TU Delft

Delft University of Technology

Document Version
Final published version

Licence
CC BY

Citation (APA)
Song, H., Wang, C., Zhou, S., Sprecher, B., & Wang, P. (2026). Political acceleration fuels the deep-sea gold rush: A call for science-informed global governance. *Innovation Geoscience*, *4*(1), Article 100188. https://doi.org/10.59717/j.xinn-geo.2026.100188

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright
In case the licence states “Dutch Copyright Act (Article 25fa)”, this publication was made available Green Open Access via the TU Delft Institutional Repository pursuant to Dutch Copyright Act (Article 25fa, the Taverne amendment). This provision does not affect copyright ownership.
Unless copyright is transferred by contract or statute, it remains with the copyright holder.

Sharing and reuse
Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy
Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

This work is downloaded from Delft University of Technology.

Political acceleration fuels the deep-sea gold rush: A call for science-informed global governance

Huiling Song,[1] Chang Wang,[2,*] Siyuan Zhou,[2] Benjamin Sprecher,[3] and Peng Wang[4,5,*]

[1]School of Business, Zhengzhou University, Zhengzhou 450001, China
[2]School of Business, Central South University, Changsha 410083, China
[3]Department of Sustainable Design Engineering, Faculty of Industrial Design Engineering, Delft University of Technology, Delft 2628 CD, the Netherlands
[4]State Key Laboratory for Ecological Security of Regions and Cities, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen 361021, China
[5]University of Chinese Academy of Science, Beijing 100049, China
*Correspondence: changwang@csu.edu.cn (C.W.); pwang@iue.ac.cn (P.W.)

Received: November 4, 2025; Accepted: December 31, 2025; Published Online: January 5, 2026; https://doi.org/10.59717/j.xinn-geo.2026.100188

© 2026 The Author(s). This is an open access article under the CC BY license (https://creativecommons.org/licenses/by/4.0/).

Citation: Song H., Wang C., Zhou S., et al. (2026). Political acceleration fuels the deep-sea gold rush: A call for science-informed global governance. *The Innovation Geoscience* **4**:100188.

The global scramble for critical minerals is now reaching the ocean floor. In April 2025, U.S. President Donald Trump signed an executive order encouraging the commercial extraction of deep-sea minerals. A few months earlier, Norway became the first country to formally approve deep-sea mining within its national waters. Meanwhile, countries including Saudi Arabia, Japan and China have also accelerated their deep-sea exploration efforts. These moves signal a growing political appetite in extracting the critical minerals on the ocean floor.

These critical minerals, such as rare earth elements, cobalt, have become indispensable for enabling the low-carbon energy transition as well as national security. The deep seabed harbours vast deposits of minerals essential for clean technologies.[1] As terrestrial sources become more geopolitically concentrated and environmentally contested, seabed deposits offer an alternative,[2] especially for countries with limited access to land-based resources.

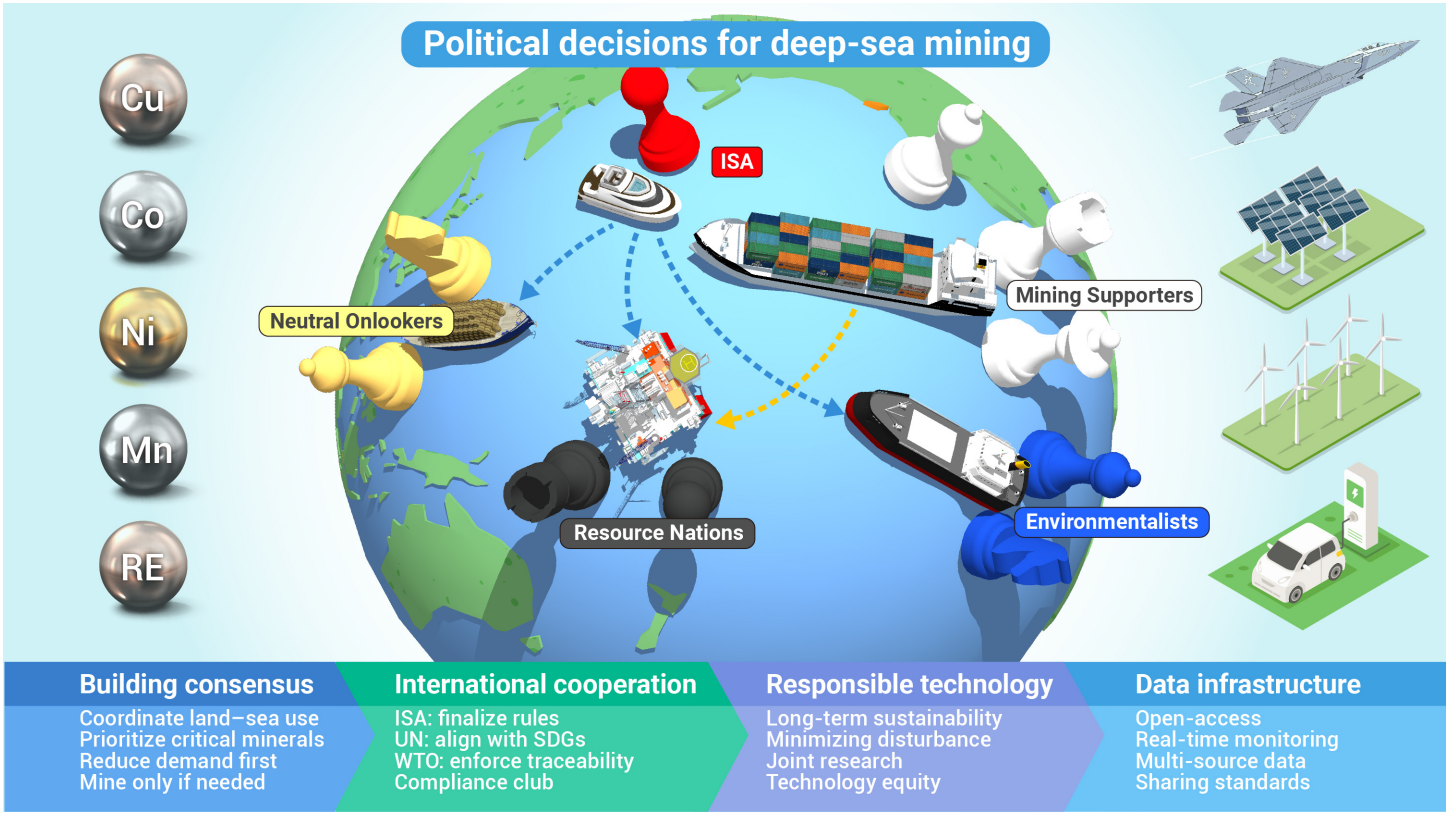

Figure 1. Political decisions for deep-sea ming.

Yet deep-sea mining remains fraught with considerable uncertainty, including, but not limited to, substantial technical challenges, poorly understood environmental consequences, and unresolved legal and governance frameworks.[3,4] Despite these concerns, perceptions of resource insecurity, geopolitical competition, and economic opportunity are clearly keeping deep-sea mining in the center of attention. Here, we argue that the international community must move beyond passive resistance or delay, and science-informed global joint actions are urgently needed before irreversible extraction begins. Without such foresight, short-term political decisions risk triggering long-term ecological and geopolitical consequences.

POLITICAL DRIVERS ACCELERATING DEEP-SEA MINING

Over the past few years, a growing number of countries have taken decisive policy steps to ramp up their deep-sea mining efforts (Figure 1). Norway approved the first commercial seabed mining in its waters in 2024. The U.S. followed in 2025 with an executive order linking deep-sea mining to national security. China, the holder of the largest number of exploration contracts issued by the ISA, has advanced from domestic planning and autonomous trials. Saudi Arabia, as part of its Vision 2030 economic diversification strategy, launched a Red Sea deep-sea exploration initiative and entered into technology partnerships with China and South Korea. Japan and South Korea, while more cautious in authorizing commercial operations, have steadily expanded their national roadmaps, technological capabilities, and

international collaborations. These initiatives reflect a growing perception that deep-sea minerals are strategic assets, yet this approach risks creating regulatory asymmetries and eroding international coherence.

RIPPLE EFFECTS OF POLITICAL ACCELERATION

These political developments, while domestically motivated, have triggered ripple effects across ecological, governance, and geopolitical dimensions.

Intensifying ecological risks amid uncertain knowledge

The recent policy push has accelerated the momentum toward commercial deep-sea mining—despite persistent gaps in scientific understanding. Humanity still knows little about the deep-sea environment, due to sparse ecological surveys and limited long-term monitoring data.[5] Mining technologies under development could cause irreversible harm, including biodiversity loss, food web disruption, and large-scale ecosystem degradation. Compounding this, restoration methods remain largely untested and are unlikely to reverse these impacts in the foreseeable future. There is also no clear liability framework to hold early movers accountable in the event of irreversible damage. Therefore, accelerating the shift from exploration to exploitation without environmental clarity risks inflicting lasting damage on one of Earth's last ecological frontiers.

Jeopardizing global ocean governance

Such unilateral national actions risk undermining the International Seabed Authority's capacity to develop and enforce coherent global regulations. While the ISA has issued more than 30 exploration contracts to date, commercial deep-sea mining has not yet begun. The recent U.S. executive order and Norway's national policy signal a shift toward nationally driven mining agendas—outside the ISA's authority. These actions undermine the legitimacy of the multilateral framework enshrined in UNCLOS and expose the ISA's limited capacity to enforce compliance and deliver a comprehensive regulatory framework. Worse still, these political signals may trigger a wave of imitation. Countries with high resource demand or weak legal safeguards could bypass international procedures and accelerate unilateral exploration. This opens the door to a race to the bottom, where minimal environmental and social standards are used to attract investment—pushing global governance from cooperation toward fragmentation.

Shifting geopolitical dynamics

Deep-sea minerals are increasingly seen as strategic assets in the race for energy transition minerals. Major powers are now treating deep-sea resources not as global commons to be governed collectively, but as assets to be claimed and protected. This shift reinforces a logic of strategic competition, not multilateral cooperation. Such trends risk entrenching "resource blocs", in which mineral-rich areas of the ocean become instruments of geopolitical leverage. Countries with technological advantage or early access may dominate exploration and licensing processes, reinforcing existing global inequalities. Without a transparent, inclusive framework, deep-sea mining could widen the gap between resource-owning and resource-seeking nations—intensifying tensions rather than reducing dependence.

FROM PRECAUTION TO PREPARATION: A CALL FOR GLOBAL ACTIONS

Calls for a global moratorium have played an important role in highlighting the risks of deep-sea mining. However, with political decisions now accelerating mining efforts, moratoriums alone are no longer sufficient. The world must move from precaution to preparation guided by science, equity, and cooperation.

(1) Building consensus on sustainable deep-sea mining. Deep-sea mining must be clearly positioned as a potential supplement, not a replacement for terrestrial extraction. The development of land- and sea-based mineral resources should be coordinated to avoid overexploitation. Meanwhile, not all seabed minerals are equally critical, and targeted prioritization is needed. Alternatives such as recycling, substitution, and circular economy practices should be actively promoted to reduce overall demand, before starting to put pressure on fragile deep-sea ecosystems.

(2) Strengthening international cooperation. Advancing global cooperation on deep-sea mining requires both institutional coordination and market alignment. Institutionally, the ISA needs to reinforce its legitimacy by accelerating exploitation regulations and clarifying legal responsibilities. The United Nations can integrate deep-sea mining governance within the broader framework of the SDGs, while the WTO can embed environmental and traceability standards into global trade rules, making responsible sourcing a prerequisite for market access. On the market side, developing a global framework for "responsibly sourced deep-sea minerals" certification and traceability could link environmental compliance to access in finance, insurance, and logistics. Such a "compliance club" would encourage responsible investment and discourage unilateral exploitation.

(3) Prioritizing responsible technology breakthrough. Technological progress should extend beyond extraction efficiency to emphasize environmental stewardship and long-term sustainability. Innovations must prioritize minimizing ecological disturbance through real-time monitoring, adaptive control of sediment plumes, and precision recovery techniques that target specific mineral deposits while preserving surrounding ecosystems. Development of low-impact collection systems, closed-loop waste management, and biodegradable operational materials can further mitigate harm. To narrow technological disparities, joint research platforms and technology-transfer partnerships should be fostered, enabling developing countries and small island states to participate fairly in sustainable deep-sea mining.

(4) Advancing global data infrastructure. The deep sea is a shared global common, yet current data on its ecosystems and mineral resources remain fragmented and inaccessible. A collaborative, open-access data platform is essential for building ecological baselines, assessing cumulative impacts, and supporting real-time environmental monitoring. This platform should integrate data from satellites, autonomous underwater vehicles, and national research programs into interoperable formats accessible to all. To ensure inclusivity, participation by developing nations and small island states must be embedded in both data collection and governance processes. Establishing transparent data-sharing protocols and standardized metadata frameworks would enable science-based decision-making and equitable benefit-sharing across the global community.

Deep-sea mining is no longer a slow-moving scientific debate, but a fast-moving geopolitical reality. While deep-sea mining may be inevitable, the global community still has the opportunity to shape its governance.

REFERENCES

1. Wang C., Shu X., Zhou S., et al. (2025). Embracing a new era of deep-sea mining: Research progress and prospects. *Mar. Policy* **180**:106778. DOI:10.1016/j.marpol.2025.106778
2. Lebre E., Kung A., Savinova E., et al. (2023). Mining on land or in the deep sea? Overlooked considerations of a reshuffling in the supply source mix. *Resour. Conserv. Recy.* **191**:106898. DOI:10.1016/j.resconrec.2023.106898
3. Zhang Q., Chen X., Luan L., et al. (2025). Technology and equipment of deep-sea mining: State of the art and perspectives. *Earth Energy Sci.* **1**:65–84. DOI:10.1016/j.ees.2024.08.002
4. Brotherson M. and Jr S. (2025). A message from island leaders: Protect the Pacific Ocean from deep-sea mining. *Nature* **642**:299–302. DOI:10.1038/d41586-025-01774-w
5. Gilbert N. (2023). Major ocean database that will guide deep-sea mining has flaws, scientists warn. *Nature*. DOI:10.1038/d41586-023-01303-7

FUNDING AND ACKNOWLEDGMENTS

This work was supported by the National Social Science Fundnation of China (23&ZD106, 22&ZD098), the National Natural Science Foundation of China (72304251, 72534006, 72274187) and the Deep-earth Probe and Mineral Resources Exploration-National Science and Technology Major Project of China (2025ZD1007006, 2025ZD1007007). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript and approved the final version.

DECLARATION OF INTERESTS

The authors declare no competing interests.