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Seafloor mining: the future or just another pipe dream?

The world provides natural resources, including energy and mineral deposits that are vital for modern human life. But as the global demand for these finite resources grows, their supply continues to diminish. This is especially the case for strategic metals, whose commodity prices have increased many fold during the last decade. As a result, there is now a potential risk of supply shortage for some elements identified as critical to modern industrial economies. In response, there is growing pressure for science and technology to provide solutions that will secure the future supply of these strategic metals.

With nearly three-quarters of the solid earth's surface lying under water, it is not surprising that interest in the resource potential of sea-floor mineral deposits is growing rapidly. Within the last decade, mining the deep-sea floor, specifically sea-floor massive sulphide (SMS) deposits and in the vast areas covered by polymetallic nodules, has gone from a distant possibility to a likely reality.

Since the discovery of the first hydrothermally active 'black smoker' chimneys and their associated mineral deposits at the East Pacific Rise in 1979, more than 400 sites of hydrothermal activity and seafloor mineralisation have been located. About 165 of these sites have high-temperature SMS deposits of significant economic value, containing high concentrations of metals such as copper, zinc, gold, and other trace and rare earth elements.

Given that only a small fraction of prospective areas along the entire 60,000km of oceanic spreading ridges spanning the world's oceans have been thoroughly surveyed, a much larger number of SMS deposits still remain to be found. This resource potential is even greater since the largely unknown inactive sites of mineralisation that are thought to be ten times more abundant than the more easily located hydrothermally active ones.

Despite occurring in extreme environments, sea-floor mineral deposits are becoming increasingly attractive as a potential resource. There are two reasons for this: compared with their terrestrial counterparts on-land, the base-metal grades of SMS deposits are high. In addition, the mineral deposits are exposed on the seabed rather than buried on-land under hundreds of metres of rock. Although being at water depths ranging from 2000–5000m, this lack of overburden makes sea-floor mineral deposits relatively accessible and hence potentially economically viable. This will especially be the case once the underwater technology to locate, assess, extract and process the ore is fully established.

At present, the global offshore mining industry is still in its infancy. As demand continues to push commodity prices even higher, it is increasingly likely that offshore mining will become a mainstream industry in the near future. For example, a recent analysis by the European Commission estimated that by 2020, about 5% of the world's minerals including cobalt, copper and zinc could come from the ocean floor. This could rise to 10% by 2030, with global annual turnover of marine mineral mining growing to 10 billion euros.

Bramley Murton, BSc, PhD

Dr Bramley Murton received his first degree in geology at the University of Edinburgh and later a PhD under the supervision of Prof Ian Gass FRS at the Open University, Milton Keynes. Bramley is currently a geologist at the Natural Environment Research Council's (NERC) National Oceanography Centre in Southampton (NOCS) where he studies mid-ocean ridges including sea-floor volcanism, hydrothermal systems and mineralisation. Between 2010 and 2013, Bramley was chairman of InterRidge, which is an international consortium for ocean crustal research. The views expressed here are his own and do not represent those of his employers, NERC, NOC, or any other organisation.

Worldwide, the commercial deep-sea floor mining trend is currently being led by three companies. Nautilus Minerals Inc is developing the first commercial mining of high-temperature hydrothermal SMS deposits for the recovery of copper, zinc, silver and gold from the 2000m-deep Solwara 1 prospect, located off the coast of Papua New Guinea. The Vancouver-based company, DeepGreen Resources Inc, has recently signed a contract with Glencore International Inc (the resource commodity giant) to buy 50% of the nickel and copper that it aims to produce from the polymetallic nodule fields in the Clariton-Clipperton area of the Pacific Ocean. UK Seabed Resources Ltd (a subsidiary of Lockheed Martin) is also planning to harvest the polymetallic nodules fields of the north Pacific within the next five years.

International state interests in sea-floor resources are also growing fast. In the past 18 months alone, the International Seabed Authority (established by the UN to manage the sea-floor outside of national jurisdiction) has licensed four blocks, each up to 1000km long, for SMS exploration along the mid-ocean ridges. These licences are granted to nation states or state-sponsored commercial enterprises. The first of these was granted to China and Russia in 2011, followed by France and Korea in 2012. Further licence applications are imminent, coming from Brazil (for the Mid-Atlantic Ridge) and India (for the Indian Ocean).

So, should we applaud this 'gold rush'? Certainly our offshore industries and marine research centres have considerable experience and highly capable technology that can be deployed to overcome the many remaining technical issues. For example, we need a better understanding of the actual resource potential, so requiring new technologies and scientific methodologies for mineral exploration, assessment and prediction. Bulk extraction methods for solid materials from between 2000 and 5000m water depths also remain unresolved and require innovative engineering solutions.

Crucially, however, we must also have a full and proper understanding of the potential ecosystem impacts that such exploitation might bring. Many hydrothermally active SMS deposits are colonised by unique fauna – animals that were unknown to science just a couple of decades ago. These creatures and their hydrothermal habitats are not just charismatic, they may have been the crucible from which life itself sprang.

For example, vent fauna include chemosynthetic organisms that use the chemical energy from deep within the earth for life. They flourish in high-temperature and high-pressure environments that are also toxic and radioactive. We have much to learn about how these creatures survive, and it is highly probable that they have much to give us. It would be unforgivable if, in our haste, we were to trample the very things that turned out to be priceless.