basket price: \$237.23/kg TREE
weighted value

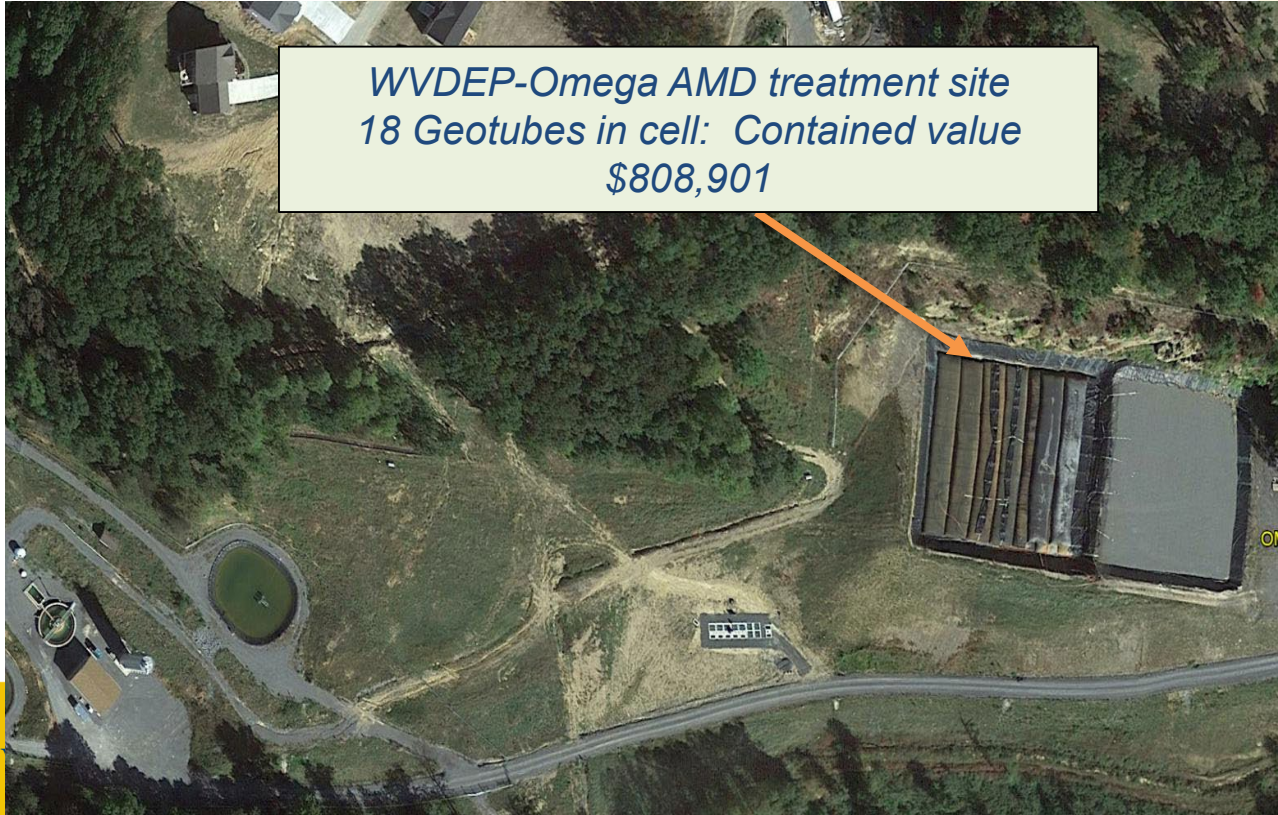
Contained value: \$166/t dry sludge
accounts for handling and processing



CONTAINED SLUDGE VALUE=MARKET VALUE OF REES EXCLUDING TRANSPORT AND PROCESSING



ACCESSIBILITY/EXTRACTABILITY/DEWATERING



*WVDEP-Omega AMD treatment site
18 Geotubes in cell: Contained value
\$808,901*

ESTIMATED REE PRODUCTION CAPP/NAPP



Sludge cells sampled, this project		76
Sludge volume (Dry)	482,915	m ³
Sludge mass (Dry)	1,062,413	tons DW
average TREE grade	663	g/t
TREE mass	350	tons
REE Basket Price (MREO)	\$ 237.23	/kg TREE
estimated CV	\$ 79,633,629	

Estimated annual REE production: Appalachian Basin

	low	High
AMD production	1,503,371	6,626,156 gpm
avg. TREE concentration	0.269	0.269 mg/L
Annual TREE production	807	3,555 tons/year
REE Basket Price (MREO)	\$ 237.23	\$ 237.23 /kg
Contained TREE value	\$ 191,362,343	\$ 843,435,793 /yr



MOUNTAIN PASS RESERVE STATEMENT JANUARY 2012¹

			Contained TREG	Recoverable TREG
	<u>Tons</u>	<u>TREG %</u>	<u>Tons</u>	<u>Tons</u>
Proven	155,767	8.45%	11,935	6,570
Probable	<u>18,266,775</u>	<u>7.98%</u>	<u>1,321,723</u>	<u>727,593</u>
Proven + Probable	18,422,542	7.98%	1,333,658	734,163

¹SRK Consulting, 2012.



THE AMD SLUDGE RESOURCE

Key findings:

REE content, untreated coal mine AMD

CAPP	233.5	µg/L
NAPP	304.2	µg/L
all	286.9	µg/L

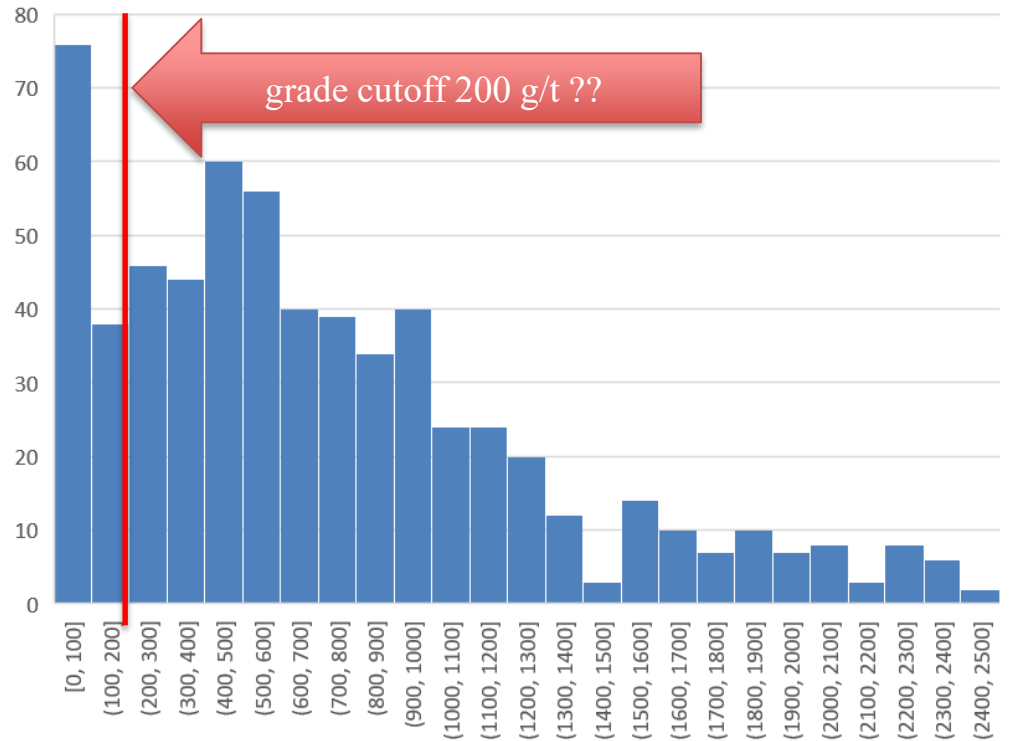
REE content AMD sludge:

CAPP	666.4	g/t
NAPP	750.6	g/t
all	708.5	g/t

Available REE stored at mines

350 t
\$ 80 million

Frequency distribution: Sludge REE concentration (n=631)



BENCH-SCALE, CONTINUOUS FLOW PLANT

ROCKWELL AUTOMATION IS PROVIDING CONTROLS, SENSORS AND EXPERTISE

AL/SX pilot



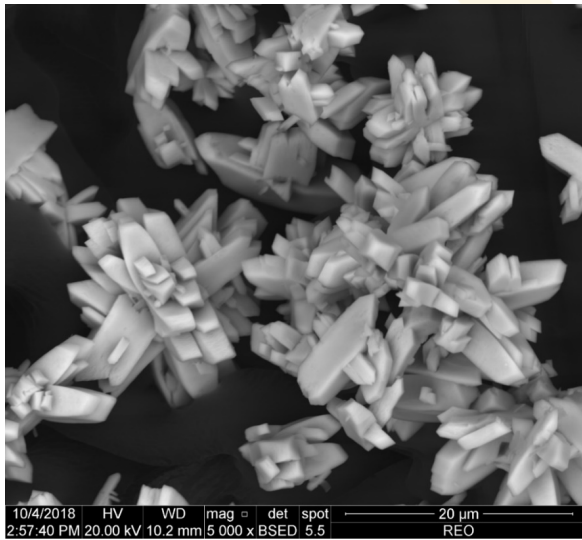
Rockwell's Support



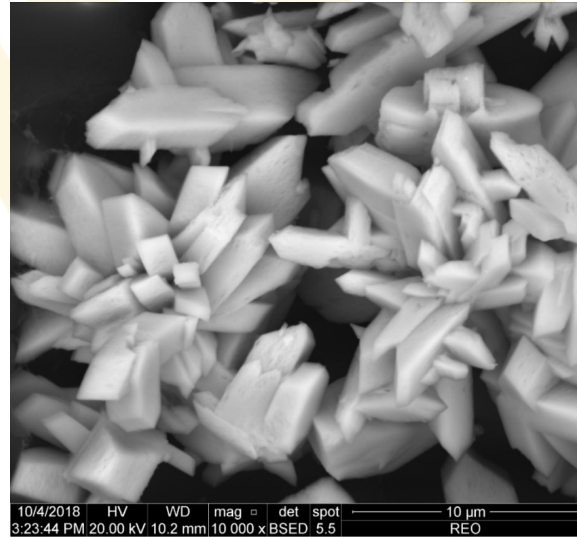
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Questions?



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