STIRRING THE WATERS

FROM DEPTHS BELOW TO DEPTHS BEYOND

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ABOUT DRA'S FUTURE OF MINING SERIES

The mining industry is one laden with contradictions. On the one hand we must produce faster, smarter and more lucratively than before, and on the other we must consider the environment, sustainability and even the end consumer. Is there a common ground to achieve mutually beneficial outcomes on this unchartered and, often unstable, terrain?

We've seen accelerated strategies in environmental, social and corporate governance (ESG), digitisation and automation since the outbreak of the COVID-19 pandemic. Change has become business as usual and compared to a long history of using the past as our compass, the industry is now looking to the future as a driver of fundamental and sustainable change.

Disruptive technologies continue to shape and reshape our picture of the future. There's no clear or definitive image of what that will look like but we unpack some fundamental elements of what success might look like in our next horizon. Share our journey, as we imagine the workforce of tomorrow, explore socially conscious mines of the future, weigh up the risks, investigate new business models and get real with artificial intelligence.

In DRA's Future of Mining Series, we take a look at the challenges the industry is facing. We leverage the knowledge from our expert team of advisors to highlight some considerations for mining companies and its value chain to navigate the future with confidence. Join us as we step into tomorrow.

FROM DEPTHS BELOW TO DEPTHS BEYOND

Deep-sea mining has emerged as one of the most contentious and promising frontiers in the quest for critical minerals. With the rising global demand for renewable energy technologies, electric vehicles, and advanced electronics, the ocean floor has become a vast, untapped reservoir of precious resources. Hidden within the depths are abundant deposits of nickel, cobalt, copper, and rare earth elements, ready for extraction. The Clarion-Clipperton Zone (CCZ) in the Pacific Ocean, for instance, is a treasure trove of polymetallic nodules[1], while other notable zones include the Cook Islands EEZ, the Rio Grande Rise off Brazil, and the Bismarck Sea in Papua New Guinea.

However, this burgeoning industry is not without its controversies. The technical challenges are immense but navigable, and the potential rewards are appealing, but the environmental implications can be profound and far-reaching.

Critics argue that deep-sea mining could lead to irreversible damage to marine ecosystems, disrupting the delicate balance of life in the depths of the ocean. Companies like The Metals Company (TMC), China Ocean Mineral Resources Research and Development Association (COMRA), and Ocean Minerals[2] are pioneering advanced technologies to harvest these resources from depths of 1,500 to 6,000 meters below sea level.

Since 2001, the International Seabed Authority (ISA) has granted 31 permits for exploration and scientific research in the deep ocean, focusing mainly on nodules and other mineral-rich geological formations. As of July 9, these permits can now be expanded to allow for the industrial mining of these resources[1].

The ethical considerations of exploiting these pristine environments for human gain cannot be ignored. Can we balance the insistent demand for critical minerals with the imperative to protect our planet's most remote and fragile ecosystems? The future of deep-sea mining will undoubtedly shape the trajectory of our technological advancement and environmental stewardship.

THE DARK SIDE OF DEEP-SEA MINING

The long-term impacts of deep-sea mining remain largely unknown. A study revisiting a mining test site from the 1970s revealed that the tracks of the mining equipment were still visible[3], and the impact on some wildlife was ongoing. This raises serious questions about the sustainability and environmental cost of deep-sea mining. The extraction process threatens to disrupt fragile marine ecosystems, particularly in the midwater zone, home to unique and poorly understood species.

Mining operations can create sediment plumes that spread over vast areas, spanning tens of thousands of square kilometers beyond mining sites,[4] affecting marine life far beyond the immediate site. These plumes can smother marine life and disrupt feeding patterns, leading to significant ecological disturbances. A 2023 study found that over 90 per cent of the species observed in the CCZ, one of the initial areas considered for commercial deep-sea mining, remain undescribed by science. This underscores the vast gaps in our understanding of deep-sea ecosystems.[5]

Activities associated with mining can destroy habitats that take centuries to millennia to recover. For example, the CCZ, although abundant in manganese nodules, is home to over 1,000 species, many of which are endemic and could be at risk[6]. The CCZ spans approximately [6] million square kilometers and is one of the most biodiverse regions in the deep ocean[6]. The destruction of these habitats could lead to the extinction of species that have not yet been discovered or studied.

A real-world example illustrating the potential risks of deep-sea mining comes from a 2020 study by the German research vessel SONNE. This study simulated a small-scale seabed mining disturbance in the CCZ of the Pacific Ocean. Researchers discovered that sediment plumes traveled farther than expected, with fine particles remaining suspended in the water column for extended periods. Additionally, the study observed a 43 per cent reduction in biodiversity in the affected areas, even decades later, raising significant concerns about the long-term impacts of large-scale mining operations.[5]

Deep-sea ecosystems play a crucial role in carbon sequestration. Marine ecosystems, including deep-sea environments, absorb about 31 per cent of human-made CO_2 emissions each year and store an estimated 93 per cent of the Earth's CO_2.[6] The biological pump, a process where marine organisms like phytoplankton absorb CO_2 and transport it to the ocean floor, is vital for long-term carbon storage. Disruption of these habitats could impact global carbon cycles and exacerbate climate change.

Due to these risks, several organisations are actively opposing deep-sea mining.[7] Leading the charge is the Deep Sea Conservation Coalition (DSCC), comprising over 90 NGOs, fishers organisations, and law and policy institutes, advocating for a moratorium on deep-sea mining. Greenpeace highlights the risks to marine biodiversity and potential irreversible damage. Similarly, World Wildlife Fund campaigns for precautionary measures and marine habitat protection. The Ocean Foundation raises ecological concerns, while Fauna & Flora International (FFI) calls for a moratorium until environmental impacts are fully understood. Pew Charitable Trusts works to regulate and limit mining activities. Friends of the Earth, Surfrider Foundation, Mission Blue, and the Pacific Network on Globalisation (PANG) also oppose deep-sea mining due to its potential harm to marine ecosystems and resources.

These organisations are united in their call for a precautionary approach to deep-sea mining, highlighting the need for comprehensive environmental assessments and robust regulatory frameworks to protect marine ecosystems.

THE DEEP-SEA DEBATE

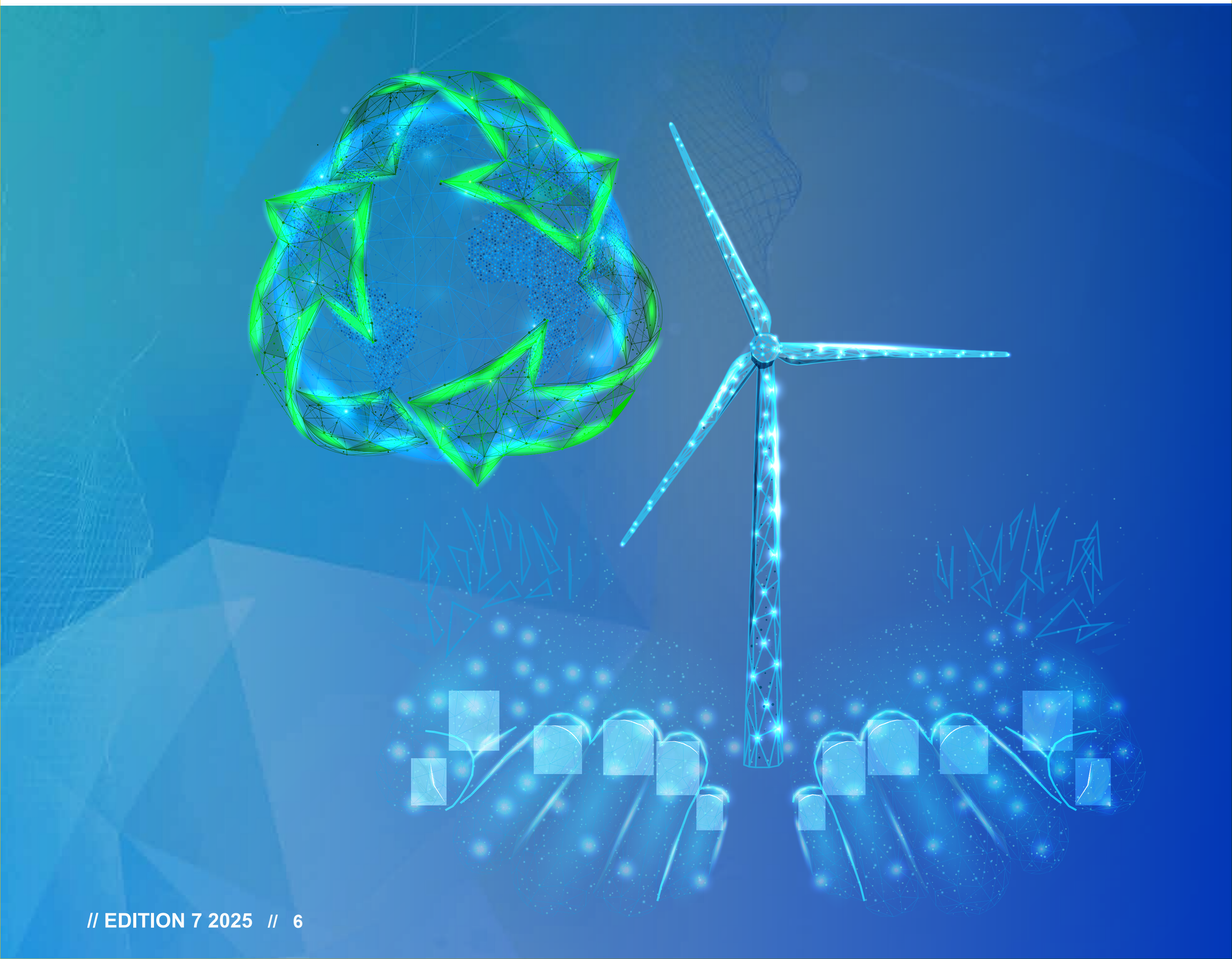
The history of terrestrial mining offers important lessons and warnings. Although the industry has a reputation for causing environmental damage, there have been notable advancements in reducing the environmental impact of mining over the years. The question is whether deep-sea mining will follow a similar learning curve or if we can learn from past mistakes and implement truly sustainable practices from the outset.

Regulatory frameworks for deep-sea mining are evolving, with a focus on balancing resource extraction and environmental protection. During the International Seabed Authority's (ISA) 30th Council session in March 2025, discussions continued on finalising the exploitation regulations.[8] The ISA is under pressure to complete the mining code by mid-2025, following the invocation of the "two-year rule" by the Republic of Nauru in 2021 – a provision under the 1994 Part XI Implementation Agreement, which complements the United Nations Convention on the Law of the Sea (UNCLOS).[8]
The mining code aims to establish comprehensive regulations for mineral resource exploitation in areas beyond national jurisdictions, balancing the need for resource extraction with environmental protection. The ISA's efforts are crucial as they navigate legal and political challenges to finalise these regulations, its mining code will cover several key areas to regulate deep-sea mining activities.

Several measures are being implemented and investigated by mining companies to minimise the environmental impact of deep-sea mining on ocean ecosystems. Advanced technologies, such as uncrewed collector vehicles, are being developed to carefully extract polymetallic nodules while minimising disturbance.[9] Efforts are also being made to manage and contain sediment plumes generated during mining operations, using techniques to limit the spread of fine particulate matter.[10] Comprehensive Environmental Impact Assessments (EIAs) are conducted before mining activities commence, evaluating potential impacts on marine ecosystems and helping design mitigation strategies to protect biodiversity.[11]

Adhering to international regulations and guidelines set by bodies like the ISA ensures that mining activities are conducted responsibly, with provisions for environmental protection and sustainable resource management.

These regulatory frameworks, continuous scientific research, and transparent stakeholder engagement are essential. Companies must invest in advanced technologies to minimise environmental impact and prioritise the protection of marine ecosystems. The precautionary principle should guide decision-making, ensuring that mining activities do not proceed until their environmental impacts are fully understood.



UNCHARTED TERRITORY

Regulatory frameworks in underground mining have evolved significantly over the years, driven by technological advancements, environmental concerns, and a growing emphasis on worker safety. These developments reflect a broader trend towards more sustainable and responsible mining practices, balancing economic interests with environmental protection and social responsibility. To gain a clearer understanding of deep-sea mining, we can compare it with traditional underground mining, analyse the lessons from each, and evaluate the associated risks.

As the mining industry evolves, the skills and expertise honed in underground mining are becoming increasingly relevant to the burgeoning field of deep-sea mining. This transfer of skills represents a new era in mineral extraction, where the boundaries between land and sea are blurred, and the potential for innovation and job creation is immense. The question is, can we leverage the knowledge and experience of underground miners to pioneer sustainable practices in deep-sea mining?

The technical skills required for operating heavy machinery and advanced equipment in underground mining are directly applicable to deep-sea mining. Remote Operated Vehicle (ROV) Specialists, for example, can draw on their experience with underground mining equipment to operate and maintain underwater robots used for exploration and extraction. This interchange of skills not only enhances operational efficiency but also opens up new career opportunities for miners who are willing to adapt to the challenges of the deep-sea environment.

Moreover, the environmental and safety protocols developed in underground mining can be transferred to deep-sea mining to mitigate risks and protect marine ecosystems. Environmental Engineers and Safety Engineers, who have extensive experience in designing sustainable mining practices and safety protocols for underground operations, can apply their expertise to the deep-sea context. This transfer of knowledge is crucial for developing comprehensive EIAs and ensuring that deep-sea mining activities adhere to stringent safety standards.

The skills of Geologists and Data Analysts is another interchangeable area between underground and deep-sea mining. Geologists specialised in underwater geology can leverage their knowledge of mineral deposits on land to identify and assess resources on the ocean floor. Similarly, Data Analysts can apply their skills in analysing data collected from underground sensors to optimise deep-sea mining operations and monitor environmental conditions. This synergy between land and sea mining not only enhances resource extraction but also promotes a holistic approach to environmental monitoring.

Project Managers, with their management and oversight skills in underground mining, offer valuable insights to deep-sea mining projects. These professionals, who are adept at planning, executing, and managing complex mining operations, can bring their expertise to the deep-sea context, ensuring that projects are conducted efficiently and responsibly. This transfer of skills is essential for navigating the regulatory landscape and balancing economic development with environmental stewardship.

Given our extensive experience in terrestrial mining, we are well-positioned to approach seabed mining with a solid foundation of knowledge and understanding. This advantage allows us to potentially avoid the mistakes made in the past. By leveraging our learnings, we can prioritise sustainability and environmental stewardship over mere profit and gain.

CONCLUSION

The regulatory landscape for deep-sea mining is intricate and fraught with significant risks. The history of terrestrial mining serves as a stark reminder of the environmental damage that can occur, but it also provides valuable lessons for a more sustainable approach to underwater mining projects.

To prevent deep-sea mining from becoming an environmental disaster, robust regulatory frameworks, continuous scientific research, and active stakeholder engagement are essential. Companies investing in advanced technologies to minimise environmental impact and prioritise the preservation of marine ecosystems are likely to pioneer the way forward. In learning from the experiences of underground mining and proceeding with caution, it may be possible to drive economic development that is not at the expense of our planet's most fragile and unexplored environments.

Through the exchange of skills between underground and deep-sea miners, a new era in mineral extraction may arise. By leveraging the knowledge and experience of underground miners, we can develop sustainable practices in deep-sea mining and create a more integrated and innovative industry. The real challenge lies in ensuring that this transfer of skills is supported by strong regulatory frameworks and a firm commitment to environmental protection.

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