METALLIC

EXTRACTIONS AND SEPARATIONS

The Extractions and Separations Center is accelerating advances in extractions and separations of critical minerals by rapidly validating and maturing new technologies and pathways to achieve low-cost and/or high-purity separation.

WHY ARE EXTRACTIONS AND SEPARATIONS IMPORTANT?

- Chemical or thermal extraction — extractive metallurgy — of a material of interest from the host material is a key cost driver in mineral and feedstock processing operations.
- Isolating critical minerals and materials (CMM) from leachates and liquids — hydrometallurgy — is necessary for a preponderance of processing circuits.
- Substantial headroom in innovation exists for elemental purification via process intensification and optimized design.
- Design and operation of circuits is sufficiently complex that expensive pilot campaigns can be required prior to adoption.

Mediated electrochemical leaching (ERECOV) at Idaho National Laboratory

WHAT ROLE AND SERVICES DOES THE METALLIC EXTRACTIONS AND SEPARATIONS CENTER PROVIDE?

The Center focuses on maturing new methods to extract and separate critical minerals from feedstocks and leachates. Activities are grouped in three categories:

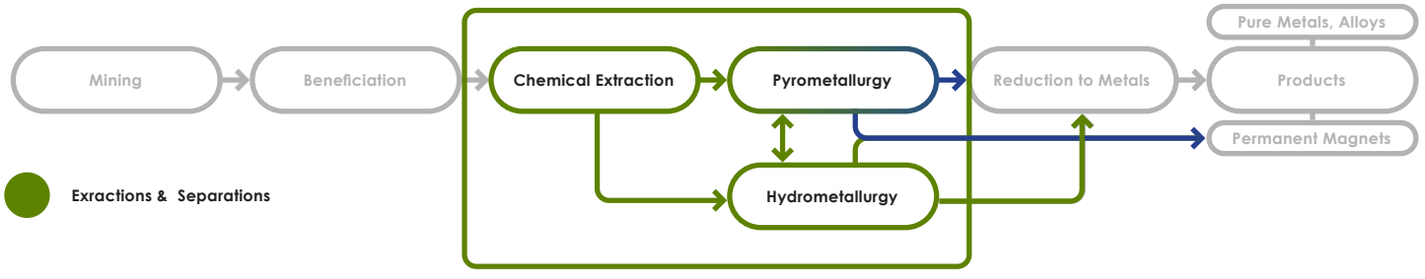
Testbed for Novel Unit Operations
Validate emerging extractive metallurgy technologies and accelerate the integration of novel and improved unit operations in CMM recovery flowsheets through testing in an integrated context

Solvent Extraction Testbeds
- Accelerate further advances in solvent extraction, such as validating optimal extractant/diluent ratios and process configurations for a specific leachate and product slate
- Test emerging membrane supports for longevity, degradation, and improved performance in membrane solvent extraction systems and validate traditional and emerging extractants

AI-Guided Autonomous Chemistry Testbeds
Test novel extractants and ion-exchange sorbents/adsorbents as part of solvent and critical mineral extraction and separation methods, with analytical instruments being incorporated to enable data streaming, on-the-fly data analysis, and simulation for AI-enabled feedback

OUR GOAL IS TO DRIVE INNOVATION IN EXTRACTIONS AND SEPARATIONS BY:

- Rapidly validating and maturing new extractive metallurgy technologies and pathways: extractants, ion-exchange media, membranes, pyrometallurgy processes, and precipitation methods
- Validating and optimizing separations technologies and flowsheets at industry-relevant scales (Technology Readiness Level [TRL] 4–6+)
- Providing “rock-to-element” integrated extraction/separation testbeds to validate mineral processing flowsheets, producing purified materials for testing/use



Configurable Facility for Processing and Purifying Solids and Liquids

FLEXIBLE TESTBEDS FOR NOVEL UNIT OPERATIONS

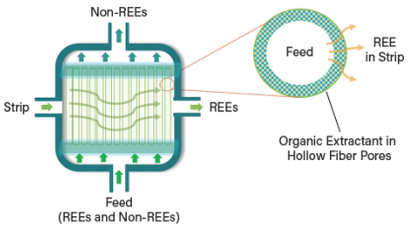
Focus
Validation of integrated flowsheets as well as new unit operations in the context of conventional and novel flowsheets

Modular, configurable, instrumented facilities for testing and validating new technologies for use with brines, slurries or complex fluids

Test platforms that bring the field to the laboratory and the laboratory to the field

Processing Scale
1–100 gallons per minute (gpm) of liquids, kilograms per hour (kg/h) of solids

Outcomes
Validate, mature, and optimize extraction and separations technologies and new flowsheets — from beneficiation to purification — at industry-relevant scales from Technology Readiness Level (TRL) 4–6+



Schematic of the MSX process for recovering Rare Earth Elements

SOLVENT EXTRACTION TESTBEDS

Focus
Accelerate further advances in solvent extraction separations pathways by validating performance of new extractants, process configurations, and contactor types (e.g., membrane solvent extraction [MSX])

Processing Scale
Milliliters to 100s of liters of solution

Outcomes
- Reduce the cost and chemical footprint of SX by de-risking new pathways (e.g. MSX) and through optimized designs
- Accelerate the adoption and deployment of new extractants and extractant/diluent pairings

Mobile Kuka Robot

AI-GUIDED AUTONOMOUS CHEMISTRY TESTBEDS

Focus
Leveraging autonomous and machine learning–driven experimentation to identify operating regimes (reducing experiments required) and reduce time required per test campaign for emerging separations technologies and user-provided materials

Processing Scale
Grams to kilograms

Outcomes
- Rapid identification of optimal operating parameters for processing user-provided materials
- Accelerated process design and optimization through machine learning

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