

PRECAUTIONARY MANAGEMENT OF DEEP SEA MINING

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Abstract

Interest in deep-sea mining developed in the early 1970's, with a focus on manganese nodules in international waters. Mining may actually occur first, however, on rich polymetallic sulfide deposits associated with hydrothermal vents within Exclusive Economic Zones (EEZs). Even though mining for polymetallic sulfides may not take place for several years, precautionary performance standards, environmental regulations, and the establishment of Marine Protected Areas may help guide the marine mining industry toward a goal of minimizing environmental impacts. Once substantial investments in prospecting and exploring a potential mining site are made, implementation of environmental regulations may prove to be much more difficult.

Key Words

Deep-sea mining, hydrothermal vents, manganese nodules, Marine Protected Areas, polymetallic sulfide deposits, precautionary management.

1. A brief history of deep-sea mining

Interest in deep-sea mining of manganese nodules and other metal deposits developed in the early 1970's as a result of rising metal prices, and out of concern for securing supplies of strategic and critical minerals. Predicted metal shortages did not materialize, however, and metal prices have remained at relatively low levels.¹ In addition, high projected costs associated with mining manganese nodules inhibited nodule mining efforts.

The regulatory environment for deep-sea mining may have also contributed to the failure of early attempts to exploit manganese nodules. Part XI of the United Nations Convention on the Law of the sea (UNCLOS) established an international legal regime governing deep-sea mining. However, several industrialised countries, including the United States, did not endorse the original 1982 Convention because they considered it to be an obstacle to the practical development of ocean mineral resources. However, in 1996, the Convention, as modified by a 1994 Agreement relating to the Implementation of Part XI, entered into force.

The International Seabed Authority (ISA), established under UNCLOS, is responsible for ensuring that the benefits of mining in international waters beyond the outer limit of the legal Continental Shelf are equitably shared, with an emphasis on ensuring a fair stream of benefits to developing countries and the protection of the environment from harmful effects

arising from mining activities in international areas². However, one of the most important impacts of the Authority's restrictions appears to be the redirection of prospecting and exploration away from international waters and into areas within the limits of national jurisdiction (Continental Shelf and EEZ) where regulations may be weaker or non-existent.

2. Nature, distribution and economic importance of polymetallic sulfide deposits

Polymetallic sulfide deposits are formed by hot (up to 350° C) seawater rising through the seafloor and precipitating leached metals in the form of submarine chimneys ('black smokers') or domes. The resulting massive sulfide deposits can reach considerable size ranging from several thousand to about 100 million tons.³ Frequently, polymetallic sulfides are associated with mid-ocean ridges. However, recent discoveries have been made at relatively shallow depths (100m to 2000m) in backarc spreading centers.^{1, 4-5} Many of these deposits are located within EEZs (Japan, Solomon Islands, Papua New Guinea), leading to the suggestion that mining of such deposits may become technically and economically feasible in the relatively near future.⁶⁻⁸

Polymetallic sulfide deposits are highly enriched in gold, copper, and base metals.⁵ For example, the recently discovered Sunrise deposit off Japan contains 20 ppm of gold, relative to a content of 0.5 ppm in an average deposit of similar geology.⁹ Sulfides from the Conical Seamount off Papua New Guinea (2.8 km basal diameter at 1,600 m water depth) have an average gold content of 26 ppm, with a maximum content in excess of 230

ppm (based on 40 samples).¹ This is about 10 times the average value for economically mineable gold deposits on land.³

Mining technology for extracting polymetallic sulfides has not been fully developed as yet. It is envisioned, however, that mining would be conducted using large remotely-controlled hydraulic grabs or continuous mining systems with cutter heads and airlift.³ Unlike broad-scale manganese nodule mining, efforts to extract polymetallic sulfides will concentrate on individual mound-like deposits ranging up to the size of Capitol Hill.

3. Trends that are increasing interest in polymetallic sulfides

Several trends appear to be increasing interest in deep-sea polymetallic sulfide mining: 1) advances in remote sensing, positioning, and underwater technology⁷; 2) the discovery of gold and silver deposits near hydrothermal vents in shallower water^{1, 7, 9}; and 3) a move away from prospecting in highly regulated international seabed areas, toward activities within the EEZs of several countries (e.g, Papua New Guinea and Fiji). Currently, several private companies are proceeding with plans to prospect for deep-sea mineral deposits.⁶

The first polymetallic sulfide deposits reported within EEZs were discovered in the southwest Pacific in the mid-1980's.³ Since sulfide deposits within EEZs do not fall under the jurisdiction of the International Seabed Authority, ISA fees, environmental regulations, and technology transfer provisions do not apply, perhaps accelerating the development of polymetallic sulfide mining.

Recently, Papua New Guinea issued an exploration license to Nautilus Minerals Corp. for finding and mining high-grade seafloor polymetallic sulfide deposits within an area of about 5,000 square miles of its EEZ.^{1,10}

Nautilus plans to extract 10,000 tons of polymetallic sulfide mineral deposits within two years, as part of the exploration, and to begin commercial mining by 2003. Sample ores contain up to 26% zinc, 15% copper, with 200 g of silver and about 30 g of gold to the ton.¹¹ Furthermore, the Metal Mining Agency of Japan has begun a 5-year study of the feasibility of mining a large sulfide deposit in the Okinawa Trough. Industry analysts indicate that the economic prospects for mining polymetallic sulfide deposits associated with hydrothermal vents are increasing, and that mining operations could start within 5 to 10 years.^{6-7,11}

4. Potential Environmental Impacts

Although it is now thought that hydrothermal vents may have been the cradle of life on earth, the unique biological communities associated with them were discovered quite recently (in 1979). These communities, making up the world's only fully chemosynthetic ecosystems, are very productive, ranking with estuaries and salt marshes. They are oases of very high biomass in the deep sea. Most vent animals, including giant tube worms, clams, and crabs, are new to science and found nowhere else. The high productivity, the degree of endemism, and other unique characteristics of vent communities give them high intrinsic value. Unique vent species may, in the future, be of use for biotechnology purposes.¹²

The Manus Basin north of Papua New Guinea is the first location other than a mid-ocean spreading axis where hydrothermal 'chimney' deposits and associated vent fauna have been discovered.¹³ A hydrothermal field in the Manus Basin, which is targeted for mining, supports an exceptionally abundant biological community dependent on chemosynthetic bacteria.¹⁴

Some mining industry representatives have acknowledged the environmental sensitivity of vent ecosystems and have pledged to avoid large scale destruction of habitats. Published interviews^{6, 11, 15} suggest that many in the mining industry and some in the scientific community share a perception that sulfide deposit mining poses fewer environmental risks than does terrestrial mining. This perception appears to be based on several assumptions: 1) mining would not occur directly on vents, due to the hazardous conditions there; 2) sulfide deposits are not covered by thick layers of sediment, which could otherwise give rise to a destructive sediment plume; 3) the high density of sulfide particles will cause immediate redeposition of mining debris; and 4) vent communities are relatively ephemeral, reducing the risk of long-term damage (some have compared sulfide mining to farming⁶).

While it seems clear that miners would avoid active vents (due to hazardous conditions), direct impacts on biological communities peripheral to vents and indirect impacts on vent communities themselves remain possibilities. Significant biological communities occur near cool or cold vents, as well as at hot vents.¹⁶ Crabs and other vent organisms have been observed quite far from actual vents, and may use large ranges for feeding.⁴ The Marine Minerals Service of the US Department of Interior concluded that a major fraction of the benthic life around vents would be destroyed by mining nearby.¹⁷ Furthermore, while vent communities may indeed be relatively ephemeral, we do not believe that this detracts from their intrinsic value.

Environmental impact is dependent on the mining technology used. At present, the exact technology to be used for mining of polymetallic sulfides is not known. The ISA anticipates that polymetallic sulfide deposits will probably be subjected to strip mining and open cast mining.³ These types of mining will likely kill surface and subsurface organisms directly. Some

degree of resuspension due to mining is bound to occur, even though it is thought that most sulfide deposits are not covered by significant amounts of sediment.³ If mine tailings are discharged at sea, they could have many adverse effects on organisms¹², including: mortality of zooplankton, fishes, and deep diving mammals caused directly by the sediment plume or associated metallic substances; depletion of oxygen by bacterial growth on suspended particles; and dissolution of heavy metals and their potential incorporation into the food chain. It can also be expected that EEZ mining, which takes place much closer to land, will pose higher environmental risks than mining in the International Zone far away from land. For example, a sediment plume of mine tailings released into shallow water could be transported towards the shelf area, where it could result in unknown and unpredictable impacts on shelf and near-shore habitats and environments. Moreover, deep-sea mining is likely to be far more mobile than terrestrial mining and thus would be expected to have more widespread impact than terrestrial mining operations, because no infrastructure is left behind after a site is closed.¹⁵

Almost any conceivable deep-sea mining operation will involve lifting ore and deep water to surface ships. Deep water lifted to the surface during a mining operation (especially if a hydraulic pump system is used) has a high nutrient content, which could lead to local or regional increases in primary productivity and associated trophic impacts, including eutrophication and changes in community structure.¹² This is especially true for the oligotrophic tropical ocean, which is particularly sensitive to nutrient inputs.

Processing of ore retrieved from deep-sea sites may produce additional waste. Waste created during land-based ore processing might be discharged into the ocean in coastal states that do not have sufficient

onshore storage space. This would likely have adverse effects on the coastal marine ecosystem.¹⁸

5. Environmental Policy Implications

It is well known that terrestrial and aquatic ecosystems can be disrupted, damaged, or destroyed by terrestrial mining operations. Relative to terrestrial and aquatic systems, deep-sea ecosystems are much less understood and more difficult to monitor. Until and unless a better understanding of these ecosystems has been reached, the threats posed by deep-sea mining will be uncertain but potentially serious.

The current consumption rate and the projected increase of consumption of minerals may increase incentives to proceed with deep-sea mining. Because the environmental impacts of deep-sea mining are uncertain but potentially serious, a prudent policy approach would consist of: 1) conserving mineral resources, 2) increasing the recycling of minerals, and 3) exploiting land based mineral resources with much greater efficiency and more stringent environmental regulation. Mining on land has caused environmental devastation, certainly, but environmental risks of terrestrial mining are better known and perhaps could be more easily contained than those of deep-sea mining. Environmental impacts associated with terrestrial mining should be reduced before deep-sea mining is allowed to proceed. Once these concerns are addressed, comprehensive risk assessment for commercial deep sea mining can be conducted.

A precautionary approach can create incentives for reducing uncertainty and minimizing ecological impacts associated with deep-sea mining. A presumption that deep-sea mining will have adverse ecological impacts until compelling evidence shows that it will not creates a strong incentive to conduct credible research on impacts. We therefore recommend the

establishment of Marine Protected Areas around hydrothermal vents to facilitate monitoring and regulation of all activities in these zones.

Conditions on the expansion of a mining operation from pilot phase to commercial phase and a mechanism to halt mining if adverse impacts are detected create incentives for minimizing ecological impacts.

Since there are no physical borders, mining of one area can affect other areas. This is especially true for mining within the EEZs where sediment plumes can not only drift towards the shelf or coastline, but also into international waters. Therefore the international community should be concerned about pollution of international waters by unregulated mining activities within the EEZs of individual countries. This problem is similar to that posed by air pollution that crosses borders. While there are legal mechanisms for controlling transboundary air pollution (e.g., European and Canadian agreements to control acid rain), to our knowledge there is no regulatory policy in effect in international law to control this kind of pollution in the sea. Hence, a binding treaty may be required to prohibit pollution of international waters resulting from activities conducted within EEZs.

Since less developed nations may lack adequate environmental regulations or sufficient funds for environmental studies, mining within the EEZs of the above countries could cause serious marine environmental degradation. Incentives and financial resources to study and reduce environmental impacts related to the mining activities will likely be needed.

New discoveries of rich and massive mineral deposits could spur a great deal of investment in deep-sea mining. Historically, environmental regulations have followed the development of new technologies and industries, rather than anticipating and guiding them. Massive investment in economic activities tends to result in resistance to environmental

regulation. Performance standards and other types of regulations that anticipate potential environmental impacts have the potential for guiding technological innovation and industry operations toward the goal of minimizing such impacts. Lack of regulation within EEZs could result in harm to deep-sea ecosystems rich in species. Presently, a window of opportunity exists for the international community to implement scientific, technological, and legal measures to minimize negative environmental impacts before a sudden rush to commercialization (and attendant opposition to regulation) develops.

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