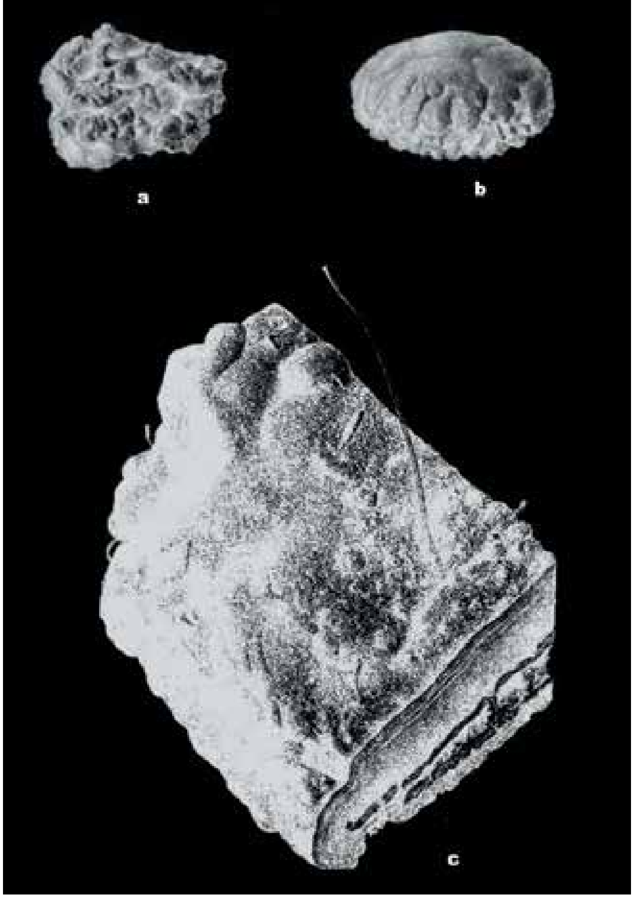
The impact of mining polymetallic nodules on deep-seabed communities



Deep-sea scientists are calling for more time to enable informed decisions about deep-sea mining. By **Paul R. Dando.**

Polymetallic nodules were first discovered during the 1872–1876 expedition of HMS *Challenger*, at depths of 3,800 to 5,700 m (Fig. 1). They form from the deposition of concentric layers of iron and manganese carbonates and hydroxides around a nucleus, frequently of pumice, and build up over millions of years. Subsequent nucleation sites can lead to the formation of mamillated nodules (see Fig. 1b and Box). Other metals, including cobalt, nickel, copper, and rare earths are present to a lesser degree, and it is these that create the mining interest, given the demand for the metals for batteries and electronic components.

Box: Nodule fauna

Nodules collected by the *Challenger* dredge were described as looking like 'a lot of potatoes'. The section in Fig. 1c is one quarter of a large nodule measuring approximately 31 x 20 x 6 cm. Attached to the upper surface of the whole nodule were four hydrozoans, two actinians, two bryozoans, a turbularian, and a hydroid. A polychaete tube was attached to the lower surface. Mammilated nodules (Fig. 1b) contain small channels and cavities inhabited by a nodule infauna.

Figure 1. Examples of nodules collected by HMS *Challenger*. (a) a typical nodule from the North Pacific; (b) a typical nodule from the central Pacific with a smooth upper surface, the lower surface with rough mammillae, having spaces between; (c) a section of one-quarter of a large nodule that supported several epifaunal species. (Out of copyright).

The most abundant deposition of polymetallic nodules is believed to occur on the seabed in the Clarion-Clipperton Fracture Zone (CCFZ) in the north-east Pacific, where yields up to 15 kg m^{-2} have been reported (Fig. 2). This region occupies an area of 6 million km^2 and has generated applications for 17 exploration licences for potential extraction of nodules, issued by the International Seabed Authority (ISA). Both governments and the ISA are obliged 'to ensure effective protection for the marine environment from harmful effects which may arise from such activities'. The two ISA exploration licenses in this area sponsored by the UK government, were issued to UK Seabed Resources Ltd, a company wholly owned by the US company Lockheed Martin. They have produced a video showing proposed mining equipment in operation[1].

The schematic of a proposed mining system (Fig. 3) illustrates three of the likely impacts of mining: removal of the nodule habitat, re-suspension and redistribution of the upper sediment layer, and the release of a sediment cloud in the upper water column due to tailings release. The sediment plumes would affect the marine environment well beyond the actual mining site. It has been estimated that a single mining operation would impact 100 km^2 of seabed every year, with sediment plumes potentially affecting a five-fold greater area. Long-term surveys of small-scale nodule harvesting have shown that the direct impacts of seafloor disturbances may persist for over 30 years.

In trials, removing the nodules from the seabed proved to be much harder than expected, because many were partially embedded in stiff clay and thus would need a greater disturbance of the seabed (and produce potentially larger sediment plumes) during harvesting. Greater compaction of the remaining sediment might also be a problem, blocking infaunal burrows. The re-suspended sediment clouds are likely to affect the mucosal-filtering nets of deep-sea pelagic plankton, thus affecting the carbon cycle, given the multi-decade activity of the mining.

A number of survey and sampling expeditions to the CCFZ in the last decade have investigated nodule abundance and seabed fauna, with particular attention

1 https://www.youtube.com/watch?v=71J8Yqykgs0&feature=emb_title

to the geographic distribution of species. These have confirmed that the nodules have a specific epifauna, and shown that mamillated nodules also have a specific infauna. Stalked glass sponges, attached to the nodules, support a high diversity of epifauna. The sponges allow filter feeders to extend their habitat above the seafloor and are thus a critical group in ecosystem function.

Most surprising was a 2019 study of benthos in the CCFZ, involving 34 box core samples. Forty-nine per cent of all the species of polychaetes recovered (the numerically dominant macrofaunal group) were only represented by a single specimen. It was therefore difficult to estimate the mean geographic range of CCFZ species, and the best estimate of this was an average species range of only 25 km, very much less than the proposed mining footprint in a given licence area. This data also suggests that the true number of polychaete species in the CCFZ is higher than the total number of all known marine animal species. The high percentage of recovered species being represented by a single specimen was found for several other animal groups.

Given the remoteness and abyssal depth of the nodule fields, investigations into the benthic fauna are expensive and time-consuming. Most faunal sampling has been confined to the upper 10 cm of sediment, since this is the easiest to sieve. We know very little about the deeper infauna, although in other deep-sea areas the major biomass can be found below this depth in the sediment. Obtaining life-history data on the fauna will be extremely difficult, given the low densities and unknown, but very large, number of species present. Detailed environmental impact statements are likely to require decades, rather than years, of investigation.

Although most studies of simulated mining disturbance in nodule fields show some short-term recovery in faunal density and diversity, very few faunal groups return to baseline conditions after two decades and recovery after larger areal disturbances are likely to be even slower.

In summary, species extinctions, irreversible habitat damage, and unknown consequences for the carbon flux to the deep-sea floor are likely to result from deep-sea mining. Concerns over long-term environmental damage have led to a statement, signed by over 500 deep-sea scientists (see link in Further reading), strongly recommending that the transition to the exploitation of mineral resources be paused until sufficient and robust scientific information has been obtained to make informed decisions as to whether deep-sea mining can be authorized without significant damage to the marine environment and, if so, under what conditions.

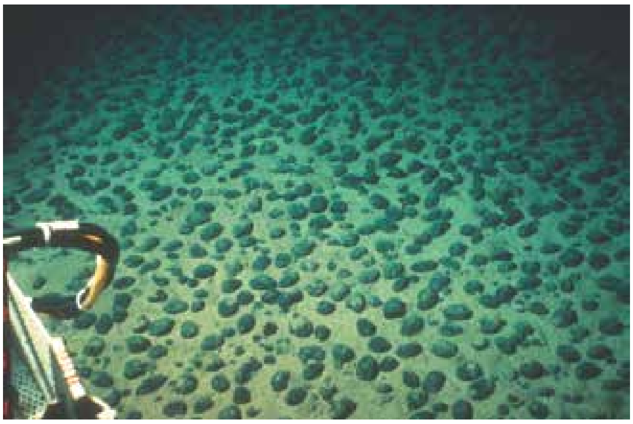


Figure 2. A dense polymetallic nodule field in the Clarion-Clipperton Fracture Zone, north-east Pacific. Philweb CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons).

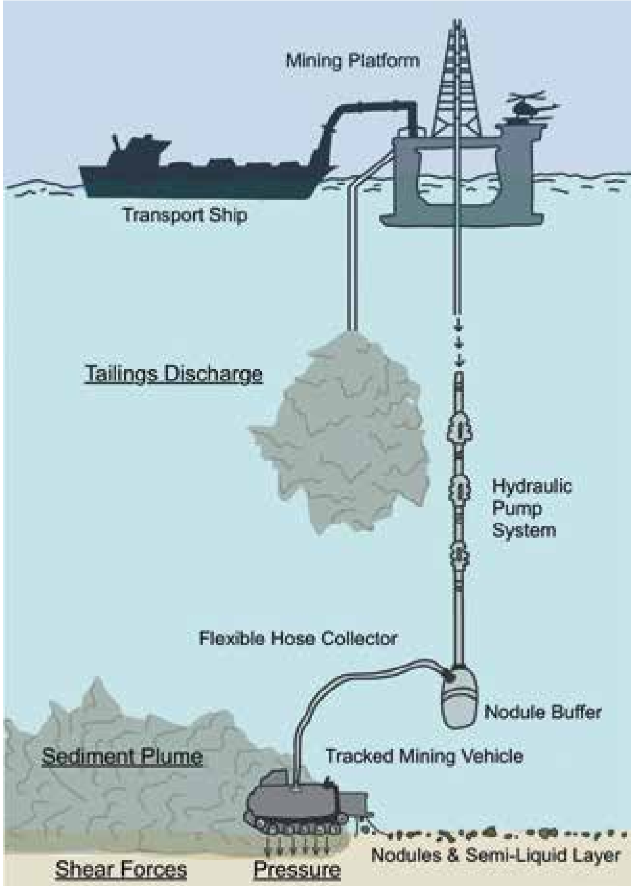


Figure 3. A schematic of manganese nodules mining on the deep seafloor (drawn by MimiDeepSea, Creative Commons Attribution License 4.0 (CC-BY).

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Further reading

https://www.seabedminingsciencestatement.org

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