

# **Environmental Studies for Mining of Deep-sea Polymetallic Nodules – Accomplishments and Future plans**

**Rahul Sharma**

*National Institute of Oceanography, Dona-Paula, Goa, 403004, India*

## **Abstract**

Environmental studies for mining of deep-sea polymetallic nodules were initiated to evaluate the possible impacts of mining on benthic environment and develop protocols for environmental studies, to fulfill one of the obligations of the country as a Pioneer Investor under the UN Law of the Sea. The studies have lead to the generation of significant results development of an environmental database as well as capacity building in the field of deep seabed mining.

## **Introduction**

As a result of the exploration for polymetallic nodules (Fig. 1), an area of 150,000 sq.km with promising deposits was identified in the Central Indian Basin (CIB). Arising from the need for evaluation of environmental data for designing a mining system as well as for prediction of potential impact of mining on marine ecosystem, the project on 'EIA studies for nodule mining in CIB' was initiated in 1996, under the national programme on polymetallic nodules funded by the Dept. of Ocean Development.

Mining of the deep-sea minerals [1] is expected to alter the environmental conditions in the marine ecosystem. Studies have been initiated to understand the potential impacts of mining on the marine environment.

The objectives of the study are as follows:

- To evaluate baseline environmental conditions of marine minerals
- To study the effects of sediment redistribution on marine environment
- To monitor the processes of environmental restoration and recolonisation
- To provide inputs for design and operation of a marine mining systems
- To develop protocols for environmental data collection for mining

Since its inception, 3 of the activities (viz. environment of baseline condition, assessment of benthic impact, and monitoring of restoration) have been completed successfully. Currently, the ongoing activities are collection of environmental data for environmental variability in and around the proposed first generation mine-site, modeling of sediment plume dispersal and creation of database for deep-sea mining.

This program has resulted not only in assessing the potential impacts of deep seabed mining and generating environmental data, but also in capacity building for multi-disciplinary oceanographic research, recognition to Indian efforts in this field and providing advisories to national and international regulatory agencies.



*Fig. 1: Polymetallic nodules on the seafloor*

## Potential impacts of deep-sea mining

Although, development of deep-sea mining systems is underway [2], it is almost certain that any mining device would definitely create a sediment plume while collecting the nodules, that would in turn have an impact on different components of the marine ecosystem (Fig. 2). In order to analyze the possible effects, several experiments were conducted in the Pacific Ocean [3,4,5,6] and in the Indian Ocean [7] in the nineties. As per the stipulation under the UN Law of the Sea (UNLOS) and guidelines issued by the International Seabed Authority, every prospective contractor of deep-sea mining is expected to provide data related to the existing environmental conditions in the potential mining area, the possible effects expected to be caused by mining and a statement of the methods to be adopted for conservation of marine environment from the harmful effects of such mining activities.

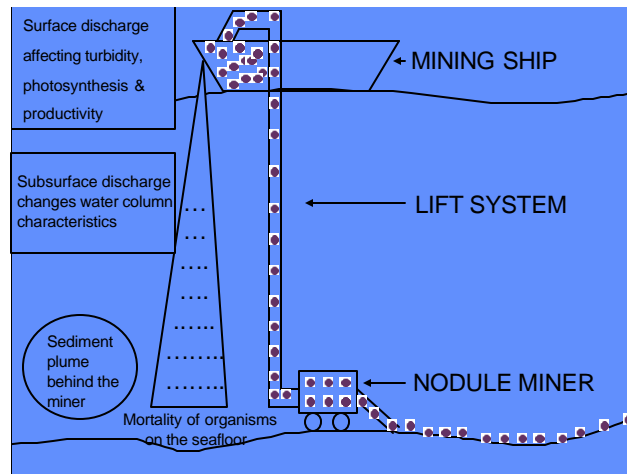


Fig. 2 : Schematic of deep-sea mining impacts

## Activities completed

### i. Selection of Test and Reference areas and baseline data collection

The detailed bathymetry maps generated from hydrosweep surveys in the Central Indian Basin, were used and alternative sets of study areas (of 10x10 nautical miles) were selected. The selected areas were surveyed with a total of ~300 km of echosounding and sub-bottom profiling and > 60 sediment core

samples for the selection of Test and Reference Areas, which were later used for conducting the disturbance experiment, and to monitor the undisturbed environment for comparison with the disturbed one, respectively.

Baseline data were collected on various parameters in water column as well from 36 locations for conductivity, temperature and depth measurements, and also current meters deployed over a period of ~200 days at 4 locations in the area. The parameters analysed as baseline data were seafloor features and sediment thickness, nodule distribution & morphology, interstitial water, and sediment chemistry, sediment size and mineralogy, geo-technical properties, biostratigraphy, mega, macro- & meio-faunal (nos. & diversity), sediment microbiology and biochemistry, watermass circulation, temperature, salinity, productivity and chlorophyll, chemical characteristic, meteorology.

## ii. Benthic disturbance and impact studies

In order to study effects of sediment resuspension and resettlement, a Benthic Disturbance experiment was carried out during July- August 1997, in a strip of 3000 x 200 m by a hydraulic device [8] in test area (Fig. 3). During the disturbance experiment, the disturber was towed 26 times for 9 days resuspending >6000 cu.m. of sediment along 88 km distance [7].

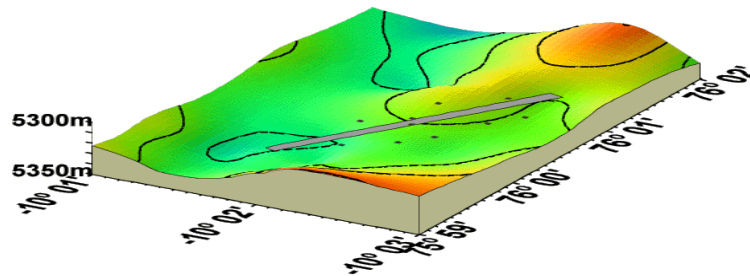


Fig. 3: Test site for benthic disturbance experiment

Analyses of seabed samples immediately after the experiment had indicated the impact of disturbance on the benthic ecosystem, in terms of changes in seafloor characteristics, geochemistry, sedimentology, geotechnical properties of sediment and biomass on the seafloor. Sediment traps showed a 2 to 3 fold increase in sediment fluxes during disturbance period immediately after the experiment. A comparison of results from baseline, pre-disturbance and post-disturbance studies indicated (a) vertical mixing of sediment on the seafloor, (b) lateral migration of sediment plume, (c) changes in physical,

geochemical and biochemical characteristics of the sediment, and (d) an overall reduction in benthic biomass.

### **iii. Monitoring of recolonisation and restoration of environment**

Deep-towed photography data, seafloor sediment samples as well as water column data were collected during the first monitoring cruise onboard RV AA Sidorenko during March-April 2001, 44 months after the experiment at the locations that were sampled in the pre- and post-disturbance phases, to monitor the restoration and recolonisation of the benthic environment. Core samples at the same locations occupied during the 1<sup>st</sup> monitoring in 2001, and 2<sup>nd</sup> monitoring in 2002, were once again occupied during the 3<sup>rd</sup> monitoring in April 2003. Sediment samples collected using a box corer were analysed for sedimentology, sediment and porewater geochemistry, geotechnical properties, microbiology, biochemistry, meiofauna, macrofauna and megafauna

The results indicated that whereas the sediment characteristics appear to have regained the conditions similar to that of pre-disturbance stage, the numbers and diversity of benthic organisms showed only marginal restoration. The nutrient profiles and organic carbon content have shown change in feeding habit and indicate increased burrowing activity, which is confirmed by increase in the number of macrofaunal organisms in deeper levels. Marginal increase in meiofaunal density as well as substantial increase in taxon diversity suggest initiation of recolonization in the area. Gradual increase in labile organic matter, proteins and carbohydrates suggest that the benthic environmental conditions are recovering, although bacterial numbers are taking longer time to get restored. The above parameters indicate that the benthic conditions are steadily moving towards restoration and the effect of disturbance is waning off.

## **Major accomplishments**

**The major accomplishments of the program have been as follows:**

- Development of multi-disciplinary research group for deep-sea environment
- >40 publications in international journals and symposia, including special issues of 2 international journals
- Technology development for In situ pressure water sampler, calibrated core cutter, and process for preparation of extract with carotenoids, UV absorbent, anti-bacterial and pH indicating properties from deep-sea bacteria.
- Diversification into mining of placer deposits

- Training of post graduate, graduate and doctoral students.
- Providing advisories to International Seabed Authority (ISA) for formulation of 'Guidelines for environmental data collection for deep seabed mining'.
- Recognition to members of the group as experts of international committees

## Future activities

The following activities are proposed for the future

- Development of predictive ecosystem models
- Creation of environmental database
- Evaluating the biogeochemical coupling of biota with deep-sea ecosystem
- Development of environment management plan for nodule mining

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