

Japan's Ocean Test of the Nodule Mining System

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ABSTRACT

The R&D of "Manganese Nodule Mining System," a Japanese national project, started in 1981. The Technology Research Association of Ocean Mineral Resources Mining System was in charge of this project. Since fiscal year 1997 was the final year of this project, four ocean and on-land experiments to investigate the results of R&D so far and to collect various data that are useful for the future mining system were conducted. The following four experiments were conducted independently of each other: 1. Nodule collection at ocean; 2. Behaviors and handling of lift pipes at sea; 3. Behaviors of flexible hose in collector landing and recovery operation on land; and 4. Operation control of air-lift compressors on land. This paper outlines the nodule mining system developed and reports the result of the above experiments.

KEY WORDS: Deep-sea minerals, deep-sea mining technology, manganese nodules, ocean test.

INTRODUCTION

The self-support ratio of rare metals in Japan is very low and the dependence on imports is 100% for cobalt and 95% for manganese. Hence, the development of manganese nodule mining technology is very important for Japan in order to secure long-term and stable supply of rare metals. On the other hand, the deep-sea where manganese nodules are abundant is an extremely hard environment with hydrostatic pressures of 500 times of the atmospheric pressure and a temperature of 2 to 3 °C. Thus, there are many problems to be solved technically in this development that needs large funding and a long lead time.

Since early 1970's a deep-sea mineral development was adopted as one of the government's principal mining policies in Japan. Then, the research institutes of the Ministry of International Trade and Industry (MITI) such as the Geological Survey of Japan (GSJ) and the National Institute for Resources and Environment (NIRE), played an important role in the geological study and the fundamental engineering research

of the deep-sea mineral resources development (Kuriyagawa, 1995).

The Agency of Industrial Science and Technology (AIST) of MITI started the R&D project of manganese nodule mining technology in 1981 as one of its Industrial Science and Technology Frontier Programs. In addition, the Technology Research Association of Ocean Mineral Resources Mining System (TRAM) has been established in 1982 to conduct the R&D of the mining system under the contract with AIST and has implemented the study. This program has successfully completed in FY 1997.

In this paper, the nodule mining system developed in this program and the results of the ocean test conducted in 1997 are reported.

JAPAN'S DEEP-SEA MINING SYSTEM

The manganese nodule mining system developed in Japan is an integration of seafloor collector system, ore lifting system, machinery handling system, and control and measurement system (Inokuma, 1995).

The outline of each subsystem is as follows:

Seafloor collector system: Reliability, tractability, safety, and collection efficiency are the most important factors in this system. A tow sled-type collector with a pressurized water jet flow collecting mechanism based on the Coanda effect was designed. The larger nodules are crushed in the collector for ore lifting. The collector will be towed by a pipe string composed of a flexible hose and lift pipes, collect nodules with water jet, separate seafloor sediments, crush nodules to desirable size distribution, and feed them into the ore lifting system.

Ore lifting system: Slurry of nodule-water-mixtures can be transported by an underwater pump system or an air-lift system through the lift pipes. The vertical nodule-water two-phase and nodule-water-air three-phase flows were studied by NIRE based on a laboratory size test and a 200 m deep tank test (Saito et al., 1989). The important factors are the optimum mixture ratio of nodules or nodule pieces in the slurry, the friction factor, wear, and so forth.

The underwater pump system lifts the nodules in two-phase flow with pumps set in series through the lift pipes. Deep submersible pumps, driven by submerged electric motors filled with insulation oil