Chapter 4 Summary

4-1 Outline of Topography

The SE01 Seamount was surveyed in fiscal year 1991 and the survey covered only southeastern half of the seamount. To complete the survey of SE01 Seamount, the survey of this year (2003) was conducted in the northwestern half of the seamount. As the results of the survey, it becomes clear that there exists two seamounts in the northwestern part (Northwest Seamount and Center Seamount), thus adding already explored seamount occupying the southeastern half of the area, Southeast Seamount, the SE01 Seamount consists of three seamounts

Among the three seamounts, the Southeast Seamount is the largest, flat summit seamount (guyot) with a longer axis trending N40°W, parallel to the general trend of the SE01 Seamount. The Southeast Seamount rises 2,900m high from the base of seafloor 4,100m deep, and the area of the summit shallower than 1,500m is 690k m^2 (46 ×15km).

The two seamounts, Northwest and Center Seamounts, found by the survey of year 2003 in the northwestern areas of the SE01 Seamount, are connected by col of 2,200m deep, and both of them are small in scale compare with Southeast Seamount. The longer axis of elongated summit of both seamounts trends in N45° W, and sizes are approximately 190km^2 (27×7km) and 150km^2 (15 ×10km), respectively, for Northwest and Center Seamounts. The water depth of summit becomes shallower toward northwest, and Northwest summit is 1,128m deep, Center summit 1,145m, and Southeast summit is the deepest, 1,261m.

4-2 Topography and Top sediments

Both of the Northwest and Center Seamounts have flat summit and the water depth of both of shoulder parts are 1,500m. They have dome-shape summit, gradually diminishing depths from edge part toward the center. The both summit areas do not have dominant ups and downs, and gradients of the Northwest and Center Seamounts are 5.7°in average, a little steeper than that of Southeast Seamount (2.1°). The surface of the summit is smooth and assumed to be laid by unconsolidated sediments. The slopes of the seamounts are comparatively gentle. In the upper part of the slope of Southeast Seamount, gradient is 15.2°, of Northwest Seamount, 14.7°, and of Central Seamount, 11.4°. The middle slope is slightly gentler than the upper slope, ranging from 11° to 13°,and the slope of the seamounts deeper than 3,500m is more gentle, 5°to 7° and it merges to the foot of seamount

According the survey of 1991, Type-T with acoustically transparent layer is widely distributed over the summit area of the Southeast Seamount of the SE01 Seamount, and its thickness reaches to 150m at the maximum In the two seamounts surveyed this year, Northwest and Center Seamounts, SBP patterns of Type-T is predominantly distributed from flat summit to edge where water depth abruptly increases. This shows that the summit is widely covered with unconsolidated sediments and the thickness is 20m to 50m on the summit of Northwest Seamounts and 20m to 70m on the summit of Center Seamount. The SBP records of these seamounts show striped layers on the top, and the sediments on the surface are assumed to be coarse materials with high acoustic reflection response. By the MC sampling conducted at three locations in summit area foraminifer sands are obtained.

4-3 MBES Acoustic Reflection Intensity Survey

The whole summit areas of SE01 Seamount are represented by pale color on the MBES image, suggesting unconsolidated sediments covering the whole areas of summits. By the coverage of unconsolidated sediments, the summits form a dome-like smooth shape without ups and downs

For the previously surveyed (1991) Southeast Seamount, acoustic reflection intensity data has not been obtained, however, from SBP records, summit area of this seamount is expected to be widely covered by unconsolidated sediments as same as Northwest and Center Seamounts.

The dark color area, reflecting exposed rocks, is observed in the col, 1,300m deep, connecting two summits within the Northwest Seamount and the col of 2,100m to 2,200m deep connecting the Northwest Seamount and the Center Seamount. Other dark color areas, where exposed bedrock is expected, are seen at the edges of the summit and on a part of the slope. At the edge of summit, transition zone to the slope, the boundary of exposed rocks and unconsolidated sediments is clear due to high contrast of acoustic reflection intensity. In the slope area deeper than the edge of summit, the acoustic reflection intensities reflecting valley and ridge topography are observed and a distribution of unconsolidated sediments is expected at topographic lows such as valley bottom.

Toward the foot of seamount, image becomes lighter in color, suggesting the increasing thickness of unconsolidated sediments. Particularly, the seafloor deeper than 4,000m seems to be widely covered by uniform unconsolidated sediments. Foraminifer ooze was collected by the sampling conducted at western edge of foot of seamount (water depth 4,200m) where represented by pale color.

4-4 Outline of Geology

From the results of AD sampling conducted this year and previous year (a total of 16 points, 8 points in 2003 and 8 points in 1991), the exposed rock area, assumed by MBES image, seem to be mainly occupied by limestone and phosphoric rock, and these rocks are mostly coated by manganese oxides. The calcareous nannoplankton fossil in the limestone suggests that the age of sedimentation is Late Eocene to Early Oligocene time. While the foraminifer fossil suggests that the sedimentation environment had changed from pelagic environment far off the shelf to shallow and to terrestrial environments. The age determined by nannoplankton fossils indicates post-uplifting age, thus, the sedimentation of limestone is assumed to be older than the age of nannoplankton fossil. After the uplifting, the seamount subsidized again and cobalt crust started to grow on the surface of the limestone at or after Late Eocene to Early Oligocene

4-5 Occurrence of Crust

The selection of AD sampling site was done by bathymetric data and acoustic reflection intensity data obtained by MBES. All through the samplings of this year and previous year in SE01 Seamount, cobalt crust was collected only at 03SE01AD09 (bottom touch depth of 1,910m) and at the other sampling points only thin manganese oxides (coating) were observed covering the surface of rocks

The cobalt crusts collected at 03SE01AD09 are crust and boulder type crust. The average thickness of the crust is 35mm (ranging from 35mm to 45mm). The crust shows botryoidal texture on surface and has a two-layers structure. Boulder type crust, with nuclei of angular breccia of phosphatized limestone, has average thickness of 20mm (ranging from 5 to 25mm). It shows one layer structure with a surface of smooth botryoidal structure. Nuclei are muddy to sandy, inhomogeneous phosphoritic rock of limestone origin, and abundant grains of minute manganese oxides are included in it. This phosphoritic rock is very hard and seems to be strongly phosphatized.

The samples collected at other seven sampling points were mainly limestone (partly phosphatized) and pumice fragments. These are soft rocks and only thin-coated manganese oxides are observed, and not encrusted by thick manganese oxides.

4-6 Chemical Composition of Crust

Among the cobalt crust collected at the 03SE01AD09 point, two samples were selected and the chemical analyses of 36 elements were conducted. The average contents of major metal elements are Co 1.24%, Ni 0.69%, Cu 0.03%, Mn 31.04%, Fe

14.39%. Of them, Co content is high compared to that of cobalt crusts from other seamounts of the Kiribati area and the Marshall Islands area. Mn is over 30% and very high, and Fe, on the other hand, is slightly low. Consequently, Mn/Fe is higher than that of other seamounts of the Kiribati area and the Marshall Islands area. The contents of Cu and Ni are low compared to Fe and Mn, and the cobalt crust of the SE01 Seamount is assumed to be hydrogenous origin.

4-7 Environmental Survey

This 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, water content, specific sediment gravity, total organic carbon, total nitrogen and sediment particle size distribution of the sediments as well as the distribution of meio- and macrobenthic organisms were investigated.

Core samples were taken at four stations in the SE01 Seamount located in the EEZ of the Kiribati Islands. Station MC01 is located in deep area, at western foot of SE01 Seamount, while MC02 and MC04 are located in relatively shallow area, on the summit of, respectively, Northwest and Center Seamounts. MC03 is located on the col between the two seamounts.

The results of this survey show that the water content was highest in the 0-1cm layers at the deepest station at foot of seamount, where it decreased from the surface to the bottom. Although the water content was also highest in the 0-1 cm layers of the stations on the summit of seamounts and the col, no clear tendency for a vertical decline below the 1-2 cm layers could be seen. There is only a little variation in the specific sediment gravity among the stations.

Total organic carbon concentration was the highest in the 0-1 cm layer at the deepest station of western foot and the Northwest Seamount station, lower in the Center Seamount station, while the lowest concentration was found in the sediments of the station at col. Total organic carbon concentration showed the tendency to decrease from the surface to deeper layers at the deepest station, while only a small vertical variation was observed at the other stations. The highest total nitrogen concentration was found in the 0-1 cm layer of the deepest station on western foot and the Northwestern Seamount stations, but a clear vertical variation was not detected. Furthermore, it was observed that smaller particles (3.3μm diameter) showed the highest frequency in all layers at the deepest station, with a second peak frequency at larger particle size (40～80μm) in some layers. At other stations, a frequency peak

similar to a normal distribution with the highest frequency at larger particle size (48~68μm) was found.

An analysis of the metazoan meiobenthos revealed many taxa of arthropods. Arthropods, annelids and nematodes were observed at every station. The total metazoan meiobenthos abundance was highest at the stations on the summit of the seamounts, followed by the western deepest station, while the abundance was lowest on the col. Nematodes were the most dominant organisms at every station. At all stations, densities of the meiobenthic organisms were highest in the 0-1 cm layers and tended to decrease with depth from the surface to deeper layers. Furthermore, almost all organisms were only observed in the upper 2 cm of the sediment with the exception of nematodes at the western deepest station. Metazoan macrobenthos taxa were more than meiobenthos taxa. As seen for the meiobenthos, arthropods, annelids and nematodes were observed at every station. The highest variety of taxa was found at the stations on the summit of the seamounts, where the abundance was also highest. The lowest abundance was found at the col station. At the western deepest station arthropods were the most dominant organisms followed by nematodes, while annelids or arthropods were the dominant organisms at other stations. At all stations, the highest densities of macrobenthos were observed in the uppermost layer and decreased with increasing sediment depth, while only a few taxa were found below the 2-3 cm layers.

An analysis of the relation between organic material concentrations and benthic organism density showed that high benthos abundance was found at stations with high concentrations of total organic carbon. At the shallow stations a linear relation between total organic carbon concentration and macrobenthos densities ($R=0.95$, $n=6$) was found, with annelids and arthropods being the dominant organisms. In contrast, although the concentration of organic material was higher at the deepest station, the abundance of the macrobenthic annelids was lower. These results support the assumption that at the stations on the summit of the seamounts and col the general abundance of benthic organisms is mainly controlled by the quantity of available organic material. Since the relationship between organic material concentrations and density of benthic organisms is different at the deepest station, water depth and topography might influence the heterogeneity in feeding conditions for benthic organisms at this station.

These findings lead to the conclusion that in future studies i) the details of benthic organisms distribution in relation to water depth and ii) the relationships between the environment of surrounding areas and the accumulation mechanisms of organic material should be investigated.

4-8 Conclusions

As the results of the surveys of this year and the previous year in SE01 Seamount, cobalt crust was collected from only one sampling point in the northern part of the Center Seamount. The collected cobalt crust is rather thick with average thickness of 35mm, and very high Co content of 1.24% on average. Considering the results, there is a possibility of thick, high Co, cobalt crust being distributed in the SE01 Seamount, but this was confirmed at only one sampling point. Therefore, the occurrences of cobalt crust in the SE01 Seamount seem to be local, not widespread over SE01 Seamount.