

Chapter 5 Summary

High abundance (more than 30kg/m²) of manganese nodules was confirmed by the results of surveys previously (1986, 1990, 2000) conducted in the Cook Islands area. In this year under the request of SOPAC, the survey for manganese nodules has been carried out in the sea area within the EEZ of Niue, adjacent area to the Cook Islands area.

5-1 Seafloor Topography

The Niue area is topographically subdivided into two provinces: Hilly Province including seamounts and knolls and Plain Province. The Hilly Province of the survey area continues to the hilly terrain of the western margin of the Cook Islands area (166° W) where the previous survey was done in the fiscal year 2000.

In the area, acoustic survey mainly by MBES was conducted during the time of ship cruising from one sampling station to the other. Comparison of the bathymetric map by this survey with existing map of satellite gravity data shows that they, generally, coincide well with exceptions of a newly found knoll (19° S · 168° 10' W; 3,800m deep at summit) and a topographically high (184° 0' S · 167° 15' W; 4,000m deep).

5-2 Acoustic Survey and Bottom Sediments

(1) SBP type and Distribution of Acoustically Transparent Layer

In the area, the SBP type lacking acoustically transparent uppermost layer is dominant. Particularly, the area north of 20° S, Type d2, represented solely by acoustically opaque layer, is widely distributed, and poor distribution of unconsolidated sediments is expected in the area. On the other hand, the area south of 20° S, Types ac and ec, represented by intercalating acoustically transparent layer in the middle with thin acoustically opaque layer at the uppermost part, are distributed. The SBP types without uppermost transparent layer are predominant in the area and potentiality of the manganese nodules is generally low in the area represented by these types of SBP.

(2) MBES Acoustic Reflection Intensity Survey

The results of MBES acoustic intensity survey coincide well with SBP types. The area north of 20° S, where SBP Types of d1 and d2 (consisting only of acoustically opaque layer) were observed, is dominated by high intensity of acoustic reflection, expressed by dark color. This suggests a scarce distribution of unconsolidated sediments in the area. The area south of 20° S, on the other hand, shown by the SBP type with

uppermost opaque layer intercalated by intermediate transparent layer, is dominated by relatively low intensity of acoustic reflection, expressed by relatively pale color. This suggests a distribution of unconsolidated sediments in the area. Considering from the SBP results, the unconsolidated sediments distributed in the area do not seem to be as soft as ooze, it is more likely to be coarse and acoustically relatively hard material.

(3) Manganese Nodules Survey by MFES

Based on the results of SBP and MBES, the most of the area is characterized by acoustic nature without transparent layer and even the transparent layer exists, it is covered by thin opaque layer on the top. This means, whole the seafloor surface of the area is covered by acoustically "hard" material. The results of MFES survey revealed pseudo-anomaly on the most of track lines, reflecting distribution of materials with relatively high reflection such as semi-consolidated sediments and coarse grained sediments.

(4) Bottom Sediments

All of the bottom sediments collected from 16 sampling points (FG 13 points, SC 3 points) were classified into insoluble brown clay category. Reflecting water depth of this area deeper than 5,000m~5,500m, calcareous grains comprising foraminifer fossils and so on, are rare. On the other hand, volcanogenic clastic grains (plagioclase, quartz, pyroxene etc.) are comparatively abundant and this nature is characteristic of the area. The sample collected at sampling point 03S2027SC01, located at the center of the area, has comparatively abundant zeolite mineral (phillipsite).

The bottom sediments of sampling points 03S1929FG01 to FG03, only the points manganese nodules samples were collected, show clearly different nature from other sampling points characterized by very few radiolarian fossils and abundant volcanogenic clastics.

The results of chemical composition of bottom sediments shows that LOI is comparatively low and SiO₂ and FeO are high. This is conformable with the evidence that many volcanic clastics grains, escaped from post depositional alteration, are included in the bottom sediments. At the sampling point 03S2327SC01, where buried manganese nodules were collected, clear compositional gap was observed at the buried manganese nodules-bearing horizon. The manganese nodules-bearing horizon has a similar chemical composition to that of present bottom surface materials, showing tendency of low CO₂ and LOI, and high SiO₂ and, CaO.

According to the principal component analysis using the chemical composition of

bottom materials, a group of elements such as Mn, Pb, Ni, Co was extracted as the first principal component, which can be related to the enrichment of Mn. The samples containing abundant foraminifer fossils show high scores of the second principal component, and this component seems to have relation with carbonate material such as foraminifer fossils.

From the results of fossil inspection of SC samples at 3 sampling points, fossil faunas of foraminifer, radiolaria and ichtyolith were found and the deposition ages of the bottom sediments of 0 to 0.54 Ma was determined, and these give sedimentation rates of 0.6 to 2.1+ α cm/1,000year. Paleo-ecological analysis of radiolarian fossils of these samples suggests sedimentation environments with weak influence of up-well current, such as tropical shallow water or cool environment affected by deep current or bottom current. While, the foraminifer fossils suggest tropical to subtropical geographic province, almost same latitude as the present, for sedimentation environments of these samples. Concerning production rate of radiolarian fossils, it is low at sampling point 03SS2326SC01 in southern part of the area, compared to other two points.

5-3 Abundance of Manganese Nodules and Characteristics of Grade

(1) Occurrence

By the manganese nodule survey in Niue area, samplings of a total of 36 sampling sites (12 sampling stations), comprised of 29 sites by FG and 7 sites by SC for environmental survey, were conducted. Of them, manganese nodules were collected at only one station of 03506 out of 12 sampling stations. The average manganese nodule abundance at the station is 1.02kg/m² (actual amount of collected nodule and abundance of each sampling point are: 03S1929FG01=162g, 1.25kg/m², 03S1929FG02=48g, 0.69kg/m², 03S1929FG03=146g, 1.13 kg/m²).

At the station 03504, where FG sampling failed to collect nodule samples, seafloor occupancy rate of nodule was calculated using sea-bottom photographs, and the average of 3 sampling points was calculated to be 48.9% (at each point 03S2028FG 01=54.1%, 03S2028FG 02=54.1%, 03S2028FG03=46.2%). When this is converted to the abundance of manganese nodules it gives values of approximately 8 ~10 kg/m².

From these sampling results, the abundance of manganese nodule in the survey area is assumed to be lower than 2.5kg/m².

The follow up dredge sampling at station 03504 to confirm the occurrences of manganese nodules and manganese crust shown by the sea-bottom photograph resulted in collecting manganese crust and boulder type crust in addition to manganese nodules. Further dredge sampling was conducted at station 03511 to evaluate the slop of sea

mountain, and manganese crust and nodules were collected.

(2) Characteristics of Grade

The results of chemical analysis of manganese nodules show that there are two types of manganese nodules with slightly different chemical composition corresponding to topographic sub-division. The one type includes manganese nodules collected from three sampling stations (03506, 03507, 03513) located within the flat area (Plain Province) at the east and south of the area, and the other type includes nodules collected from three sampling stations (03504, 03509, 03511) located within the hilly area associated with seamounts (Hilly Province) at the western part of the area. In the former area only manganese nodules are distributed and in the latter manganese nodules are distributed associated by manganese crust. Of them, station 03511 is the Arm Dredge (AD) sampling station conducted on the slope of seamount. The former (Plain Province samples) is high in Ni and Cu and low in Mn and Co. compared to the latter (Hilly Province samples). The latter nodules show similar composition to that of the associated manganese crust, and the composition is similar that of cobalt-rich manganese crust in the Marshall Islands area. The ratio of Mn/Fe is about 1.0, a little higher than that of the Cook Islands area (0.7), but lower than that of the Clarion-Clipperton area of the East Pacific Ocean (4.0).

The chemical composition of manganese nodules of both the Plain Province and the Hilly Province resembles that of s-type proposed by Usui and Moritani (1992), and smooth surface of nodule samples of the area is also correspond to s-type. The origin of s-type manganese nodule is considered to be hydrogenous (Usui and Moritani, 1992). On the other hand, buried manganese nodules have slightly different chemical composition, slightly higher Fe compared to Mn, and the composition is different from that of the Plain Province and the Hilly Province.

The characteristic feature of rare earth element of the area is positive anomaly of Ce. In addition to this, high concentrations of rare earth elements of the area suggest hydrogenous origin for the manganese nodules of the area. High Ce concentration of manganese nodules is attributed to oxidized environment of deep seawater during the growth of manganese nodules (De Carlo and Mc Murty, 1992).

5-4 Environmental Survey

The environmental survey was conducted as a baseline study to understand environmental situation of present day for future evaluation of potential mining impacts on the deep-sea environment. For this purpose, nature of sediments (water

content, specific sediment gravity, total organic carbon, total nitrogen and grain size analysis) and benthic organisms (distribution of meio- and macro-benthos) were investigated. Core samples were collected at three stations located in the EEZ of the Niue Islands. 03S2027SC01 is located at the foot of a seamount in the central part of the survey area, while 03S2326SC01 and 03S2327SC01 are located on almost flat seafloor in the southern part of the survey area.

The results of this survey show that the water content of the sediment decreased from the surface to the bottom at central station, while at the two stations in southern area the water content was higher in the deeper layers than in the surface layers. At the station in central part, only a slight vertical variation of specific sediment gravity was observed. In the surface layers of the southern two stations, sediment gravities were higher than at the central station. Total organic carbon concentration showed similar values from the surface to the 3-4 cm layers at the central station, but dropped in the 4-5 cm layer. At the southern stations, the vertical distribution of total organic carbon differed from the distribution at the central station, showing a tendency to increase with decreasing depth. At the southern stations, the total nitrogen concentration was also different from the central station, showing the same tendency as seen for total organic carbon. The results of sediment particle size distribution showed bimodal patterns in all layers at the central station, while at the southern two stations, patterns similar to normal distributions were found in the upper layers and bimodal distributions in the deeper layers.

Analysis of metazoan meiobenthos showed that nematodes were the most dominant organisms at every station, although the abundance of nematodes was lower at the central station than at the southern stations. Regarding the vertical distribution, high densities were observed in the surface layers of the southern two stations. Macrobenthos abundance and numbers of taxa were highest at 03S2327SC01 in the southern area. At stations 03S2027SC01 and 03S2326SC01, macrobenthos organisms were only observed at the 0-1 cm layer, while they decreased from the surface to the bottom at 03S2327SC01.

A comparison of the organic material concentrations and the density of benthic organisms shows that the abundance of benthic organisms was lower at the surface of the central station while high concentrations of total organic carbon and total nitrogen were observed. In contrast, although the concentrations of organic material were lower at the surface of the southern part of the survey area, the meiobenthos abundance was much higher at station 03S2326SC01 and both meiobenthos and macrobenthos densities were greatest at station 03S2327SC01.

These results do not support the assumption that the general abundance of benthic organisms is mainly controlled by the quantity of available organic materials. Although the abundance of bacteria, foraminiferan and other protozoan organisms were not analyzed in this survey, the recent findings lead to the assumption that the biomass of these important primary consumers should be higher in the central area than that at the southern stations. Since the patterns of sediment particle size distribution at the surface layers of the southern stations were different from that at their deeper layers and from all layers of the central station, it is reasonable to assume that the qualitative accumulation action of ocean currents and topography has been different in the southern and central areas. This might influence the heterogeneity in feeding conditions for benthic organisms.

For the future studies, the estimation of biomass including bacteria and nanobenthos and the survey of the relationships between environments of the surrounding areas and the accumulation mechanisms of organic material are recommended.

5-5 Evaluations and Recommendations

The manganese nodule survey conducted in the eastern half of Niue EEZ suggests that potentiality of manganese nodules in the area is not high, however, dredge sampling (03511 site, Fig. 3-5-3), conducted on the northern slope of the seamount located in the south of the area ($21^{\circ} 04' S \cdot 168^{\circ} 52.5' W$), gives encouraging results collecting manganese crusts with an average thickness of 25mm. This warrants further survey to assess the potentiality of manganese crust in the seamounts distributed in the area.