Physical resources

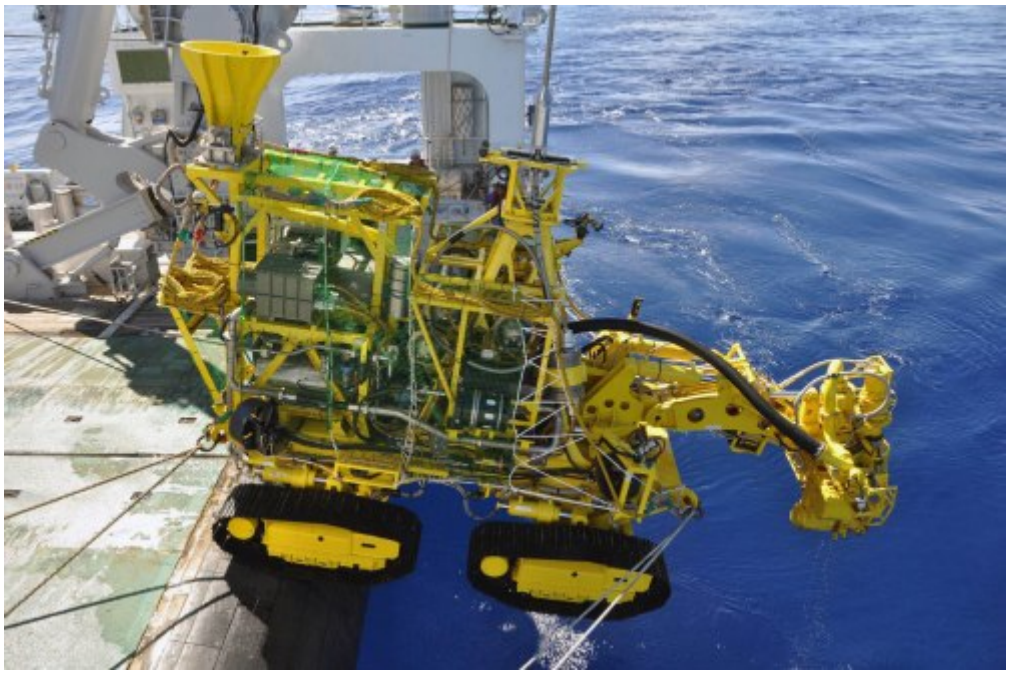
How rich are deep-sea resources? (*April 2018*)

My first task as a Lecturer in Earth Sciences at the British Open University, from 1971 onward, was to write teaching materials about the economics, formation and geological setting of metal resources. Much of the content was about the full range of 'conventional' metal ores, but something then being publicised as having huge potential intrigued me. This concerned manganese-rich nodules (with all the aesthetic appeal of unwashed potatoes) and crusts found sitting on top of sediments of the abyssal ocean floor, at depths between 3 to 5 kilometres. While manganese is by no means a rare element and occurs in vast ore reserves on the continents, the nodules contain unusually high concentrations of other, more valuable metals, such as copper, nickel, zinc, cobalt and lead. Some contained more than 3% of Cu, Ni and Co combined, above the 'grades' of economic deposits of ores of the individual metals on land. This was the source of their potential: simple, albeit very deep dredging of the nodules would provide multi-metal ore of very high profitability. Moreover, the nodules are in truly vast tonnages (about 10 kg m^{-2}) and continually grow by precipitation from seawater in the underlying sediments at a few millimetres per million years – they are renewable resources.

Manganese nodules from the Pacific abyssal plains. (Credit: Wikipedia)

A variety of reasons, not the least of which was the vexatious question of ownership of sea-floor resources far from land, have meant that commercial operations have yet to begin. However, spiralling prices for metals on the world market together with depletion of on-shore, high-grade reserves are beginning to make the opportunity of nodule mining irresistible. Fifteen companies, with licence areas issued by the intergovernmental International Seabed Authority of around 75 000 km^2 each, are now engaged in economic assessment of one of the most remote swathes of the Pacific abyssal plains (Peacock, T. & Alford M.H. 2018. Is deep-sea mining worth it? *Scientific American*, v. **318**(5) (May 2018

issue), p. 63-67; DOI: 10.1038/scientificamerican0518-72). There are several controversial issues surrounding deep-sea mining. First, dredging, like beam trawling disturbs and destroys ocean-floor ecosystems and turns bottom water turbid, the very fine grain size of sediments resulting in settling being very slow (about 1 mm s^{-1}). Second, preliminary ore processing on board dredging vessels results in plumes of turbid and metal-rich slurry in the wakes, threatening surface and mid-water ecosystems. Such plumes will rapidly spread far from operational areas in surface current systems, eventually to smother pristine areas of ocean floor. Re-examination of areas of experimental dredging from 30 years ago have revealed that they are still sterile of lifeforms larger than 50 micrometres. Added to these effects, onshore processing will produce large amounts of waste – about 75% of the volume of dredged nodules. Conventional mines eventually backfill their excavations, but with nodule mining disposal would be an environmental nightmare.



Japanese sea-floor mining machine. (Credit: Japan Times)

Economically, it seems that nodule dredging is potentially highly profitable. To break even requires lifting about a million metric tons, which would yield of the order of 37 000 t of Ni, 32 000 t of Cu, 6000 t of Co and 750 000 t manganese. If all 15 companies begin extraction, production at these levels will have a downward effect on world metal prices, tending to undercut production from conventional mines. One little-considered issue is that the 'blend' of metals from nodules will not match the industrial demand for each of them, further destabilising markets. Added to mining of the abyssal plains, plans are well advanced for multi-metal mining of massive sulfide deposits forming at hydrothermal vents or 'black smokers' along mid-ocean ridge systems, in which gold figures strongly. Only a few Pacific island states have resisted the 'promise' of such operations. Japanese companies are already mining the seabed off Okinawa within their own offshore waters and seemingly are producing zinc equivalent to the country's annual consumption as well as gold, copper and lead.

Related articles: We Are About to Start Mining Hydrothermal Vents on the Ocean Floor – Facts So Romantic (nautil.us); Why Mine Asteroids When We Can Mine the Deep Sea?

(gizmodo.co.uk); Progress toward management of deep seabed minerals (pacific.scoop.co.nz)