

## NIRE's Research in Ocean Mining

*M. Kuriyagawa*  
National Institute for Resources and Environment  
Tsukuba, Japan

### ABSTRACT

A review of current NIRE's research in deep-ocean mining technology is presented. Main targets in the research are manganese nodules and cobalt-rich manganese deposits on the seafloor at 800-6,000m deep. Geotechnical properties of deep-sea sediments and hydraulic lifting characteristics of manganese nodules are clarified in the research. Processing and environmental studies related to the nodule mining are also conducted. For the cobalt-rich manganese deposits, the seafloor distribution characteristics are studied in some locations of the Pacific seamounts, and the physical characteristics and properties of only a fraction of the crust samples are tested.

**KEY WORDS** : Deep-ocean mining, manganese nodule, cobalt-rich manganese deposit, exploration, mining technology, processing, environmental impact.

### INTRODUCTION

The deep seabed promises to make an enormous contribution to the world's resources once its potential is fully realized. Manganese nodules and cobalt-rich manganese deposits in Pacific Ocean are resources of current interest for exploitation (Johnson and Otto, 1986; Manheim, 1986). These are deposited over and beneath the ocean floor at 800-6,000m depth.

International consortia and government projects have invested in exploration of manganese nodules, and in R&D of mining technology these 30 years (Takahara et al., 1984; Kaufman et al., 1985; Shaw, 1993). The amount of effort has varied during this period as a function of the metal market situation. However, efforts have succeeded to extend some selective technologies for subsystems to recover the nodules on a commercial scale (Shimizu et al., 1991; Ishikawa et al., 1992; Shimizu et al., 1992). Publicly sponsored projects have been active in the 1980s and 1990s in Japan, France, and India (Herrouin et al., 1989; Yamazaki, 1990; Yates, 1990). The industrial consortia were most active in the R&D in the 70's

Japanese research for manganese nodule mining was initiated in the 1970s by the National Institute for Resources and Environment (NIRE), which was reorganized from the National Research Institute for Pollution and Resources, and the Deep Ocean Minerals Association (DOMA). NIRE studied basic aspects of several mining methods. DOMA's effort

was primarily directed toward developing an efficient mining concept. On the basis of these preliminary research, in 1981, the Ministry of International Trade and Industry (MITI) decided to pursue further R&D of the mining concept as one of the Industrial Science and Technology Frontier Programs directed by the Agency of Industrial Science and Technology (AIST).

In the project, basic research has been carried out by NIRE, while engineering work has been conducted by the Technology Research Association of Ocean Mineral Resources Mining System (TRAM) under a management of the New Energy and Industrial Technology Development Organization (NEDO). The framework and some results obtained by TRAM were described in Wakabayashi et al. (1986) and Oyama and Ushijima (1990).

Exploration surveys on cobalt-rich manganese deposits were conducted by several countries from the early 1980s, mainly for geological interest (Halbach et al., 1982; Hein et al., 1984). The feasibility of the deposit mining was discussed (Hawaii, 1987) on the basis of many survey cruises. Since 1987, the Metal Mining Agency of Japan (MMAJ), with the interest in crust mining, has conducted extensive survey. NIRE started research, which concerned cobalt-rich manganese deposits, from late '80s.

NIRE's research relating to ocean mining current 15 years are introduced and summarized in this paper.

### MANGANESE NODULES

#### Outline

In NIRE, research on mining technology and environmental impact of manganese nodules has been carried out under the AIST's R&D project. Geotechnical properties of deep-sea sediments and fundamental problems related to the nodule collector, and lifting characteristics of the nodules have been the main items in the research of mining technology. Methods of water column and seafloor measurements before, during and after the mining test, and the data analyses have been studied in the project. The nodule processing was studied as a part of the AIST's ordinary research scheme. Table scale acid leaching and a utilization method of the tailings were also studied.

#### Mining Technology

Reliability, mobility, safety, and collection efficiency of the nodule collector are the most important parameters in the mining system. Geotechnical properties of deep-sea sediments which are the beds of the