
# Issue Brief

# Critical Minerals and the U.S. Clean Energy Transition

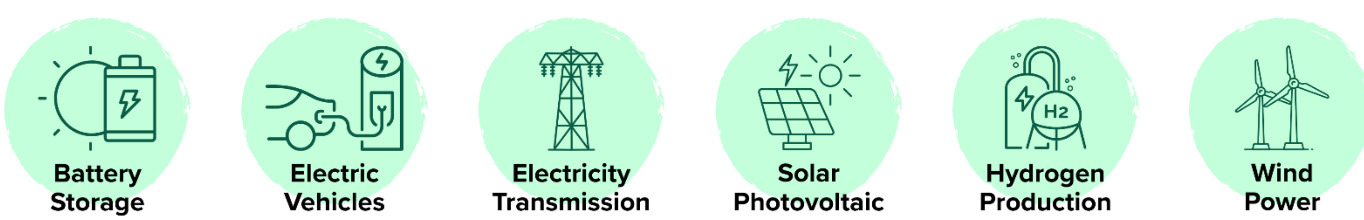
Critical minerals are key components in a range of products and equipment, from consumer electronics and military technology to solar panels and electric vehicle batteries. Their unique chemical properties make them particularly suitable for energy technologies and irreplaceable for certain purposes. Pursuant to the *Energy Act of 2020* (P.L. 116–260), the U.S. Geological Survey (USGS) publishes a revised list of critical minerals every three years. The most recent list, published in 2022, categorizes 50 minerals as critical. For clarity and consistency, this issue brief will use the *Energy Act* definition of critical minerals, which encompasses both minerals and materials.

> **Critical mineral:** a non-fuel mineral or mineral material that (i) has a high risk of supply chain disruption and (ii) is essential to the manufacturing of a product vital to U.S. economic or national security.
>
> ***Energy Act of 2020*** (P.L. 116-260)

## Critical Minerals and Clean Energy Technologies

From electric vehicles to renewable power sources, critical minerals are key to several clean energy technologies:

- **Batteries:** Lithium, nickel, cobalt, manganese, and graphite are essential to the performance of batteries that power electric vehicles and enable renewable energy storage. Lithium, nickel, and cobalt, for example, extend the life of a battery and allow for greater electricity storage capacity.
- **Permanent magnets:** Rare earth elements like neodymium and dysprosium are crucial to the composition of ultra-strong magnets that generate motion within electric vehicles and convert wind into electricity in wind turbines.
- **Electricity transmission:** The transition to renewable energy rests largely on reliable electricity transmission and distribution. The wires and cables that underpin the electric grid are often made with aluminum.
- **Solar photovoltaics:** Technologies that convert sunlight into electricity use aluminum, with other critical minerals coming into play depending on the specific technology.
- **Hydrogen production** requires metals such as platinum, nickel, or iridium, among other critical materials, depending on how it is produced.



## Critical Mineral Supply Chains

While the particulars vary by material, the critical mineral supply chain generally comprises exploration and discovery, extraction, processing, refining, and manufacturing.

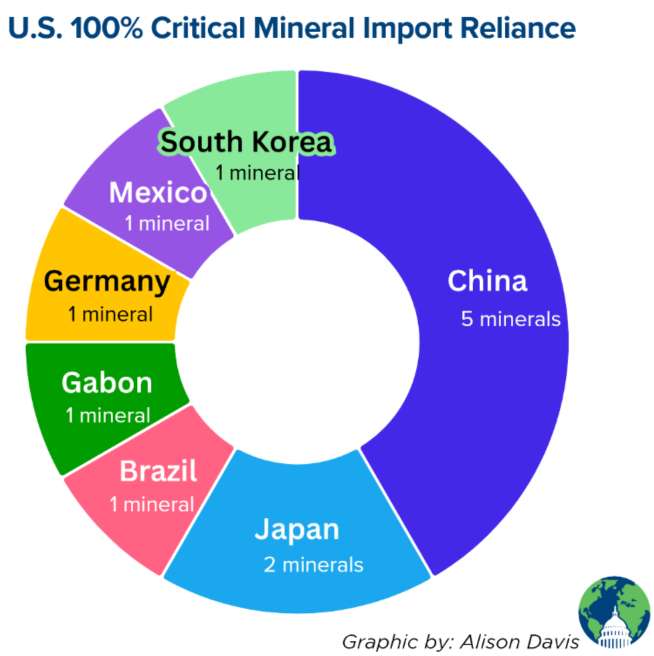
| The Critical Mineral Supply Chain | |
|---|---|
| **Exploration and Discovery** | Critical minerals can be found in natural deposits in the Earth, mining waste, or discarded end-use products such as electric vehicle batteries and electronic devices. In the United States, the exploration and discovery of raw materials involves extensive permitting processes under federal mining laws. These permitting processes take an average of 16 years to complete. |
| **Extraction (Production)** | Critical mineral extraction, or production, involves mining deposits from the Earth or removing them from secondary sources. When mined, critical minerals are typically recovered alongside other materials. For example, pure nickel cannot be readily extracted from the ground in isolation; instead, the ore that contains the nickel is mined. Proposals for mining projects can trigger further permitting requirements under laws such as the *National Environmental Policy Act* (P.L. 91-190) and the *Clean Water Act* (P.L. 95-217). |
| **Processing** | Once extracted, the sought-after mineral is separated from other matter attached to it. Depending on the critical mineral, this can involve techniques such as applying high heat to change its physical state, adding chemicals to leach out the critical mineral, or evaporating water containing the critical mineral so only it is left behind. |
| **Refining** | Any remaining impurities are removed to produce the highest possible concentration of the critical mineral, which can then be used for manufacturing. |
| **Manufacturing** | The critical mineral is integrated into a final product, such as an electric vehicle battery or an aluminum wire for electricity transmission. |

Main source: Bipartisan Policy Center

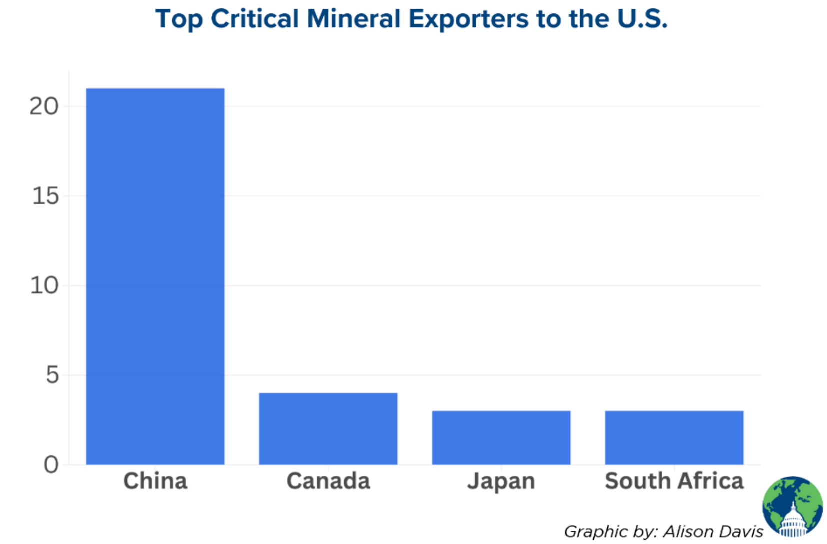
The five steps of the critical mineral supply chain often do not occur within the same country. A producer, for example, may offshore steps of the process due to a lack of advanced processing or manufacturing infrastructure in their country, insufficient "feedstock" of critical minerals, a shortage of skilled domestic workers, price competitiveness that makes it cheaper to offshore the supply chain, or lack of interest from investors to finance domestic operations.

Minerals extracted in a producer country can be shipped to a second country for processing and refining. After refining, they can be manufactured domestically or can be exported again—back to the producer country or to a third country—for integration into an end-use product (manufacturing). Supply chains dispersed in this way are inherently susceptible to delays and geopolitical risk. Countries can mitigate these vulnerabilities by onshoring or "friend-shoring" supply chain processes wherever possible.

The United States is subject to the ebbs and flows of the global critical mineral supply chain and the countries that dominate it. In 2024, the United States relied on imports, rather than domestic production, for 100% of 12 critical minerals on the 2022 USGS list. In the same year, it had an import reliance of 50% or more for an additional 28 listed minerals. The top critical mineral exporters to the United States were China, Canada, Japan, and South Africa. The top critical mineral producers were China (for 30 of the 50 USGS critical minerals), South Africa (3), Australia (2), and the Democratic Republic of the Congo (2).

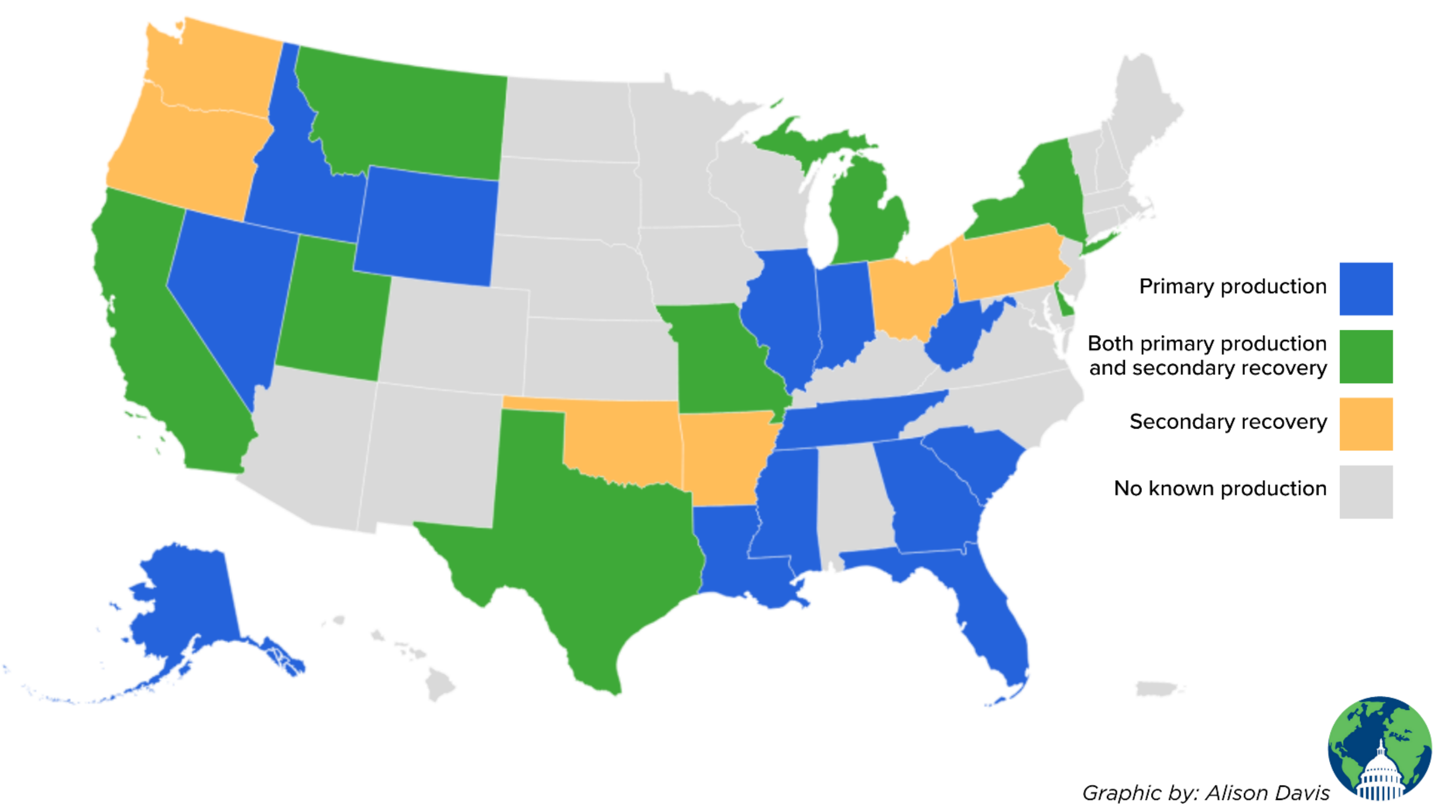


In recent years, the global critical mineral supply chain has been marked by long timelines for mineral extraction projects, a high reliance on a small concentration of producer and processing nations, and volatile mineral prices. Price volatility has risen from supply chain disruptions such as the COVID-19 pandemic and geopolitical conflict. For example, war in Ukraine has disrupted graphite and titanium production and Russian nickel exports, while China has banned exports of antimony, gallium, and germanium to the United States.




The United States has deposits of minerals and materials such as aluminum, antimony, cobalt, gallium**,** graphite**,** lithium, nickel, and several rare earth elements. Due to lengthy regulatory and permitting processes, legal battles, and cheaper overseas production, the majority of these deposits have remained in the ground. The United States produces 37 of the 50 critical minerals from mining, secondary recovery, or recycled materials. Deposits of an additional five listed minerals exist but are not mined. Twelve of the 37 (aluminum, cobalt, gallium, graphite, lithium, magnesium, nickel, platinum, and various rare earth elements) are deemed by USGS and the Department of Energy (DOE) as critical to the clean energy transition. Gallium, which increases the energy efficiency of solar photovoltaic cells, and iridium, a rare earth element used in hydrogen production, are the only clean energy critical minerals that the United States does not produce. A New York based company currently recovers gallium from scrap, while deposits of iridium exist in Alaska but are not mined.

## Domestic Critical Mineral Production



While USGS has collected robust data on mineral production by U.S. state, data on mineral processing is nominal. However, processing is known to have occurred at U.S. facilities in 2024 for beryllium and graphite. The greatest barriers to onshoring processing and refining operations are price competitiveness, a shortage of skilled labor, and a lack of interest from investors.

A potential, though not yet commercially viable, alternative to land-based mineral production lies seaward. The seabed contains critical minerals (namely cobalt, manganese, nickel, and rare earth elements) in various forms, most predominantly as potato-sized deposits called polymetallic nodules. These accumulations of critical minerals formed over millions of years and are found in the billions across the ocean floor. The nodules can be collected by remote-operated vehicles that roam the sea floor. Deep-sea mining is governed by the International Seabed Authority (ISA), which distributes licenses to member governments for mineral exploration and extraction in international waters. As of July 2025, the United States is not a voting member of the ISA and therefore cannot obtain such a license.

## Externalities of Critical Mineral Development

Critical mineral extraction, processing, and refining are linked to significant environmental and human health impacts. Open pit mining is the standard process around the world for extracting minerals like lithium, cobalt, and nickel from the Earth. According to the International Energy Agency, this energy-intensive process emits greenhouse gases; degrades surrounding lands, leading to habitat and biodiversity loss; contaminates groundwater and freshwater resources used for human consumption, crop irrigation, and livestock; and consumes immense volumes of groundwater that local communities rely on. The processing and refining of raw critical minerals into usable forms also requires high volumes of water and inputs of harmful chemicals, and leaves behind large amounts of tailings, the often-hazardous waste materials that remain after processing. These externalities directly impact communities and wildlife situated on or near mining and processing facilities, with particular impact on tribal communities. In the United States, 97% of nickel resources, 79% of lithium resources, and 68% of cobalt resources are within 35 miles of Native American reservations. Many other resources lie within or near sacred tribal sites or in areas of cultural or environmental significance to tribes.

Offshore, the ecosystem impacts of deep-sea mining are still being determined, and further research is needed to better measure the extent of harm. Past studies have found that the removal of mineral-rich nodules eliminates habitats for corals and sponges that in turn house smaller organisms, the absence of which may have ripple effects across the food chain. These studies have also found that the movements of remote-operated deep-sea mining vehicles release plumes of sediment that bury nodule fields, smother organisms, spew toxic metals, and interfere with essential functions in bioluminescent species.

According to the SAFE Center for Critical Minerals Strategy (SAFE), many mining companies around the world have a record of human rights abuses, fostered by weak or absent governance and lack of transparency. SAFE cites child and forced labor and population displacement as prevalent issues associated with mineral mining, particularly cobalt mining.

Twelve different international standards offer “best practices” for responsible mining. Developed by national governments, industries, and multi-stakeholder groups, these practices address issues including child labor and forced labor, water quality, mining waste and land reclamation, tribal engagement, and community engagement. These standards, however, are largely voluntary and lack reporting and enforcement mechanisms. The variety of these often-overlapping standards also sows confusion over which standard to sign on to, leading to inconsistencies in mining practices.

### The Energy Resource Governance Initiative

The U.S. Department of State and the governments of Australia, Botswana, Canada, and Peru launched the Energy Resource Governance Initiative (ERGI) in 2019 to promote transparency and international coordination on responsible mining. Their ERGI Toolkit shares best practices for responsible mining across the critical mineral supply chain.

## Critical Mineral Secondary Recovery and Recycling

Secondary recovery, or secondary production, refers to the recuperation of critical minerals from the tailings of the initial extraction and processing of other materials, or from discarded end-use products. This alternative to mining avoids many harmful environmental and public health impacts, conserves limited raw mineral supplies, promotes a circular economy, provides a level of resilience against supply chain disruptions, and bolsters national security.

In recent years, increased research, development, and investment has led to new methods of extracting critical minerals. For example, researchers at Oregon State University found that the brine wastewater discharged by desalinization plants across the world contains 17,400 tons of lithium. Some universities (including Oregon State), private companies, and federal agencies are now developing methodologies and technologies for recovering this lithium. A 2024 study by the University of Texas found that U.S. stockpiles of coal ash, a waste product of burning coal, contain 11 million tons of rare earth elements, worth $8.4 billion. Several U.S. National Laboratories have also explored methods of critical mineral recovery from mine tailings and brine waste.

Barriers to widespread secondary recovery remain. For one, secondary recovery is more expensive than mining raw materials. Greater technical expertise and a new and larger workforce are also needed to support the scaling-up of emerging secondary recovery techniques. As this workforce grows, it will require policies and standards to protect workers who are handling hazardous materials, such as coal ash.

### Limited Recycling Feedstock

Critical mineral recycling requires a sufficient feedstock of end-use products. This supply is hampered in the United States by inefficient, inconsistent, or absent collection systems at the federal, state, and local levels. Many viable end-use products remain in households indefinitely, or end up in a landfill. Other end-use products, like lithium-ion batteries for electric vehicles, are not expected to reach end-of-life in sufficient numbers until 2030, according to the International Energy Agency. And while valuable feedstock of products like old wind turbines and solar panels have been ready for recycling, the United States lacks viable recycling methods for these products.

Some critical minerals can, to varying degrees, be recycled for continuous reuse. The physical collection, separation, and reprocessing of scrap metal and discarded end-use materials can generate new supplies of critical minerals. The United States has recycling streams in place for at least 14 minerals, including those important in clean energy technologies such as aluminum, cobalt, gallium, magnesium, nickel, and platinum.

Domestic recycling systems for many other critical minerals are in their infancy. The lower cost of mining over recycling, gaps in research and development, limited supplies of source material (i.e., discarded products containing critical minerals), and difficulties in separating and stripping source material to extract minerals prevent recycling systems from becoming a significant and reliable source for critical minerals.

Competition for limited raw minerals and high costs of domestic mining can incentivize a shift in investment toward recycled supplies. Investment in research and development can identify ways of recycling other critical minerals for which a recycling process does not exist or is not yet scalable. The improved design and manufacturing of end-use products (e.g., using screws instead of glue during assembly) can make products easier to recycle. Finally, comprehensive policies for the collection of end-use products can help keep viable source materials in the supply chain.

## Federal Efforts to Secure Critical Mineral Supplies

The bipartisan *Infrastructure Investment and Jobs Act* (IIJA) (P.L. 117-58) infused $7.9 billion over five years into battery manufacturing, primarily, as well as into critical mineral development, processing, refining, recycling, and research. The IIJA also codifies the eligibility of domestic critical mineral extraction projects for $72 billion in loan guarantees, distributed by DOE's Loan Programs Office. The *Inflation Reduction Act* (IRA) (P.L. 117-169) supported domestic critical mineral extraction, recycling, processing, and refining through billions of dollars in tax incentives—namely, the Advanced Manufacturing Production Credit (45X), the Clean Vehicle Credit (30D), and the Qualifying Advanced Energy Project Credit (48C). More than 162 bills, amendments, and resolutions on critical minerals were introduced in the 118th Congress (2023-2024).

Notable bills reintroduced in the 119th Congress as of July 2025—all boasting bipartisan support—include:

- The ***Critical Mineral Consistency Act of 2025*** (H.R.755/S.714) would increase the number of critical minerals and materials eligible for clean energy tax credits.
- The ***Promoting Resilient Supply Chains Act of 2025*** (H.R.2444/S.257) would establish private-public partnerships to mitigate supply chain disruptions, including for critical minerals.
- The ***Intergovernmental Critical Minerals Task Force Act*** (H.R.3198/S.823) would establish a joint task force across federal, state, local, tribal, and territorial governments to identify opportunities for increased domestic critical mineral production and recycling.
- The ***Critical Materials Future Act of 2025*** (S.596) would establish a pilot program within DOE to develop critical material processing projects in the United States.
- The ***Unearth Innovation Act*** (S.598) would establish a DOE program to research, develop, and commercialize innovative critical mineral mining, processing, and recycling technologies that minimize negative environmental and human impacts.
- The ***Critical Minerals Security Act of 2025*** (S.789) would mandate a study on global critical mineral resources to help secure U.S. access to critical mineral supply chains.
- The ***STRATEGIC Minerals Act*** (S.429) would leverage international partnerships and trade agreements to secure a reliable supply of critical minerals.

In March 2025, President Trump signed an executive order, "Immediate Measures to Increase American Mineral Production" (E.O. 14241). The order wields the *Defense Production Act* to expedite permitting processes for critical mineral mining projects on federal lands. The executive order also directs agencies to expedite the mining of copper, uranium, gold, and potash in addition to the critical minerals listed by USGS. In April 2025, President Trump signed E.O. 14285, "Unleashing America's Offshore Critical Minerals and Resources," which directs agencies to explore and extract critical minerals—both within and beyond U.S. territory—through deep-sea mining.

## Federal Agencies in the Critical Mineral Mix

Due to the range of expertise needed to secure a domestic critical mineral supply, the diversity of their end-use applications, and their implications for international relations and trade, critical mineral management in the United States takes a holistic approach. The following federal agencies and offices oversee critical mineral development and security across the supply chain:

- U.S. Geological Survey
  - The U.S. Geological Survey studies U.S. natural resources, including by identifying and mapping mineral resources, and publishes the official list of critical minerals every three years.
- Department of Energy
  - The Office of Fossil Energy and Carbon Management, Division of Minerals Sustainability, the Office of Manufacturing and Energy Supply Chains, and the National Laboratories drive critical mineral research, development, and deployment across the supply chain.
- Department of Defense
  - The Defense Logistics Agency manages the U.S. critical mineral stockpile.
  - The Office of Industrial Base Policy supports domestic mineral development and identifies critical minerals needed for national security.
- Department of State
  - The Bureau of Energy Resources develops partnerships with critical mineral-producing countries to help secure domestic supply chains.
- National Oceanic and Atmospheric Administration
  - The National Oceanic and Atmospheric Administration regulates U.S. deep-sea mining.
  - The Office of Ocean Exploration studies deep-sea minerals and mining impacts.
- Bureau of Ocean Energy Management
  - The Bureau of Ocean Energy Management shares jurisdiction over deep-sea mining regulation.
  - The Marine Minerals Program studies deep-sea minerals and mining impacts.

**Author:** Nicole Pouy

This fact sheet is available electronically (with a list of sources) at **www.eesi.org/papers**.

*The Environmental and Energy Study Institute (**www.eesi.org**) is an independent nonprofit advancing science-based solutions for climate change, energy, and environmental challenges. Founded on a bipartisan basis by members of Congress, EESI has been informing policymakers about the benefits of energy efficiency, renewable energy, and environmental conservation since 1984. In 1988, EESI declared that all energy policy must be examined through a climate lens, which has since guided us toward our vision: a sustainable, resilient, and equitable world.*

**SOURCES**


American Geophysical Union, “The 2-Year Countdown to Deep-Sea Mining” (January 24, 2022), eos.org/features/the-2-year-countdown-to-deep-sea-mining

Barbara Arnold, professor of practice in mining engineering, Penn State, in discussion with the author (January 9, 2025)

Bipartisan Policy Center, “The Missing Midstream: Identifying Investment Challenges for American Critical Mineral Processing Projects” (May 2024), bipartisanpolicy.org/download/?file=/wp-content/uploads/2024/05/BPC_The-Missing-Midstream-Report_May-2024.pdf

Center for Strategic and International Studies, “Trump’s Deep-Sea Mining Executive Order: The Race for Critical Minerals Enters Uncharted Waters” (April 25, 2025), www.csis.org/analysis/trumps-deep-sea-mining-executive-order-race-critical-minerals-enters-uncharted-waters

Congressional Research Service, “Critical Mineral Resources: The U.S. Geological Survey (USGS) Role in Research and Analysis” (April 5, 2024), crsreports.congress.gov/product/pdf/R/R48005

Congressional Research Service, “Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)” (updated March 31, 2023), crsreports.congress.gov/product/pdf/R/R47034

Congressional Research Service, “Policy Topics and Background Related to Mining on Federal Lands” (March 19, 2020), crsreports.congress.gov/product/pdf/R/R46278

Deep Sea Mining Campaign and MiningWatch Canada, “Predicting the impacts of mining deep sea polymetallic nodules in the Pacific Ocean: A review of scientific literature” (May 2020), mcstrmi.org/wp-content/uploads/2024/09/Chin-A-and-Hari-K-2020-Predicting-Impacts-of-mining-Deep-sea-Polymetallic-Nodules-in-PICs.pdf

International Energy Agency, "The Role of Critical Minerals in Clean Energy Transitions” (updated March 2022), www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

International Energy Agency, "World Energy Outlook 2023” (accessed February 21, 2024), iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-edf61467e070/WorldEnergyOutlook2023.pdf

Morgan Stanley Capital International, “Mining Energy-Transition Metals: National Aims, Local Conflicts” (June 3, 2021), www.msci.com/www/blog-posts/mining-energy-transition-metals/02531033947

National Oceanic and Atmospheric Administration, “State of the Science Fact Sheet: Deep-Sea Mining” (January 2025), repository.library.noaa.gov/view/noaa/69973

Reuters, “China bans export of critical minerals to US as trade tensions escalate” (December 3, 2024), www.reuters.com/markets/commodities/china-bans-exports-gallium-germanium-antimony-us-2024-12-03/

SAFE Center for Critical Minerals Strategy, “A Global Race to the Top: Using Transparency to Secure Critical Mineral Supply Chains” (March 2023), safe2020.wpenginepowered.com/wp-content/uploads/2023/03/SAF-_CritMinReport_v06.3_Spreads_Final.pdf

U.S. Department of Energy, "Critical Materials Assessment” (July 2023), www.energy.gov/sites/default/files/2023-07/doe-critical-material-assessment_07312023.pdf

U.S. Department of Energy Loan Programs Office, “Estimated Remaining Loan Authority” (March 2024), www.energy.gov/sites/default/files/2024-04/DOELPO_Graphic_MAAR_2024-03_RemainingAuthority_PUB.png

U.S. Department of Energy Loan Programs Office, “Title 17 Clean Energy Financing Program” (accessed July 14, 2025), www.energy.gov/lpo/articles/t17-downloadable-handout-overview?nrg_redirect=473100

U.S. Department of the Treasury, “Initial Guidance Establishing Qualifying Advanced Energy Project Credit Allocation Program Under Section 48C(e)” (February 13, 2023), www.irs.gov/pub/irs-drop/n-23-18.pdf

U.S. Department of the Treasury, “Section 30D New Clean Vehicle Credit” (April 17, 2023), www.federalregister.gov/documents/2023/04/17/2023-06822/section-30d-new-clean-vehicle-credit

U.S. Department of the Treasury, “Section 45X Advanced Manufacturing Production Credit” (December 15, 2023), www.federalregister.gov/documents/2023/12/15/2023-27498/section-45x-advanced-manufacturing-production-credit

U.S. Executive Office of the President, “Immediate Measures to Increase American Mineral Production” (E.O. 14241) (March 20, 2025), www.federalregister.gov/documents/2025/03/25/2025-05212/immediate-measures-to-increase-american-mineral-production

U.S. Executive Office of the President, “Unleashing America’s Offshore Critical Minerals and Resources” (E.O. 14285) (April 24, 2025), www.federalregister.gov/documents/2025/04/29/2025-07470/unleashing-americas-offshore-critical-minerals-and-resources

U.S. Geological Survey, “2022 Final List of Critical Minerals” (February 22, 2022), d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/2022%20Final%20List%20of%20Critical%20Minerals%20Federal%20Register%20Notice_2222022-F.pdf

U.S. Geological Survey, “Critical Mineral Recovery Potential from Tailings and Other Mine Waste Streams” (September 23, 2019), www.usgs.gov/centers/geology-energy-and-minerals-science-center/science/critical-mineral-recovery-potential#overview

U.S. Geological Survey, "Frequently Asked Questions: Minerals” (undated), www.usgs.gov/faqs/how-do-we-extract-minerals

U.S. Geological Survey, "Mineral Commodity Summaries 2025” (updated March 2025), pubs.usgs.gov/periodicals/mcs2025/mcs2025.pdf

U.S. Geological Survey, “Rare Earths Statistics and Information” (accessed March 13, 2025), www.usgs.gov/centers/national-minerals-information-center/rare-earths-statistics-and-information.

U.S. Geological Survey, “USMIN Mineral Deposit Database” (undated), mrdata.usgs.gov/deposit/map-us.html#home

U.S. House and Senate, 116th Congress, *Energy Act of 2020* (P.L. 116–260) (December 27, 2020), www.congress.gov/116/plaws/publ260/PLAW-116publ260.pdf

U.S. House and Senate, 119th Congress, *Critical Mineral Consistency Act of 2025* (H.R.755/S.714) (January 28, 2025), www.congress.gov/bill/119th-congress/house-bill/755

U.S. House and Senate, 119th Congress, *Intergovernmental Critical Minerals Taskforce Act* (H.R.3198/S.823) (March 3, 2025), www.congress.gov/bill/119th-congress/senate-bill/823

U.S. House and Senate, 119th Congress, *Promoting Resilient Supply Chains Act of 2025* (H.R.2444/S.257) (January 27, 2025), www.congress.gov/bill/119th-congress/senate-bill/257

U.S. Senate, 119th Congress, *Critical Materials Future Act of 2025* (S.596) (February 13, 2025), www.congress.gov/bill/119th-congress/senate-bill/596

U.S. Senate, 119th Congress, *Critical Minerals Security Act of 2025* (S.789) (February 27, 2025), www.congress.gov/bill/119th-congress/senate-bill/789

U.S. Senate, 119th Congress, *STRATEGIC Minerals Act* (S.429) (February 5, 2025), www.congress.gov/bill/119th-congress/senate-bill/429

U.S. Senate, 119th Congress, *Unearth Innovation Act* (S.598) (February 13, 2025), www.congress.gov/bill/119th-congress/senate-bill/598

The World Bank Group, “Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition” (accessed July 14, 2025), documents1.worldbank.org/curated/en/099052423172525564/pdf/P16627806f5aa400508f8c0bdcba0878a3e.pdf

Yale School of the Environment, “In Seawater, Researchers See an Untapped Bounty of Critical Metals” (May 15, 2024), e360.yale.edu/features/desalination-saltwater-brine-mining