GSA Position Statement

CRITICAL MINERAL RESOURCES

The Mountain Pass REE mine in the Mojave Desert, California. Source: T. Morton/ USGS, https://www.usgs.gov/centers/gmeg/science/multidisciplinary-investigations-ree-mineralization-mountain-pass-and

Position Summary. **Mineral resources, in general, are important, but "critical" minerals are officially defined as "any non-fuel mineral, element, substance, or material essential to our economic or national security, have a supply chain vulnerable to disruption, serve an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economic or national security of the United States" (USC, 2021). In addition, critical minerals are required for the transition to a low-carbon economy based on clean energy technologies and are essential for defense and consumer technologies. The United States is overwhelmingly dependent on foreign countries for critical mineral supplies. As such, a thorough understanding of their national and global distribution and abundance, impacts of extraction and processing, and the potential effects of mineral supply disruption, is important for sound public policy.**

This position statement (1) summarizes the consensus view of the Geological Society of America (GSA) on critical mineral resources; (2) advocates for better understanding of their distribution, the potential for disruption of their supply, and the consequences of their extraction and use; (3) encourages educational efforts to help the general public, lawmakers, and other stakeholders understand that mineral resources are used in almost every aspect of their daily lives, including modern technology, housing, transportation, information systems, and defense; and (4) recommends scientific investigation of nonconventional resources, better understanding of the full life-cycle consequences of their use, and international collaboration.

Conclusions and Recommendations

Government, educational, and private sector organizations, individually as well as collectively, should address the following critical resource challenges:

1. **Assessment of mineral resources**. There is a vital need to understand the abundance and global distribution of continental and oceanic critical mineral resources. To accomplish this goal requires improved fundamental understanding of the geologic processes that form mineral deposits and improved methodologies of exploration for more deeply seated and remote resources. This requires a sound mineral inventory based on geological and geophysical mapping, mineral exploration, and the assessment of abandoned mines, old mine tailings and waste rock piles. Support for research and development into methodologies for secondary extraction of minerals from mine waste and tailings is also needed. Sufficient government and private sector funding should be provided to ensure that these tasks continue to be completed (or executed) by government agencies, universities, other research institutions, and industry.
2. **Socially and environmentally responsible and respectful mining practices**. Governments, through legislation and holding bonds, need to ensure that the mining sector engages in environmentally and socially responsible and ethical mining practices in the United States and globally, and on private, federal, state, and Tribal lands. In addition, the mining sector should promote early and ongoing community engagement throughout the lifecycle of a mine. GSA encourages industry to meet and exceed existing environmental and labor legislation at all levels and prepare to monitor the effectiveness of mine reclamation to ensure proper containment of potential contaminants in perpetuity.
3. **Secondary extraction, substitution, and recycling**. As technologies, national needs, and commodity values change, governments and industry need to devote sufficient resources to enhanced and more efficient mineral recovery methodologies, environmentally contained mineral processing systems, resource assessment, and recycling of mine waste and discarded electronics. Material research for elements that will serve as substitutes for those that are in short supply or threatened is also essential.

4. **Education**. Education is important to ensure that the public is aware of the importance of critical minerals to their daily lives, their health and well-being, environmental improvement, and national security. Increasingly, the general public is required to make decisions regarding mining and the environment. Education is also necessary to develop a highly qualified workforce able to address the numerous issues related to critical mineral security. Earth science education that includes mineral resources should be part of the K–12 curriculum, along with an understanding of the work and the essential role of geologists in society. Similarly, universities should be encouraged to maintain and enhance geoscience programs bridging resource geology with environmental geoscience.
5. **International collaboration**. Modern society depends on critical minerals. However, such resources are unevenly distributed across the planet. A safe and secure supply chain requires open communication and collaboration across borders.

RATIONALE

The U.S. Geological Survey publishes annual summaries for more than 80 mineral commodities documenting global production and U.S. import reliance. Which minerals are considered critical is context-specific and dynamic. For example, those minerals essential to the transition to a low-carbon economy are currently considered critical.

Projected Increased Demand

Demand for a variety of mineral resources, such as rare earth elements (REEs), platinum group elements (PGE), cobalt, beryllium, lithium, and iodine has increased with continued consumption in developed economies and the emergence of Brazil, China, India, and other developing economies (Price, 2010). Such elements are crucial to a variety of manufacturing, high-tech (NRC, 2008), and military applications (DOE, 2021; Parthemore, 2011). Demand for energy-related minerals has increased as global energy production diversifies beyond carbon- and nuclear-based sources. For example, the World Bank estimates that the mineral intensity of the coming decades will increase demand for certain critical minerals like lithium and graphite by almost 500% by 2050 (Hund, 2020). In addition, photovoltaics, computers, cell phones, phosphorus, liquid crystal displays (LCD), and other components crucial to a high-tech, low-carbon, sustainable future require increased production and/or recycling of REEs, PGE, lithium, tellurium, gallium, and other elements (Roskill Information Services, 2010).

The demand for electric vehicles and their batteries, rich in lithium, nickel, manganese, and cobalt, has skyrocketed, and governments around the world have released trillions of dollars in federal funding to spur EV manufacturing investments (IEA, 2022). To meet demand, our nation needs a stable supply of both domestic and internationally sourced mineral resources

Global Supply

The mineral production that supplies many of these elements is concentrated in certain countries. In 2020, the United States was 100% reliant on other countries for processed REEs, and in 2021, the United States mined <16% of the global rare earth element supply. China produces most of the global REE supply (Tse, 2011). Furthermore, reserves of elements are often concentrated in one location, e.g., platinum in South Africa, lithium in South America (U.S. Geological Survey, 2022), and cobalt in the Democratic Republic of the Congo (Tahil, 2007). The tenuous nature of the mineral supply chain was highlighted in 2010 when China stopped exporting REEs to Japan for almost two months (Bradsher, 2010).

Geoscientists have a prominent role in the exploration for, management of, and environmentally safe handling of critical mineral resources. To provide a solid base for the future, it is necessary to identify the global distribution, potential for supply disruption, and environmental consequences of the production and use of these resources. Meeting global demands will become more challenging as the world's population and standards of living continue to increase and as proven developed reserves of critical minerals are depleted.

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ABOUT THE GEOLOGICAL SOCIETY OF AMERICA

The Geological Society of America (https://www.geosociety.org) unites a diverse community of geoscientists in a common purpose to study the mysteries of our planet (and beyond) and share scientific findings. Members and friends around the world, from academia, government, and industry, participate in GSA meetings, publications, and programs at all career levels to foster professional excellence. GSA values and supports inclusion through cooperative research, public dialogue on earth issues, science education, and the application of geoscience in the service of humankind. Inquiries about GSA or this position statement should be directed to GSA's Director for Geoscience Policy, Kasey S. White, at +1-202-669-0466 or kwhite@geosociety.org.

Opportunities for GSA and its Members to Help Implement Recommendations

To facilitate implementation of the goals of this position statement, GSA recommends that its members take the following actions:

- Support funding for geoscience organizations (federal, state, and provincial governments) and academic institutions involved in understanding the genesis and global distribution of mineral resources.
- Encourage companies and governments to collaborate internationally and share information that helps society understand the limitations and potentials of mineral resource development.
- Encourage research and data-gathering to determine which mineral resources are "critical" from different private sector and governmental perspectives.
- Encourage research on the consequences of exploiting resources in different environments and on new opportunities for substitution, recycling, and discovery of new types of resources.
- Promote the inclusion of mineral-resource information (global distribution, use and criticality for society, consequences of use, etc.) in educational materials at the K–12 and college levels and for popular media.

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