

Challenges and Opportunities in the Extraction of Rare Earths

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The rare earth elements, along with their compounds and alloys, play vital roles in many modern devices, including nearly all “clean energy” technologies. They provide key functionality in devices that produce, transmit and manipulate light, and they are used in making magnets for motors, generators, sensors, actuators and other components in an enormous range of different applications. In most cases, the capabilities provided by rare earth materials cannot be delivered by other substances, so the rare earths are considered to have very low substitutability. In addition to being irreplaceable, rare earths are only provided from a small number of sources, and the combination of restricted source diversity and low substitutability makes the rare earths the leading example of what are called “critical materials.”

The risks associated with manufacturing with rare earths can be mitigated through efforts to avoid waste during manufacturing, or provide for recycling at the end of life. In a few cases, the risks can also be avoided if substitute materials can be invented. Ultimately, however, there will inevitably be a need for new sources of rare earths. Source diversification – effectively the development of new mines – depends entirely upon economics: the cost of opening a mine, and the cost of operating the mine, must result in products that generate a return on the investment in the shortest possible time. While the prices of the rare earths are not easy to predict, it is always important to find ways to reduce the capital expenditures (CAPEX) and operating expenditures (OPEX) for mining. In this paper, we review the opportunities for reducing CAPEX and OPEX associated with converting ore into rare earth metals, improving mine revenues, and the contributions to these that can be made by fundamental scientific research.