DEEPSEA MINING

Harvesting the ocean scavengers

Polymetallic nodules may supply critical metals for low carbon energy if their mining is environmentally sound, writes *Maria Kielmas*.

Collecting deepsea bed samples from the Clarion Clipperton Zone (CCZ) of the northern equatorial Pacific Ocean

Reliable supplies of critical metals are vital as countries pursue a low carbon future. Cobalt, copper, lithium, nickel, manganese, cadmium and rare earth elements are needed for electric vehicles (EVs), batteries, photovoltaics, wind turbines, energy storage and nuclear reactors.

As global terrestrial supplies of these metals are often heavily monopolised by a single or handful of countries, and increasingly confronted by environmental devastation and human misery in the form of child and prison labour, researchers and pioneering mining corporations are seeking mineral wealth in the deep oceans. For some, it is all about terrestrial versus seabed mining. 'Terrestrial mining is not sustainable given its social impact,' says Chris Williams, CEO of London-based UK Seabed Resources, a subsidiary of the British arm of US aerospace and defence corporation Lockheed Martin.

Principal sources

Three principal sources of marine minerals are of interest to the seabed miners – cobalt-rich crusts on the flanks of seamounts; seafloor massive sulphides (SMS) around hydrothermal vents near spreading centres and subduction zones; and the favourite, polymetallic nodules on the abyssal plains.

First discovered south-west of the Canary Island of Ferro by the pioneering *HMS Challenger* (1872–1876) ocean expedition, polymetallic nodules are the crustaceans of the mineralogical world. Located just below or above sediment in the abyssal plain at water depths of 4.5–6.5 km, they accrete over millions of years around a nucleus such as a shark's tooth or a cetacean ear bone by scavenging critical metals from seawater. Although their composition is dominated by manganese and iron bearing oxides, they contain appreciable amounts of copper, nickel, cobalt, lithium, zirconium, molybdenum and rare earth elements. Nickel and cobalt are key components of lithium-ion batteries and are expected to see huge demand growth for use in future energy storage. Terrestrial resources of copper could be exhausted, some researchers think, given the future demand for increased electrical wiring.

Nodules accrete through two known processes. *Hydrogenetic precipitation* is driven by the oxidation of manganese and iron ions in oxygen-rich seawater, resulting in the accretion of colloids of these metals around the nucleus at the rate of a few millimetres per million years. *Diagenetic precipitation* occurs within the pore spaces of ocean sediments with the reduction and dissolution of manganese oxides and the release of associated elements of copper, lithium and nickel. The nodules thrive in 'apparent symbiosis' with benthic fauna.[1] Nodule growth depends on the activity of benthic megafauna while the nodules, in turn, provide a hard substrate for the attachment of sessile organisms such as barnacles, mussels and coral polyps.

While terrestrial mining works with well-defined ecosystems, the majority of the sea floor is unexplored and deepsea knowledge is only at its initial stages. So, the mining, or any version of removal, of these nodules will impact on unknown biota to an unknown extent by removing the habitat of nodule dependent fauna.

Regulations

The environmental liabilities of corporations and states involved in seabed mining will be crucial to its future. The legal basis and authority to issue regulations on the exploration and exploitation of seabed resources lies with the 1982 United Nations Convention on the Law of the Sea (UNCLOS), a treaty with 168 parties including the European Union but not the US.

The Jamaica-based International Seabed Authority (ISA), a UN agency, is tasked with carrying out and controlling these rules in the deepsea bed beyond national jurisdictions. The ISA has formulated provisions that recognise threats posed by deepsea mining and its draft regulations adopt a precautionary approach as required by the Seabed Disputes Chamber of the International Tribunal for the Law of the Sea.

But problems remain. 'The precautionary approach cannot meaningfully address what we don't know about the ecosystems of the seabed,' says Donald Anton, Honorary Professor of Law at the Canberra-based Australian National University. 'We are so ignorant about so much of these ecosystems that even the most scrupulous application of the precautionary approach cannot provide cautionary protection as intended.'

The mining pioneers acknowledge this uncertainty.

While it may be relatively straightforward to define the nodule resources that they target, the building of an environmental baseline – a reference level for conditions before exploitation – will consume most of their time and costs, says Kris Van Nijen, Managing Director at Antwerp, Belgium-based Global Sea Mineral Resources (GSR). He estimates these costs at $75–100mn. The total project cost for a 3mn t/y nodule production project would be about $3–3.5bn.

Location and composition

Polymetallic nodules are present throughout the world's oceans, but the largest accumulation occurs in the Clarion Clipperton Zone (CCZ) of the northern equatorial Pacific Ocean. An area stretching over about 4.5mn sq km between Mexico and Hawaii, most miners and researchers estimate about 21bn tonnes of potato-sized nodules containing on average 1.3% nickel, 0.25% cobalt, 1.2% copper and 27% manganese.

In the 1970s and 1980s Lockheed Martin headed a consortium that collected nodules from the CCZ holding 0.08% on average of rare earth elements, together with low thorium and uranium contents compared with land-based ores. Over the years, researchers have found that nodule composition varies with latitude, biological productivity, the carbon compensation depth (the depth below which carbonate particles cannot accumulate), sedimentation rate and bottom currents. In parts of the CCZ, bottom sedimentation rates and currents are so weak that the tracks from Lockheed Martin's exploration in the 1970s are still visible, says UK Seabed Resources' Williams.

Mining here would be outside any country's jurisdiction and controlled by the ISA. Similar nodules occur in the South Pacific Penhryn Basin and Cook Islands' exclusive economic zone (EEZ), the Peru Basin, and the Central Indian Ocean Basin. ISA has signed 21, 15-year contracts for the exploration of seabed mineral resources, of which 18 are for nodule exploration – 16 in the CCZ, one in the Western Pacific Ocean, and one in the Central Indian Ocean. Initially, these contracts were with governments directly or government agencies in China, Korea, Japan, Russia, Poland and France, and since 2010, with private sector companies. In August 2018, the ISA released a draft version of exploitation regulations containing a comprehensive set of legal and fiscal terms, expecting these to be finalised by 2019. Known as the Mining Code, it is now in its 4th draft and out for consultation with interested parties. Approval has been delayed because of the COVID-19 pandemic, although miners and lawyers expect a finalised version to be ready within two years.

Exploration licences

To get an exploration licence a company needs to be established in a country that has signed and ratified the UNCLOS and passed enabling legislation, says Eleanor Martin, Partner at London law firm NortonRoseFulbright. GSR is sponsored by Belgium, its home government, while UK Seabed Resources is sponsored by the UK, given its base in London, even though its ultimate parent is a US corporation and the US has not signed UNCLOS. Vancouver-based explorer DeepGreen Metals has established two subsidiaries in the Pacific islands – Nauru Ocean Resources and Tonga Offshore Mining, each sponsored by the governments of those islands.

Seabed miners face the challenge of harvesting nodules either using robot collectors or vacuum devices, and reinjecting mining waste into the seafloor, while causing minimal mobilisation of seabed sediment into vast plumes and contaminating the seafloor. Researchers have been devising quantitative models of such plumes, but so far these are only assumptions. The real test comes with mining.

A harvesting vehicle would have to be deployed from a vessel at sea, travel kilometres down to the seafloor and probably suck in about four inches of sediment from the seafloor, according to research by the Massachusetts Institute of Technology (MIT). Onboard the ship, the nodules have to be separated from collected sediment, which in turn is channelled back into the ocean floor. 'Deep sea mining companies have been quick to point to their reduced environmental impacts relative to terrestrial mining. This is disingenuous,' notes John Childs, Senior Lecturer at Lancaster University Environment Centre. The impact of seabed mining is not limited to its point of extraction. 'We are talking about the large-scale movement of mined material through the water column and transported across great distances above sea.' Potential long-term impacts of deepsea mining are both uncertain and unlikely to show up and be realised with the lifespan of mining activity, he adds.

Polymetallic nodules

Environmental baseline

Environmental planning is crucial. 'The environmental plan for harvesting by a company or country has to be published and then the ISA takes on comments,' says NortonRoseFulbright's Martin. This has to be accompanied by environmental guarantees in the form of insurance policies, letters of credit, and performance bonds. GSR's Van Nijen explains that in 2018, the company published the world's first such environmental impact statement (EIS) for collector trials due in 2021. This EIS has gone through a public participation process organised by the Belgian government. An environmental study for exploitation is ongoing, he adds.

In a 2019 paper[2] Van Nijen wrote that environmental damage from seabed mining, which creates an external cost, is unlikely to receive substantive remediation, if at all, due to the nature of the resources in the deepsea environment. Without remediation, contractors do not bear corresponding remediation costs as they are normally expected to do. Today, Van Nijen adds that this does not mean that remediation options aren't carefully studied during the environmental studies in preparation for exploration.

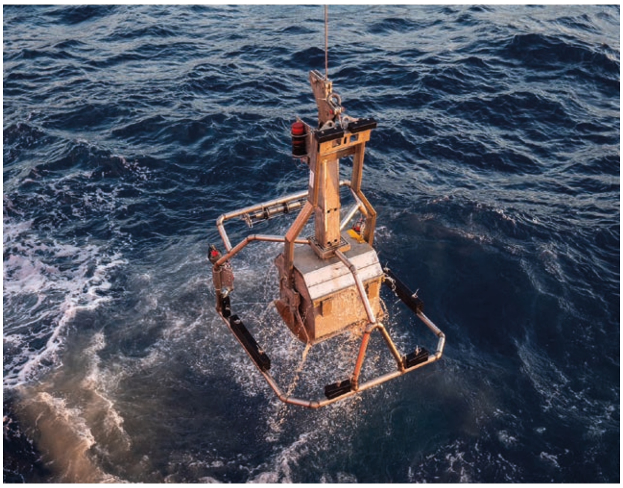
To date, only one company, Toronto-based Nautilus Minerals, has embarked on a deepsea mining project. Nautilus had been exploring offshore Papua New Guinea since 1997 and planned to mine SMS in the Bismarck Sea in its Solwara-1 prospect. But the venture failed and the company went into administration in 2019 while the Papua New Guinea government, who held a 30% share in the project, lost an estimated $125mn.

The Nautilus experience has

been weaponised by NGOs in Canada and worldwide to oppose deepsea mining. DeepGreen Metals CEO Gerard Barron was a major investor in Nautilus, but says he exited in 2007–2008 when the company had completed environmental studies, secured a mining licence and had a healthy cash balance. Nautilus was a pioneer, and made mistakes focusing on SMS that require invasive, destructive machinery to break up hard subsea rock, he adds. These have not been found on a large scale and then only in shallower waters. DeepGreen focuses solely on nodules. In mid-October 2020 a research ship set sail from San Diego to conduct an environmental baseline survey in the DeepGreen licence area in the CCZ. The company aims to produce copper and nickel from harvested polymetallic nodules.

Fiscal regime

The key commercial drivers of taxes and royalties for seabed mining have received less coverage than the environmental issues. The commercial royalty payment scheme is a key element of the code, notes NortonRoseFulbright's Martin, But the question is: are royalties payable on each metal content of a nodule, or each metal successfully extracted? 'You could end up paying for something you cannot exploit,' she says.



Boxcore sampler being lowered to 4.5 km water depth

The intention of the ISA has been to charge a royalty on a basket of metals. This royalty will be an ad valorem royalty based on the nodule's pre-processing value. UK Seabed Resources' Williams thinks that the royalty scheme should be within some margin of terrestrial royalty regimes. The ISA will be reporting soon on this issue. It has been looking at changes in the metal markets and manganese pre-market trading.

However, the African Group of countries in the ISA has already expressed concern that deepsea bed royalties should be set at a level that do not give the marine miners a competitive advantage over terrestrial miners. Government entities such as Umweltbundesamt, the German Environment Agency, are calling for benefit sharing mechanisms from profits of deepsea mining to be allocated according to the Common Heritage of Mankind Principle, a core component of UNCLOS. This is the obligation to balance exploitation of resources with the environment. It is moving in the right direction but, so far, nodule harvesting remains an aspiration. ●

All photos: UK Seabed Resources

References

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