COMMITTEE ON
SCIENCE, SPACE AND TECHNOLOGY
CHAIRMAN FRANK LUCAS

FULL COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HEARING CHARTER

"The Role of Federal Research in Establishing a Robust U.S. Supply Chain of Critical Minerals and Materials"

Thursday, November 30, 2023
10:00 a.m.
2318 Rayburn House Office Building

Purpose
This hearing will explore the role that Federal research agencies can play in strengthening U.S. supply chains of the minerals and materials that are essential for U.S. energy independence and international competitiveness. This hearing will specifically examine relevant research, development, demonstration, and commercial application activities carried out by key research agencies like the U.S. Department of Energy and the National Science Foundation, among others. This hearing will provide members an opportunity to review the implementation status of critical minerals R&D provisions recently authorized in the Energy Act of 2020 and the CHIPS and Science Act of 2022.

Witnesses
- **Mr. Ryan Peay**, Deputy Assistant Secretary for the Office of Resource Sustainability, Office of Fossil Energy and Carbon Management, U.S. Department of Energy
- **Dr. Jef Caers**, Professor of Earth & Planetary Science and Director of Stanford Mineral-X, Stanford University
- **Mr. Drew Horn**, Chief Executive Officer, GreenMet
- **Dr. Dustin Mulvaney**, Professor of Environmental Studies, San Jose State University
- **Mr. Thomas E. Baroody**, President & Chief Executive Officer, K-Technologies, Inc.

Overarching Questions
- What are some fundamental and early-stage research and development challenges associated with extracting, recovering, and recycling of critical minerals and materials?
- How has recently enacted R&D legislation such as the Energy Act of 2020 and CHIPS and Science Act impacted the U.S.' ability to complete in the critical minerals and materials supply chain?

- When it comes to the future of U.S. critical mineral and materials security, what areas of research should Congress prioritize?
- How will emerging technology areas like artificial intelligence and machine learning impact our mineral security?

BACKGROUND

Critical minerals are non-fuel minerals like lithium, graphite, and cobalt, or materials that are essential to U.S. energy independence, national security, or economic growth, and which have a supply chain vulnerable to disruption.[1] With applications in healthcare, defense systems, smartphones, laptops, energy storage, and renewable energy technologies, these resources are essential to our modern way of life.

Despite substantial domestic reserves, a large proportion of the critical minerals used in the U.S. are sourced abroad. In fact, the U.S. is net import-reliant for approximately 31 of the 50 mineral commodities designated as critical by the U.S. Department of the Interior and relies completely on imports to supply 12 of these minerals.[2] This heavy dependence on foreign supply chains, including those of adversarial nations, creates alarming strategic vulnerabilities. Through years of investment and strategic partnerships, China now controls over 60% of worldwide production and 85% of processing capacity of critical minerals. [3] As a result, the U.S. has a 50% net import reliance on China for about 26 mineral commodities.[4]

Ensuring a stable U.S. supply of critical minerals and materials starts with encouraging responsible critical minerals production and use here at home. Federal research agencies like the U.S. Department of Energy (DOE) and the National Science Foundation (NSF) have a central role to play in reducing U.S. dependence on foreign sources of critical minerals by supporting domestic mineral development and innovation.

U.S. Department of Energy:

DOE stewards robust cross-cutting activities in critical minerals and materials research and development, which prioritize the creation of a circular supply chain through recycling, development of new alternatives through material sciences, and formation of new mineral resources through extraction. These activities are carried out through various offices including the Office of Fossil Energy and Carbon Management (FECM), the Office of Science (SC), the Office of Energy Efficiency and Renewable Energy (EERE), the Advanced Research Projects Agency (ARPA-E), and the Office of Manufacturing and Energy Supply Chains (MESC).

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[1] "H.R.133 - 116th Congress (2019-2020): Consolidated Appropriations Act, 2021." *Congress.gov*, Library of Congress, 27 December 2020, https://www.congress.gov/bill/116th-congress/house-bill/133.

[2] "U.S. Reaches Highest Recorded Mineral Import Reliance." National Mining Association, 31 January 2023, https://nma.org/2023/01/31/u-s-reaches-highest-recorded-mineral-import-reliance/#:~:text=Of%20the%2050%20mineral%20commodities%20identified%20in%20the,import%20reliance%20greater%20than%2050%25%20of%20apparent%20consumption.

[3] Glaser, Bonnie S., and Abigail Wulf. "China's Role in Critical Mineral Supply Chains." *GMFUS*, German Marshall Fund, 2 Aug. 2023, www.gmfus.org/news/chinas-role-critical-mineral-supply-chains.

[4] U.S. Geological Survey, 2023, Mineral commodity summaries 2023: U.S. Geological Survey, 210 p., https://doi.org/10.3133/mcs2023.

Within FECM, DOE's Office of Resource Sustainability manages its critical minerals and rare earth element (REE) programs. This office prioritizes the development of new sources of critical minerals using unconventional feedstocks and legacy waste. In addition, the Office of Resource Sustainability advances the creation of novel technologies, which improve extraction and processing of critical minerals. Largely carried out by DOE's National Energy Technology Laboratory (NETL), FECM also supports R&D into the extraction, separation, and recovery of rare earth elements from coal.[5] Over the last ten years, NETL has progressed from its feasibility studies and partnered with universities such as the University of North Dakota, University of Kentucky, and West Virginia University to host pilot scale projects. These projects have demonstrated the use of coal-based materials to secure rare earth elements. Recently, DOE selected University of North Dakota and West Virginia University to host the Rare Earth Element Demonstration Facility, which will develop a first of its kind rare earth and critical minerals extraction and separation facility.[6]

Through EERE, DOE hosts the Critical Materials Institute (CMI) Energy Innovation Hub at Ames National Laboratory. CMI brings together industry, universities, and the national laboratories – including Oak Ridge, Lawrence Livermore, and Idaho National Laboratory – to address fundamental critical materials science challenges. Through the CMI, DOE supports crosscutting research in four key areas, including critical material reuse and recycling, the development of novel material substitutes, the creation of new research tools, and broadening of the supply chain.[7] Moreover, CMI strives to transfer innovations and technological breakthroughs from the lab to the market. In addition, EERE supports related R&D activities in vehicle technologies, renewable energy technologies, and advanced materials and manufacturing technologies. For instance, the Office of Geothermal Technologies advances R&D activities involving the extraction of critical minerals from geothermal brines.[8]

MESC manages programs relating to the critical minerals and materials supply chain. Authorized and appropriated in the Infrastructure, Investment, and Jobs Act (IIJA), MESC manages the Battery Manufacturing and Recycling Grants, Battery Materials Processing Grants, and Battery and Critical Mineral Recycling programs. These programs support the development of a domestic battery ecosystem in the United States and the recycling of these materials as well. For example, the Battery and Critical Mineral Recycling program advances the extraction or recovery of critical minerals from batteries, which creates a closed loop supply chain.[9]

Similarly, other DOE offices like SC and ARPA-E play an important role in DOE's critical materials R&D activities. SC's Basic Energy Sciences program has expertise in material sciences, chemical sciences, geosciences, and biosciences, which is essential to understanding these materials and their properties. SC's National Laboratories and their user facilities prioritize

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[5] "Report on Rare Earth Elements from Coal and Coal Byproducts." *Energy.Gov*, 2 Feb. 2017, www.energy.gov/fecm/articles/rare-earth-elements-report-congress.
[6] "Funding Notice: Bipartisan Infrastructure Law: Rare Earth Element Demonstration Facility." Energy.Gov, 4 Apr. 2023, www.energy.gov/fecm/funding-notice-bipartisan-infrastructure-law-rare-earth-element-demonstration-facility.
[7] "About the Critical Materials Innovation Hub." *Ameslab.gov*, https://www.ameslab.gov/cmi/about-critical-materials-institute
[8] "U.S. Department of Energy Awards $2 Million for Innovations to Source Domestic Lithium From Geothermal Brines." *Energy.gov*, 19 September 2023, https://www.energy.gov/eere/articles/us-department-energy-awards-2-million-innovations-source-domestic-lithium-geothermal
[9] "Biden-Harris Administration Announces $192 Million to Advance Battery Recycling Technology" *Energy.gov*, 12 June 2023, https://www.energy.gov/articles/biden-harris-administration-announces-192-million-advance-battery-recycling-technology

basic research along with the creation of new technologies and processes. Meanwhile, ARPA-E has one main program dedicated to advancing mineral production. Known as MINER, the Mining Innovations for Negative Emissions Resources program seeks to increase mineral yields through reprocessing while reducing carbon emissions. To date, ARPA-E has awarded over $39 million to 16 projects, which include universities, national laboratories, and companies.[10]

National Science Foundation:

The National Science Foundation has regularly funded proposals on fundamental research to facilitate the discovery, characterization, extraction, and separation of critical minerals. This research is key to ensuring the availability of essential metals and rare earth elements required to achieve a clean-energy future. The CHIPS and Science Act of 2022 directed NSF to fund basic research that will accelerate innovation and advance critical mineral mining strategies and technologies to support supply chain resilience by increasing the efficient use of domestic resources. In addition to funding research proposals, NSF also supports the education and workforce training necessary to prepare the next generation of mining engineers and researchers. However, the industry has seen a 39% drop in graduations from domestic degree-granting programs. In 1982, there were 25 mining and mineral engineering programs in the United States. In 2023, there are only 14 accredited mining engineering schools. These remaining institutions will be crucial to filling the estimated 221,000 jobs needed by 2029.[11]

Recent Legislation:

In the Energy Act of 2020, Congress authorized many of DOE's research and development activities in this space, including the research and development of alternatives to, recycling of, and efficient production and use of critical materials (activities which may be carried out by DOE's critical materials Energy Innovation Hub.) Importantly, the law requires the executive branch to designate a list of critical minerals and update that list every three years.. In addition, the Energy Act of 2020 directs the National Science Foundation to develop curriculum for institutions of higher education to build a strong critical minerals workforce.[12]

In 2021, the IIJA expanded on Energy Act of 2020 critical minerals authorizations while appropriating over $800 million for these programs and activities like the DOE Rare Earth Element Demonstration Facility. In addition, the IIJA gave DOE's Loan Program Office new authority to provide financing to critical mineral projects involving production, processing, manufacturing, recycling, and fabrication of mineral alternatives. In January of 2023, DOE awarded Ioneer a $700 million loan for a lithium carbonate plant in Nevada.[13]

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[10] "Press Release: U.S. Department of Energy Announces $39 Million for Technology to Grow the Domestic Critical Minerals Supply Chain and Strengthen National Security." *Arpa e*, 27 Oct. 2022, arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-announces-39-million-technology-grow-domestic.

[11] Hale, Thomas. "The United States Needs More than Mining Engineers to solve Its Critical Mineral Challenges." *Center for Strategic and International Studies*, 8 May 2023, https://www.csis.org/analysis/united-states-needs-more-mining-engineers-solve-its-critical-mineral-challenges#:~:text=The%20workforce%20and%20talent%20gap,2029%20(roughly%20221%2C000%20workers).

[12] "H.R.133 - 116th Congress (2019-2020): Consolidated Appropriations Act, 2021." *Congress.gov*, Library of Congress, 27 December 2020, https://www.congress.gov/bill/116th-congress/house-bill/133.

[13] Shah, Jigar. "LPO Announces Conditional Commitment to Ioneer Rhyolite Ridge to Advance Domestic Production of Lithium and Boron, Boost U.S. Battery Supply Chain." *Energy.Gov*, 13 Jan. 2023, www.energy.gov/lpo/articles/lpo-announces-conditional-commitment-ioneer-rhyolite-ridge-advance-domestic-production#:~:text=The%20U.S.%20Department%20of%20Energy's,Project%20(Rhyolite%20Ridge)%20in%20Esmeralda.

In the CHIPS and Science Act of 2022, Congress authorized the Carbon Materials Science Initiative: it directs the Office of Science to coordinate research activities with the Office of Fossil Energy and Carbon Management pertaining to the extraction and processing of coal and carbon-based compounds. This partnership will accelerate FECM's current research and development activities as it secures critical minerals from untraditional feedstocks. In addition, CHIPS and Science created a Critical Materials Interagency Subcommittee housed under the National Science and Technology Council. Its goal is to coordinate between various agencies to ensure a reliable critical minerals supply chain and provide recommendations for future programs and activities. Also, the law authorized two NSF programs: Critical Minerals Mining Research and Development program, and Carbon Materials Research Centers. The former will provide grants to universities to fund basic research involving critical minerals and examine the use of artificial intelligence and machine learning in this space. Likewise, the Director of NSF will establish two Carbon Materials Research Centers, which will support early-stage research and development activities.[14]

[14] "H.R. 4346 – 117th Congress (2021-2022): CHIPS and Science Act." *Congress.gov*, Library of Congress, 9 August 2022, https://www.congress.gov/bill/117th-congress/house-bill/4346?q=%7B%22search%22%3A%22chips+and+science+act+hr+4346%22%7D&s=4&r=1