

Assuring rare earth mineral supply: A literature review and a systems model

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Abstract: A reliable and uninterrupted supply of rare earth (RE) minerals is essential to national security and economic growth. RE minerals are crucial inputs to the manufacturing, defence, and high-tech industry sectors. While RE minerals are not necessarily scarce, extracting and purifying them is challenging. These activities require considerable capital investment, which means RE supply chains are often subject to control by several large actors. As such, RE minerals supply poses risks to downstream actors, and this raises a need to understand the security of RE minerals supply more comprehensively.

To address these concerns, we critically analyse the existing approaches and theories used to evaluate RE minerals supply chain security and explore pathways to achieve RE minerals supply security. To do so, we collect and analyse 323 articles from Web of Science, Scopus, and Google through a systematic literature review process.

Based on our literature synthesis, we suggest four pathways to improve RE minerals supply chain security: circular economy strategies, supply chain agility, building domestic supplies, and exploring beyond terrestrial mining.

Circular economy approaches involve recycling and reusing RE minerals to minimize the need for new mining. Supply chain agility approaches focus on diversifying the sources of RE minerals to reduce reliance on single, powerful suppliers. Building domestic supplies approaches involve developing domestic mining capabilities and investing in research and development to improve RE extraction technologies. Finally, exploring beyond terrestrial mining approaches involve exploring alternative sources of RE minerals, such as deep-sea mining and asteroid mining.

To depict the complexity and dynamics of the different system elements affecting RE minerals supply chain security, we use Systems Thinking to develop a preliminary causal loop diagram (CLD) to conceptualise the roles and effects of factors evident in the literature. The CLD is a step towards RE mineral supply chain transparency and is useful to help policymakers and stakeholders develop effective strategies to ensure a robust supply of RE minerals.

This study underscores the critical role of RE minerals in national security and economic growth. Our literature synthesis suggests there are at least four approaches a country can adopt to secure its RE minerals supply and that it is possible to understand this using CLD techniques.

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