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A primer for the Environmental Impact Assessment of mining at seafloor massive sulfide deposits

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ABSTRACT

Seafloor massive sulfides (SMS) contain commercially viable quantities of high grade ores, making them attractive prospect sites for marine mining. SMS deposits may also contain hydrothermal vent ecosystems populated by high conservation value vent-endemic species. Responsible environmental management of these resources is best achieved by the adoption of a precautionary approach. Part of this precautionary approach involves the Environmental Impact Assessment (EIA) of exploration and exploitative activities at SMS deposits. The VentBase 2012 workshop provided a forum for stakeholders and scientists to discuss issues surrounding SMS exploration and exploitation. This forum recognised the requirement for a primer which would relate concepts underpinning EIA at SMS deposits. The purpose of this primer is to inform policy makers about EIA at SMS deposits in order to aid management decisions. The primer offers a basic introduction to SMS deposits and their associated ecology, and the basic requirements for EIA at SMS deposits; including initial data and information scoping, environmental survey, and ecological risk assessment.

Introduction

The high grade ores associated with Seafloor Massive Sulfide (SMS) deposits make them an attractive commercial prospect for mining [1]. These deposits can occur at depths up to 4960 m and where vent hydrothermal fluids have temperatures exceeding 450 °C [2]. The extreme nature of these environments poses technical obstacles for mining companies, but there are also challenges for environmental managers.

Hydrothermal vent habitats typically support endemic benthic communities dominated by large, biomass-rich populations of invertebrate species in symbiosis with chemoautotrophic bacteria [3]. Communities of vent endemic species, together with diverse associated organisms, are expected to be impacted severely by mineral extraction [4]. This prospect has created an urgent need to develop evidence-based criteria for the setting of conservation objectives at hydrothermal vent sites for the sustainable and responsible management of SMS resources [4,5].

Arguments relating to the pros and cons of the exploitation of deep-sea hydrothermal vents will logically end in two extremes, those for and those against. The extreme argument against the exploitation of hydrothermal vents calls for an outright ban of all environmentally exploitative actions until environmental risks are negligible. Similarly, the argument for exploitation would involve a *laissez faire* approach where all exploitation is allowed. Neither is reasonable or realistic, a zero risk impact is unachievable and exploitation without regard for consequences will create conflict among stakeholders. A compromise between the two sides is required where risks are identified, acknowledged, discussed and reduced.

The application of the precautionary principle is often touted as solution where we do not understand the risks of the proposed exploitative process for an ecosystem [6,7]. The precautionary approach does not suggest that the proposed exploitative process is stopped, rather that it proceeds with appropriate controls and risk reductions in place. The 1992 Rio Declaration states

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that, according to the precautionary principle, a lack of scientific certainty should not preclude states from adopting cost-effective measures to control environmental risks. Central to the precautionary approach is the publication of best practice documents that can aid in the development of adaptable, open and transparent policy making.

The recent VentBase workshop (May 2012) provided a forum for stakeholders and scientists to discuss issues surrounding SMS exploration and exploitation. This forum recognised the requirement for a primer document which would relate concepts underpinning Environmental impact Assessment (EIA) to those unfamiliar with deep-sea hydrothermal vents. By producing this primer VentBase seeks to better inform stakeholders about the science underpinning environmental policy decisions relating to deep-sea mining of SMS deposits.

What is an SMS deposit?

Hydrothermal vents form chimney-like deposits produced by the precipitation of metal sulphides as acidic hydrothermal fluids exit the seafloor along the margins of tectonic plates, in back-arc basin spreading centres, and other volcanically active regions [8,9]. These chimneys may have a decadal time-span and collapse over time, with new chimneys sprouting up through new fissures [10–12]. Where hydrothermal activity persists the collapsed chimneys coalesce to form mounds known as seafloor massive sulfides (SMS) [13].

The International Seabed Authority (ISA), which has jurisdiction over mineral resources in areas beyond national jurisdictions, lists 327 hydrothermal vent sites in the world's oceans, and more vent sites are believed to exist in uncharted waters [14]. Of the known sites, just under a third has substantial SMS deposits [15]. The potential of this resource has led some to speculate that we are on the verge of a deep sea 'gold-rush' [16].

SMS deposits interest commercial bodies because they can contain a high percentage of high-grade ores. Samples from a hydrothermal area in Manus Basin (Papua New Guinea) averaged 27 wt% zinc and 11 wt% copper [1]. The by-products of mining for these metals may be also valuable, with estimations of 200 g silver and 30 g of gold per ton of ore recoverable at some sites [1]. SMS deposits are also attractive to mining companies because, compared to surface strip mines, any prospective deep-sea SMS mine would have a relatively small footprint: the mounds typical cover $< 100\ m^2$ [17], and no access roads need to be built as all the mining infrastructure floats above on barges and ships. In addition, SMS deposits usually will have little overburden compared to terrestrial sites. The SMS deposits are either still active, thus at the surface, or inactive but in areas where the seabed is still being formed so have not yet been covered with substantial quantities of sediment.

What is an EIA?

The purpose of an EIA for mining of Seafloor Massive Sulfides (SMS deposits) is to ensure that any proposed activities are performed in a way that is environmentally responsible, as defined under national or international legislation. The principles behind an EIA for mining in the deep-sea are the same for seabed dredging programmes in the coastal zone. EIAs are habitually undertaken before operations commence to remove seafloor deposits in estuaries and shelf seas, and approach used in this environment is equally applicable for undertaking an EIA for mining in the deep-sea.

The EIA process involves the carrying out of studies to define the existing environment before exploitation occurs, and the assessment of impacts and an evaluation of effective mitigation measures (Fig. 1). These studies usually comprise: (a) desk-top or Scoping Study of appropriate previous studies and data, (b) an Environmental Survey of the area in question, and (c) an Ecological Risk Assessment of the proposed mining operation. If the risk assessment identifies that significant impacts are likely to be caused by mining actions, then the EIA should suggest management strategies to mitigate the disturbance or recommend against any exploitation if impact is too damaging.

The production of an EIA is the responsibility of the company that holds the license or permits to explore for a particular mineral, and which wishes to move from the exploratory to the commercial mining stage. Although most states do not yet have specific legislation regarding deep-sea SMS mining, most will have general legislation that covers extraction of resources from the seafloor. The ISA requires an EIA for any exploratory or proposed mining of the seafloor in the area beyond national jurisdiction. Furthermore, almost all mining projects will be funded by an international financial institution (IFI) that requires EIAs to be carried out. Thus EIAs are almost always obligatory. Where an IFI is not involved or a state does not require an EIA the mining project owners are expected to adopt a policy of corporate social responsibility and undertake an EIA regardless. The EIA is usually carried out by independent consultancies, ideally after an open and transparent tendering procedure. The consultants are usually a mix of oceanographers, biologists, geologists, sometimes but not always under the umbrella of an environmental engineering concern. To ensure an unbiased approach academic institutes are often invited to carry out discrete aspects of the EIA. Their results are then published in peer-reviewed international scientific journals, ensuring quality and impartiality. The various components of the EIA may be brought together and published as a separate report. Sometimes these reports are confidential, but ideally they should be public documents.

The EIA is a clarifying process leading to a greater understanding between all stakeholders regarding the environmental consequences of mining. Cooperation among stakeholders in undertaking the EIA leads to a more efficient project (by identifying potential problems early on) and lowers the risks of recriminations and legal actions taken against contractors/project owners during or after the mining operation. Public consultation should be paramount as any mining consequences will directly affect those living to or depending on the impacted area. The public should be informed and educated about the mining process and the EIA, either through media outlets such as newspapers, radio and TV or through publicity campaigns to raise awareness of the project. This process may identify or raise the profile of impacts that require particular mitigation measures. The outreach programme is usually the prerogative of the government, and should be included as part of any EIA process concerning SMS mining within national boundaries.

The EIA informs the Environmental Impact Statement (EIS); a document that provides decision and policy makers with a balanced assessment of the environmental implications of the proposed action. The purpose of the EIS is to provide managers with processes that, if followed will maximise legislative compliance and minimise environmental impact. The EIS incorporates an overall assessment of the entire mining project from implementation to execution to long term recovery. In the EIS document the various component EIA sections are brought together and evaluated as a whole. The EIS states what actions are required during each phase of the mining operation. The EIS identifies parameters to be measured and defines critical boundaries. The EIS will usually examine alternative management strategies and make recommendations for further appraisal. The ISA is in the process of producing a succinct guide to the content required of an EIS for SMS, polymetallic nodules and cobalt-rich ferromanganese crusts mining in areas beyond national jurisdiction [18]. This template is also intended to be applicable to deep-sea mining within EEZs.