

METALLIC: The Minerals to Materials Supply Chain Research Facility

Center 1: Feedstock Beneficiation



METALLIC Industry Event
July 27, 2026

Meet the Team: METALLIC Center 1 - Beneficiation



Scott Montross
Center 1 Lead



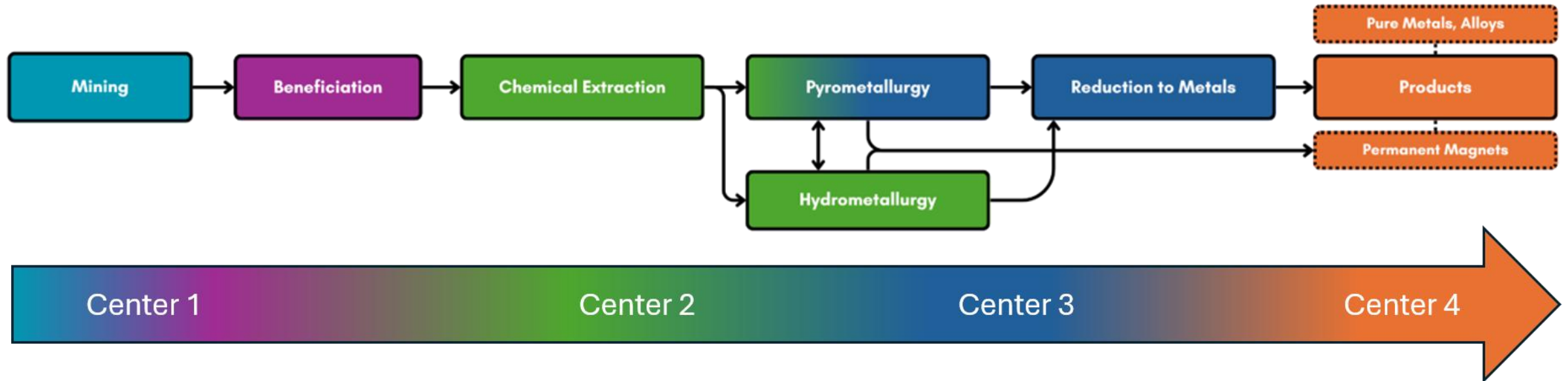
Bob Fox
Center 1 Co-Lead



Michael Whittaker
Center 1 Co-Lead

How Center 1 (Beneficiation) fits into METALLIC structure

Building collaborations and workflow across teams



Center 1: Feedstock Beneficiation

Advancing commercially scalable beneficiation solutions

Flagship Activities

1. Characterization & Liberation Analysis
2. Ore Processing & Optimization
3. Brine Testbeds & Automation

Outcomes

- **Accelerate Pathway Selection:** Using rapid, precise lab- and pilot-scale evaluations to integrate cutting-edge comminution circuits.
- **Enable Bulk Production and Scaling:** Generate up to multiple tonnes of products to support further processing at collaborating research centers.
- **Provides Configurable Testbeds:** Delivers "real-world" field validation with deployable units tailored to specific feedstocks and technologies



Flagship # 1: Characterization & Liberation Analysis

What METALLIC Offers:

- High-precision analytical equipment and expertise to support rapid chemical, molecular, and atomic characterization of critical mineral feedstocks and processed material.
- Impact beneficiation strategies, coproduction, byproducts produced, deleterious materials, and waste stream management strategies, etc.

Existing Capabilities:

- Quantitative Bulk Composition & Microanalysis
- Mineral Mapping, Elemental Mapping & Deportment
- Lab-scale feedstock preparation & testing
- NORM/TENORM characterization and processing

New Capabilities:

- Automated Mineral Liberation Analysis workflow
- WD XRF for analysis of powders, liquids, and fusions
- Multi-sensor Core Logger to automate drill core or chips analysis

New Characterization Capabilities Coming Online



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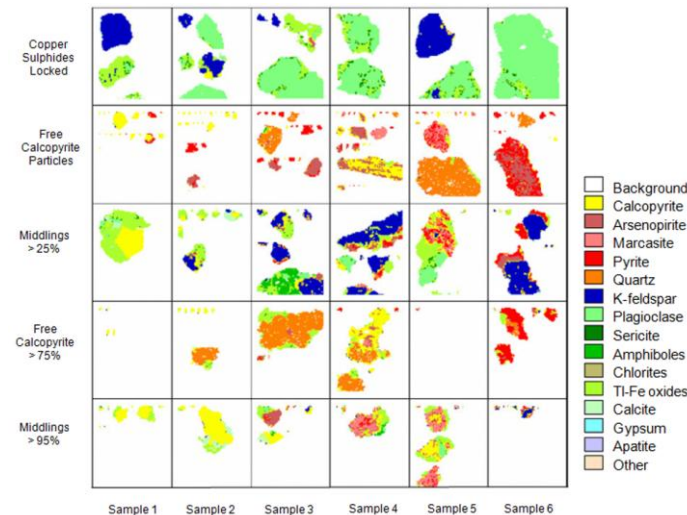
Hypermodal Intelligent Platform for Aqueous Separation Science (**HIPASS**)

Chemostatic reactor + autonomous prep, characterization, feedback

- crystallization
- dewatering
- sedimentation
- etc.



EPMA-SEM-MLA Analysis



Medical X-ray CT scanner is available for **METALLIC** to perform rapid, non-destructive 3D structural imaging of whole drill cores.

Flagship #2: Ore Processing & Optimization

What METALLIC Offers:

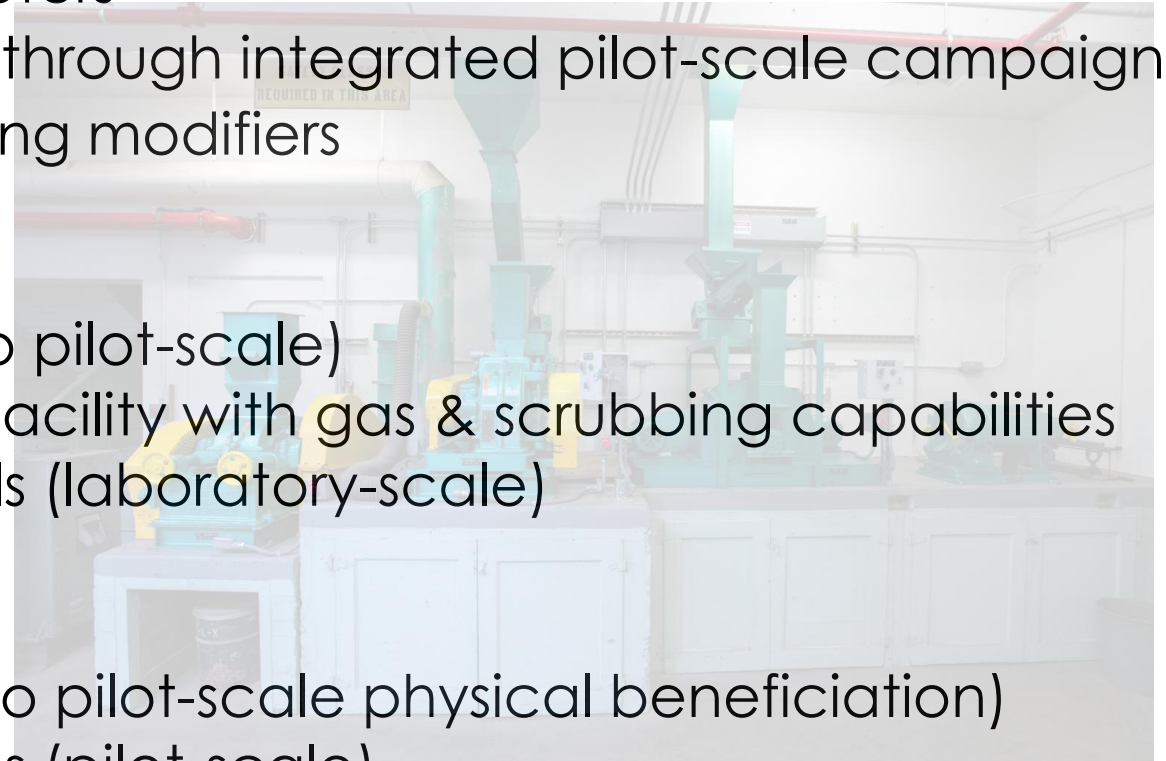
- Test, validate, de-risk, & demonstrate emerging physical/mechanical beneficiation pathways, & inform optimization parameters
- Perform individual unit operation testing through integrated pilot-scale campaigns
- Flowsheet validation, refinement, & scaling modifiers

Existing Capabilities:

- ORE-Lab Dry Comminution Circuit (lab to pilot-scale)
- Severe Environment Split-Tube Furnace Facility with gas & scrubbing capabilities
- Processing of NORM containing materials (laboratory-scale)

New Capabilities:

- ORE-Lab Wet Comminution Circuit (lab to pilot-scale physical beneficiation)
- Processing of NORM containing materials (pilot-scale)



New Mineral Processing Capabilities Coming Online

- **New investments** in Comminution equipment are limited
 - High Pressure Grinding Roll
 - Wet Ball Mill Plant with closed-loop classification (screw, hydrocyclone)
 - Capable of grinding to $\leq 40 \mu\text{m}$, nominally set to $\sim 75 \mu\text{m}$
 - Bond Ball Mill – used for determining material work indices



High-Pressure Grinding Roll



Wet Ball Mill Plant ($\leq 50 \text{ kg/hr}$)



Bond Ball Mill

Flagship # 3: Brine and Material Testbeds

What METALLIC Offers

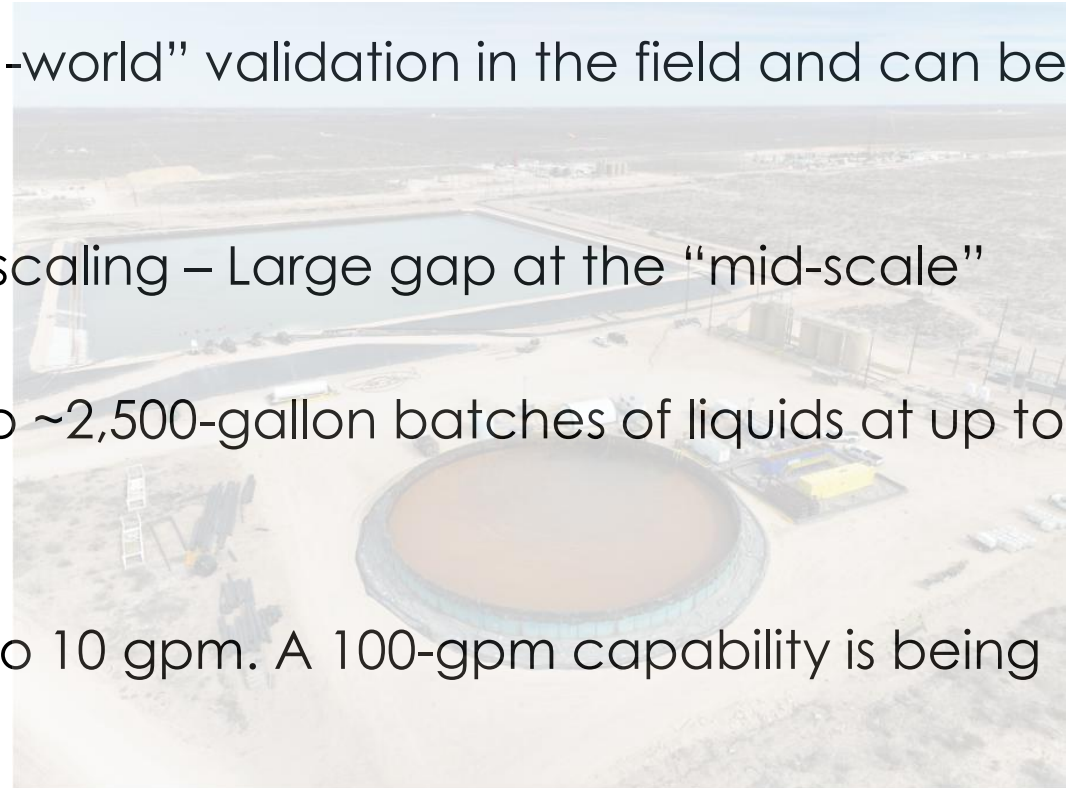
- Robust laboratory-based facilities for process identification and optimization for critical mineral extraction from brines and wastewater
- Configurable, deployable units provide “real-world” validation in the field and can be tailored to the feedstock
- Pilot-scale systems advancing
- Provides commercially relevant technology scaling – Large gap at the “mid-scale”

Existing Capabilities:

- Existing laboratory facilities can process up to ~2,500-gallon batches of liquids at up to 10s L/hr (0.044+ gallons per minute [gpm]).

New Capabilities:

- Field transportable facilities can process up to 10 gpm. A 100-gpm capability is being commissioned.
- MTEL Test Loop
- Field deployable MTEL-X and Brine and Material Processing Testbed (~1-5gpm)



Expanding “Real World” Brine Testbed Capabilities

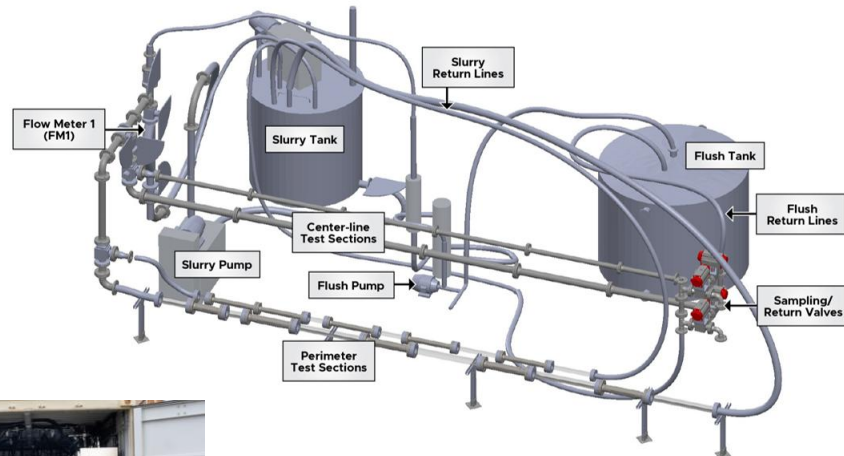


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Modular and configurable units that can handle wastewater, slurries and complex fluids to scale up new technologies for novel beneficiation, process handling and monitoring

Multiphase Transport Evaluation Loop (MTEL)

- 500-gallon capacity, 350gpm
- Laboratory based
- Instrumented
- 20+ years operational experience

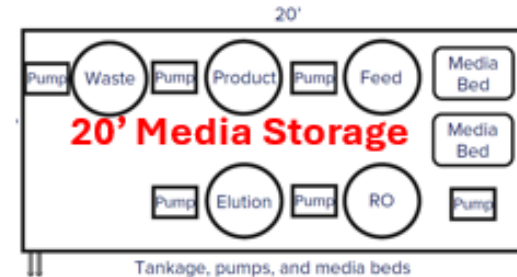


MTEL-neXt generation (mTEL-X)

- Based on MTEL, 10-15 gpm
- Field work based
- Configurable Monitoring

Brine and Material Handling Skid

- Based on operational PW plant
- Configurable processing
- Environmental controls



Coming Soon!

Autonomous Brine Processing Testbed

What METALLIC Offers

- Autonomous Brine Processing Testbed
- Automation tools for Analytical Data Reduction

Existing Capabilities:

Automation tools applied to the following

- Liquid and solid dosing
- Titration
- Physical Liquid Handling
- Solid Separations
- Leaching Experiments
- Filtration

Real-Time Peak Fitting & Data Processing

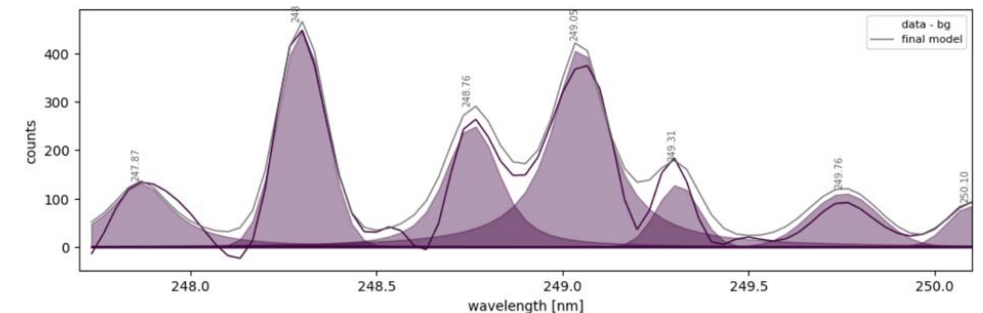
- Raman Spectroscopy
- LIBS
- ICP-OES
- Particle Size Analysis
- Turbidity
- Zeta Potential

New Capabilities:

- Fully automated Brine processing testbed



Autonomous Brine Processing Testbed



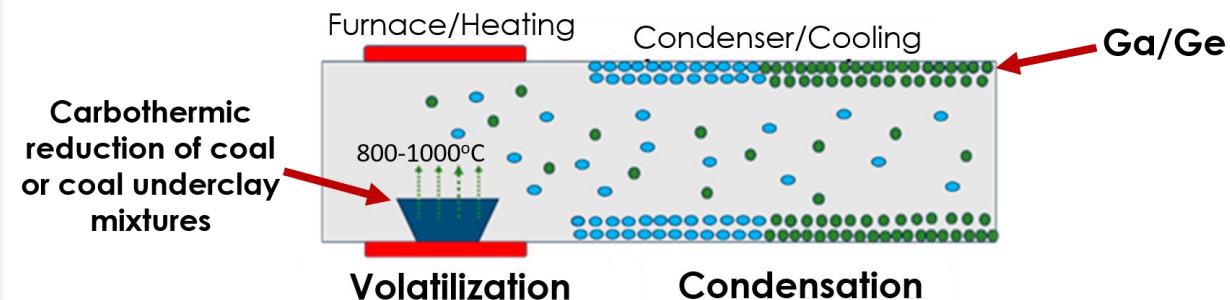
Automated Data Reduction

Existing Capabilities and Expertise

METALLIC will leverage existing capabilities and expertise across Labs:

- Severe Env. Corrosion Erosion Research Facility (SE-CERF)
- Advanced Alloy Signature Center (AASC)
- Materials Engineering Research Facility (MERF)
- Biomass Feedstock National User Facility (BFNUF)
- Geosciences Measurement Facility

**Existing capabilities not funded by METALLIC*



Ga/Ge concentrate from coal or clay feedstocks via Pyrometallurgy in the SE-CREF Facility

Expertise and capabilities to work with industrial partners on mid-scale feedstock beneficiation and comminution

Working with the Feedstock Beneficiation Flagships



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Work Characterization and Liberation Analysis can support:

- Feedstock properties, liberation, and association
- Assessing concentrate quality and impurity distribution
- Evaluating grade and feed variability

Scale: 10g to Full core

Work Brine Testbeds can support:

- Evaluate brines from multiple sources
- Screen technologies for recovery (capacity, performance, degradation)
- Evaluate fouling and long-term stability
- Continuous flow, cyclic, and integrated processing

Scale: 1-10gpm

Work Ore Processing and Optimization can support:

- Crushing, grinding, classification at scale
- Assess comminution and liberation performance
- Preparation of mineral concentrates

Scale: 25-500kg/hr

Work Autonomous Lab Capabilities can support:

- Liquid handling and processing
- Automated data reduction
- AI enabled quantification

Scale: 0.1– 1kg

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METALLIC feedstock beneficiation:

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BACKUP



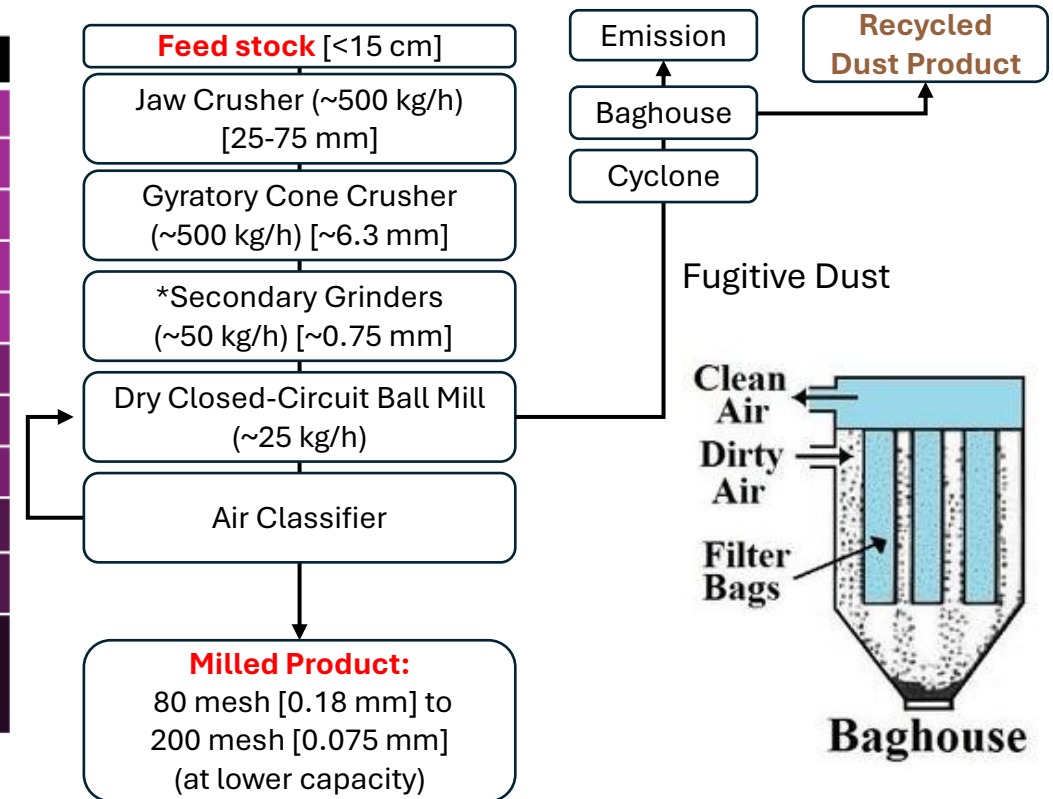
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Mineral Processing Capabilities Coming Online

Capacity & Operational Timeline

Application		Scales
Dry Comminution	Primary Crushing	0.5-15 kg/batch (10-25 kg/hr)
Dry Comminution	Secondary Milling	0.5-2 kg/batch (2-5 kg/hr)
Dry Comminution	Tertiary Grinding	0.05-2 kg/batch (~0.5 kg/hr)
Wet Comminution	Tertiary Grinding	0.2 kg/batch (0.05 kg/hr); limited setup for softer materials: coal, clay, etc.
Formation Waters & Brines		10s L/hr
Dry Comminution	Primary Crushing	250-500 kg/hr (7" to 0.75"), continuous
Dry Comminution	Secondary Milling	100-250 kg/hr (0.75" to 0.25"), continuous
Dry Comminution	Tertiary Grinding	25-50 kg/hr (0.25" to 105 µm), continuous
Wet Comminution	Tertiary Grinding	25-50 kg/hr (0.25" to 75 µm optimally, but 37 µm achievable), continuous
Formation Waters & Brines		225 L/hr, continuous
Wet Physical Separations & Floatation		Magnetic separation, spirals, shaker table, magnetic, size classification, ultra-fine cyclones, lab-scale column & floatation, filtration, and water/ slurry management

Pilot Scale Operational Flow Sheet



* Selection of **Secondary Grinders per material properties**: Hammer Sledge Mills, Horizontal Roll Crushers, or High-Pressure Grinding Rolls

Autonomous brine processing testbed

Achievement:

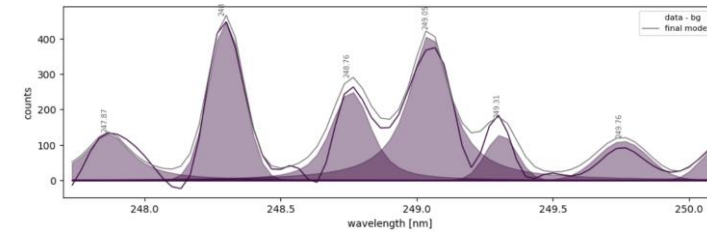
- Autonomous process optimization for crystallization, leaching, filtration, and more
- Liquid and solid dosing, titration, liquid handling, solid separation
- Real-time Raman spectroscopy, ICP-OES chemical analysis, particle size, turbidity, and zeta potential measurement

Significance and Impact:

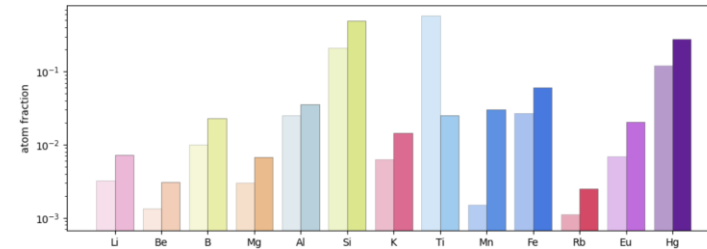
- High-throughput process testing and validation enables faster development and fine-tuning
- Integrated process control, in-line characterization, and automated analysis enables closed-loop optimization
- AI-enabled decision making and data analysis

Supply Chain Area Addressed:

- Beneficiation, separation
 - Lithium, rare earth elements, graphite, metals



Automated data reduction



AI-enabled quantification



Autonomous brine processing testbed at Berkeley Lab

Nanobubble flotation platform at LBNL

Achievement:

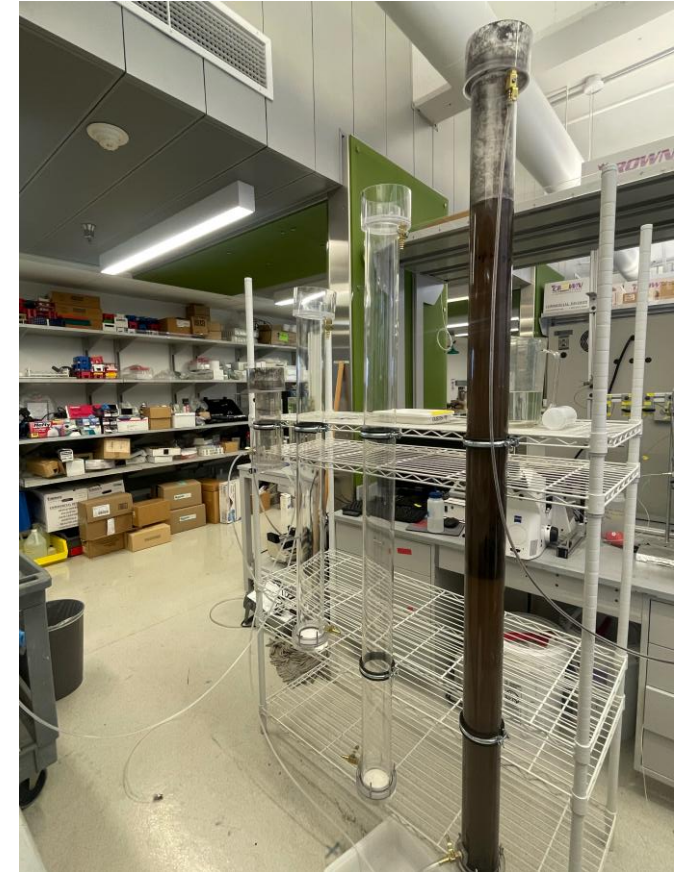
- Conducted bench-scale (1L) flotation tests with different types of nanobubbles with Pocahontas #3 coal fines;
- Achieved improved separation and recovery of fine and ultrafine particles in coal slurry with nanobubble flotation;
- A multi-column (0.5L to 50L capacity) nanobubble flotation system is being developed.

Significance and Impact:

- Conventional flotation is challenged by low fine particle recovery efficiency and high water, energy and chemical consumptions.
- Nanobubble flotation, enabled by nano-scale gas-water interfaces, is demonstrated capable to overcome the limit by enhancing bubble-particle collision and attachment, promoting fine particle aggregation, thus leading to higher recovery efficiency with less processing time and chemical consumptions.

Supply Chain Area Addressed:

- Synthetic graphite • REE



The multi-column nanobubble flotation system at LBNL