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Geotechnical Parameters and Distribution Characteristics of the Cobalt-Rich Manganese Crust for the Miner Design

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ABSTRACT

The importance of deep-ocean deposits for future cobalt resources and geological distribution characteristics have been well recognized. However, no sufficient geotechnical information of the cobalt-rich manganese deposit region is available to aid the design of seafloor mining systems. Based on the results of a recent large-diameter gravity coring, a model test of the coring, and analyses of geotechnical properties of seamount sediments, topographic and microtopographic distribution of the deposits, strength characteristics of the crusts and the substrates, and the geotechnical distribution characteristics of the deposits are presented. Although the present data represent a small coverage, the data will be useful as preliminary miner design parameters, and the initial design parameters are also discussed.

INTRODUCTION

Cobalt-rich manganese deposits on the Pacific seamounts are considered to supply a potential cobalt reserve in the next century (Halbach, 1982; Cronan, 1984; Manheim, 1986). The cobalt-rich manganese deposits were found not only on seamounts, but also on island slope (Halbach and Manheim, 1984; Cronan et al., 1991). Ferromanganese deposition itself was observed from shallow slopes to deep-sea basins. However, the zone shallower than 2,500 m was cobalt-rich, and the zone deeper than 2,500 m was nickel-rich like deep-sea manganese nodules (Hallbach and Manheim, 1984). Recent active exploration surveys on the cobalt-rich manganese deposits have been conducted by the Japanese research vessel Hakurei-maru No. 2 near Marcus Island in the North Pacific for the past few years. The results reveal that the cobalt-rich crusts are not only located on the seafloor surface, on flat to steep slopes, but also buried beneath the calcareous sediment layer (Yamazaki et al., 1993b). One estimates that the recoverable reserve in the survey zone can be 3-5 times that of a previous evaluation (Yamazaki, 1993). However, little geotechnical information of the cobalt-rich manganese deposits is available in the literature for the design of a seafloor mining system or "miner system." Only the local microtopographic features and concept studies for the mining systems have recently been published (Morgan et al., 1988; Yamazaki et al., 1992; Chung, 1994; Chung et al., 1994a; Chung et al., 1994b).

Among the many types of deposition, only crust mining is discussed in this paper. Yamazaki (1993) reported a large amount of surface-exposed crust and shallow-buried crust reserve. However, presently, there is no sufficient engineering information for nodules, boulders and pavements in the crust deposit region, except for the distribution characteristics.

Detailed data of the geotechnical parameters and distribution characteristics of the deposits in very limited regions were made available in some recent research (Yamazaki et al., 1990, 1993a and b, 1994a and b), but there is still no definite correlation among them, and re-examinations of the data are required depending upon the new findings and results. The viewpoint of the mining interest must be considered in the re-examinations.

GEOTECHNICAL DISTRIBUTION CHARACTERISTICS

Attractive Zone for Crust Mining

The topographic distribution characteristics of the crusts, nodules, and sediments are the most important factors not only for the design of the miner system but also for the selection of the mining site. Their typical distribution on the seafloor surface and quantitative analysis along an observation line have been presented by Yamazaki et al. (1994b).

From the quantitative surface observation data, the local slope angle, ranging from 0° to 4°, is characterized as crust-poor, 4°-7° crust-and-nodule even-occurrence, 7°-10° transition, and over 15° crust-rich zones, respectively (Fig. 1). Note that Fig. 1 does not include the shallow-buried crusts.

The data of the shallow-buried crusts and nodules obtained by a large-diameter gravity corer on 5 seamounts near Marcus Island in the North Pacific during the survey cruises of the Hakurei-maru No. 2 are summarized in Table 1. All 50 corer samplings were conducted in selected lesser-sediment-accumulation areas. The existence of the shallow-buried crusts and nodules is directly confirmed from 13 samples. Also, their existence was indicated by

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