Critical Minerals and Materials

Position Statement. Mineral resources are essential to modern civilization, and a thorough understanding of their distribution, the consequences of their use, and the potential effects of supply disruption is important for sound public policy.

Purpose. This position statement (1) summarizes the consensus view of The Geological Society of America on critical minerals and materials; (2) advocates better understanding of their distribution, the potential for disruption of their supply, and the consequences of their use; (3) encourages educational efforts to help the general public, lawmakers, and other stakeholders understand that mineral resources and the materials derived from them are essential to almost every aspect of their daily lives, including modern technology, housing, transportation, information systems, energy, and defense; (4) recommends enhanced mapping and assessment of critical mineral and material resources, scientific investigation of potential alternatives, improved reuse and recycling, and international collaboration; and (5) provides a communications tool for geoscientists and general GSA member use.

Rationale

The term "critical minerals" applies to nonfuel minerals or materials that are essential to our modern economy and national security and that have a supply chain vulnerable to disruption[1,2,3]. Advances in the design of vehicles, consumer electronics, energy systems, and military hardware are driving demand for materials made from an expanding suite of chemical elements derived from various mineral resources[4]. Demand for many of these elements, such as rare earth elements (REEs), platinum group elements (PGE), cobalt, beryllium, lithium, and iodine has increased with growth of consumption in developed economies and the economic expansion of Brazil, China, India, and other countries[5]. These types of elements are crucial to a variety of manufacturing, high-tech[6], and military applications[7,8]. Demand for energy-related minerals has also increased as global energy production diversifies beyond carbon- and nuclear-based sources. For example, rare earth elements are used in many renewable energy devices, including high-strength magnets for wind-power generators, and lithium and cobalt are used in electric car batteries. In addition, photovoltaics, computers, cell phones, phosphors, liquid crystal displays (LCDs), and other components essential to our technological future require increased production and/or recycling of REE, PGE, lithium, and other elements[9]. A stable supply of mineral resources is thus essential for economic prosperity and national security.

Known natural deposits of many of these minerals are concentrated in certain countries by the nature of the geology and the degree to which these regions have been explored and developed. For example, China produces >95% of the global rare earth element supply[10]; the United States produces >85% of the world beryllium supply[11]; and nearly 80% of global platinum production is in South Africa[12]. Furthermore, the largest reserves of some elements are often concentrated in one location, e.g., platinum in South Africa and lithium in South America[13]. The tenuous nature of the mineral supply chain was highlighted in 2010 when China stopped exporting REEs to Japan for almost two months[14]. The U.S. Geological Survey publishes annual summaries for more than 80 mineral commodities documenting global production and U.S. import reliance.[15]

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

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will become more challenging as the world's population increases, standards of living continue to rise, and as proven reserves of critical minerals are depleted.

Conclusions and Recommendations

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

- *Assessment of critical mineral resources* — There is a vital need to understand the abundance and distribution of critical mineral resources, as well as the geologic processes that form them, both within the United States and globally. This will require expanded collection and analysis of geological, geochemical, and geophysical data. Sufficient funding should be provided to ensure that these tasks are met by academic research institutions and government agencies.
- *Life-cycle assessment* — Governments need to devote sufficient resources to identify critical elements and support research and development that allows for economically efficient and environmentally sound mineral discovery and development, advances in mineral processing technology, and product development and manipulation — including recycling — to meet national needs.
- *Sustainability* — The adequacy of mineral resources at a given moment in time is important but should not invalidate the need for a longer-term view of finite global resources in the context of population growth, rising standards of living, dynamic geopolitics, and the environmental consequences of use. The world is not likely to run out of mineral resources in a broad sense, but shortages of particular resources at specific times and places are likely. Advances in technology will create demand for new resources and make previously marginal resources economic. Substitution and recycling will also affect the need for newly mined mineral resources.
- *Education* — Although general awareness of the importance of energy to our nation's future appears to be growing, appreciation of the fundamental role of minerals in national security and economic well-being is less evident in public discussions. Efforts to ensure a better-educated public with regard to mineral resources are important, including the teaching of economic geology and related fields at the university level to maintain an adequate workforce of exploration and production geologists.
- *International collaboration* — Modern society depends on critical minerals. However, such resources are unevenly distributed across the planet and may be located in areas of conflict. Open communication and collaboration across borders may reduce the most common supply risks for critical minerals.

References

1. National Science and Technology Council, 2016, Assessment of critical minerals—Screening methodology and initial application: Washington, D.C., Subcommittee on Critical and Strategic Mineral Supply Chains of the Committee on Environment, Natural Resources, and Sustainability of the National Science and Technology Council, March, 47 p., https://www.whitehouse.gov/sites/whitehouse.gov/files/images/CSMSC%20Assessment%20of%20Critical%20Minerals%20Report%202016-03-16%20FINAL.pdf.
2. McCullough, E., and Nassar, N.T., 2017, Assessment of critical minerals: Updated application of an early-warning screening methodology: Mineral Economics, v. 30, p. 257-272, https://doi.org/10.1007/s13563-017-0119-6.
3. Hereafter we refer to minerals and materials derived from raw minerals simply as "minerals."
4. Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., 2017, Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, 797 p., http://doi.org/10.3133/pp1802.
5. Price, J.G., 2010, The World is Changing: SEG Newsletter, July 2010, no. 82, p. 12–14, http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/.
6. NRC, 2008, Minerals, Critical Minerals, and the U.S. Economy: National Research Council, 264 p., http://www.nap.edu/catalog.php?record_id=12034.
7. U.S. DOE, 2010, Critical Minerals Strategy: U.S. Department of Energy, http://energy.gov/pi/office-policy-and-international-affairs/downloads/2010-critical-materials-strategy.

8. Parthemore, C., 2011, Elements of Security: Mitigating the Risks of U.S. Dependence on Critical Minerals: Center for a New American Security, http://www.cnas.org/elementsofsecurity.
9. LCD Screens continue to drive iodine demand, 2010, China Chemical Reporter, v. 21, Issue 15, p. 16.
10. Tse, Pui-Kwan, 2011, China's Rare-Earth Industry: U.S. Geological Survey Open-File Report 2011-1042, 11 p., http://pubs.usgs.gov/of/2011/1042.
11. USGS, 2013, Mineral Commodity Summaries 2013: Reston, Virginia, United States Geological Survey, 198 p., http://minerals.usgs.gov/minerals/pubs/mcs/2013/mcs2013.pdf.
12. APS/MRS, 2011, Energy Critical Elements: Securing Materials for Emerging Technologies: APS/MRS Report, 28 p., http://www.aps.org/policy/reports/popa-reports/upload/elementsreport.pdf.
13. Tahil, W., 2006, The Trouble with Lithium: Meridian International Research, 14 p., http://www.evworld.com/library/lithium_shortage.pdf.
14. Bradsher, K., 2010, China Restarts Rare Earth Shipments to Japan: New York Times, 19 Nov. 2010, http://www.nytimes.com/2010/11/20/business/global/20rare.html.
15. Graedel, T.E., Barr, R., Chandler, C., Chase, T., Choi, J., Christoffersen, L., Friedlander, E., Henly, C., Nassar, N.T., Schechner, D., Warren, S., Yang, M., and Zhu, C., 2012, Methodology of metal criticality determination: Environ. Sci. Technol., v. 46, p. 1063−1070.

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Opportunities for GSA and its Members to Help Implement Recommendations

- To facilitate implementation of the goals of this position statement, The Geological Society of America 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.