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By AVERY LARKIN

# New Efforts to Strengthen U.S. Critical Materials Supply

## An innovative federal lab is applying its research capabilities to strengthen domestic mineral extraction and processing.

The U.S. relies heavily on foreign sources for many of the critical materials used in defense systems, advanced manufacturing, energy technologies and electronics. In many cases, U.S. companies import not only raw materials but also refined and processed inputs from a small number of countries.

According to the U.S. Geological Survey's 2024 Mineral Commodity Summaries, the U.S. is 100% import reliant for at least 12 critical minerals and more than 50% reliant for many others used in semiconductors, batteries, defense systems and renewable energy technologies. "In several cases, processing capacity is concentrated in just one or two countries," USGS says, "increasing exposure to supply disruption and geopolitical tension."

Federal reviews warn that this dependence exposes the supply chain to disruption, price volatility and geopolitical risk. Indeed, the White House has identified processed critical minerals as a national security concern tied directly to import reliance. One of the Department of Energy's 17 national labs is stepping in to help minimize this dependence. Idaho National Laboratory (INL) says it's using its geoscience expertise and advanced technologies to develop more efficient methods for locating, extracting and processing critical materials.

"Critical materials and metals are crucial to our daily lives; we rely on them," said Travis McLing, a subsurface research scientist at INL, in "Securing America's critical materials supply chain." "However, we depend heavily on foreign entities, jeopardizing our technological leadership, modern lifestyle and national security."

**Expanding Domestic Extraction & Processing**

According to INL, its geoscientists study the location and distribution of critical materials and analyze how to extract them efficiently. These materials can come from mining, recycled electronic waste (such as computers and cellphones), industrial byproducts, geothermal brines, phosphate and mining waste. INL researchers explore every potential source to lay the groundwork for more strategic and efficient resource development.

INL's geology team examines how different materials are bonded in ore bodies, including both desired elements and hazardous ones. Once these bonds are understood, the information is passed to separation chemists who develop more efficient and environmentally friendly methods for isolating the desired materials.

"We've embraced the national lab charge to do hard things, and we have a proven history of working successfully and safely in challenging environments," said McLing, in the article. "For example, many ore bodies contain elements like arsenic, mercury or naturally occurring radioactive materials that complicate mining and research. Yet we're able to study them safely and extract the critical materials."

**Key Capabilities and Technical Strengths**

As the nation's center for nuclear energy research and development, INL's capabilities include:

- **Advanced characterization tools.** The Microscopy and Characterization Suite uses powerful tools like electron microscopes and X-ray systems to identify and map critical minerals at very small scales.
- **Next-generation exploration.** Scientists at INL use advanced software to integrate geologic, geophysical and geochemical data to build high-resolution models of underground formations.
- **AI and digital twins.** INL uses artificial intelligence (AI) and digital twin technology to speed up mineral discovery and optimize production. Digital twins are virtual replicas of mineral systems and processing operations that allow scientists to test and refine strategies before implementation. AI models trained on large geoscience datasets help predict deposit locations, identify patterns and support real-time decision making.
- **Simulating real-world conditions.** The Multiphysics Object-Oriented Simulation Environment (MOOSE) is an advanced software tool that helps scientists and engineers simulate complex physical processes such as heat, mechanical stress and fluid flow. Its versatile modeling capabilities apply to fields like nuclear engineering, energy systems, environmental science, materials science and geoscience.
- **Smarter processing and recovery.** INL is working on increasing the efficiency of comminution (the process of grinding and crushing rocks to a more manageable size) and beneficiation, which improves ore quality by separating valuable materials from rock.

**Supporting a Broader, Multi-Lab Effort**

Looking ahead, INL says its efforts are "pivotal in ensuring a stable and secure supply of these essential resources." Its capabilities and expertise allow INL to contribute to the Minerals to Materials Supply Chain Facility (METALLIC), a multi-laboratory initiative to accelerate the development and commercialization of technologies for critical materials extraction and production.

INL's role in METALLIC includes supporting research in separation science, AI, pilot-scale processing, feedstock beneficiation and critical material extraction and separation. "INL benefits from its proximity to the Intermountain West region, which is rich in critical materials," said McLing. "Our research teams are collaborative; we share what we learn to improve the work of all our teams and, by extension, the economic value and efficiencies for our partners."