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Current status, challenges, new developments: A look to the future of deep-ocean seabed minerals

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Deep-ocean seabed minerals play key roles in understanding paleoceanography and marine (bio)(geo)chemistry, as well as potentially providing metal resources for the 21st century and to transitioning to a green-energy-based future.

Four types of deep-ocean minerals are being considered as sources of critical materials required for the economic welfare and security of nations. Many of these materials have supply chains prone to disruptions. The four mineral types are seafloor massive sulfides (SMS), polymetallic nodules (PN), ferromanganese crusts (crusts), rare earth element-rich mud (REE mud). Mining operations for PN and SMS are expected to start in the 2020s at a few locations. This talk introduces deep-ocean minerals and the current rationale for and against their extraction, including comparisons with land-based mining. The unique characteristics of deep-ocean mine sites offer some advantages over land-based mine sites, but many challenges exist, most importantly a sufficient understanding of ecosystems and development of new environmentally sound extraction technologies.

Research on the geochemical processes of formation, metal accumulation, diagenesis, and long-term stability of marine minerals are still not fully understood, processes that could impact the efficacy of their paleoceanographic records. For example, does diagenesis occur in crusts, such as due to ageing for example, which might involve chemical or isotopic exchange or reorganization—little research has addressed this issue, but diagenesis likely occurs in crusts and additional studies are warranted[1]. Another poorly understood process is the role of bacteria and archaea in crusts and nodules. Both Fe and Mn oxidizing and reducing microbiota occur in these minerals, however, it is not known if crusts and nodules simply provide ample habitat or if microbiota contribute to structurally building crusts and nodules? Finally, global mass-balance of ocean chemistry will benefit from increasingly accurate estimates of the total global tonnages of marine minerals and the contained metals[2]. All of these and other (bio)(geo)chemical processes are interconnected and with further research and application of new technologies like synchrotron, nanoSIMS, micro-Raman, microscale metal isotopes, and others currently little used for understanding these complex chemical sediments, the field of deep-ocean seabed minerals will contribute much to marine geochemistry.

[1] https://doi.org/10.1029/2020GC009074; [2] https://doi.org/10.1007/978-3-030-87982-2_3