Chapter 4 Considerations

The manganese nodules sampling by Free-fall Grab (FG) conducted in the area of Niue this year resulted in collecting manganese nodules only at 5 sampling points out of 29 points, and there was no sampling point with manganese nodules weight exceeding 200g. By the dredge sampling conducted to confirm the occurrences of manganese nodules and manganese crust revealed by the seafloor photographs in Hilly Province, manganese crust and boulder type crust were collected in addition to manganese nodules. Buried manganese nodules were collected at one sampling point by spade corer but the extent of its distribution is unknown. From the above results, the potentiality of manganese nodules with high density in this area, except the area sampled by dredge, is assumed to be low.

Contrary to this area, in the Cook Islands area, eastern vicinity of Niue area, distribution of manganese nodule with high density had been confirmed by the survey conducted in previous year. The differences of manganese nodule occurrence of the both areas are considered from available data.

4-1 Seafloor Topography

The survey area of the Cook Islands sea area can be topographically divided into three, the Mountainous Province, the Hilly Province, and the Plain Province. Almost whole area is deeper than 5,000m, and shows hilly topography with small ups and downs and gradually increases the depth toward west, reaching 5,400m deep, and is generally gentle and flat. Locally, mountainous area occurs within the hilly area consisting of many small knolls with peaks of shallower than 4,800m deep.

In the topographic sub-division of the Niue area, topographic high with groups of seamounts including the Niue Island is classified into the Hilly Province. This Hilly Province intermittently continues to the hilly area of the Cook Islands sea area. The area other than this is classified into Plain Province.

Comparing topography of the both areas, the Niue sea area is deeper, reaching more than 5,000 to 5,500m deep, and occupancy rate of hilly area is smaller. Consequently, flat area is more predominant in Niue area compared with Cook Island area.

4-2 SBP Type

According to the previous survey in the Cook Islands area (surveyed in 1990, to the east of 166° W), the Types dl and ds are predominantly distributed, indicating a

distribution of many seamounts and knolls and the seafloor topography is more complicated. Type-a was observed near seamounts and knolls while Type c was found in comparatively flat areas. The following relations between occurrence of manganese nodules and SBP type was observed..

Type dl: average abundance 14.6kg/m² (11 sampling stations)
Type ds: average abundance 6.4kg/m² (6 sampling stations)
Type c: average abundance 2.9kg/m² (15 sampling stations)
Type a: average abundance 10.5kg/m² (7 sampling stations)
Type ts: average abundance 15.6kg/m² (4 sampling stations)

From the above, the area represented by Type c of SBP records shows low abundance of manganese nodules. The Type c consists of thin opaque layer on the top and transparent layer below it, and this type resembles Type ac of the Niue area. The uppermost layer of this type is assumed to be composed of unconsolidated sediments, and its high acoustic reflection suggests coarse grained or high viscous materials constituting the top layer. In the area shown by such SBP types, abundance of manganese nodule seems to be low. While, in the areas shown by acoustically transparent upper layer like Type a or Type ts, suggesting a distribution of low viscous Quaternary sediments such as brown clay on the top, abundance of manganese nodules tends to be high. Moreover, in the Cock Islands area, the abundance of manganese nodules tends to be high in the area represented by Type d1 where occupied by sea mountains and knolls and in the area with topographic change at the vicinity of sea mountain and knoll.

In the Niue area, SBP Type ac and Type ec, which correspond to Type c of the Cook Islands area, and Type d2 showing opaque layer on the top, are distributed predominantly. Topography of the area represented by these types is very flat. The distribution of manganese nodules is scarce in the area shown by Type ac and Type ec. This is conformable with the results that manganese nodules seldom occur in the area shown by Type c in the Cook Islands area. This may suggest that high viscosity of the bottom sediments hampers the growth of manganese nodules. In the area of Type d2, lacking unconsolidated sediments as the upper layer, the abundance of manganese nodules seems generally low. However in the Niue area, manganese crust and manganese nodules are confirmed locally in this area, and this rule may not always applicable.

From the above, characteristics of topography and acoustic nature of bottom

sediments are slightly different between Nieu and Cook Islands areas.

4-3 Bottom Sediments

According to Cronan (1986), the preferable conditions for development of abundant manganese nodules are: i. high biologic productivity, ii. existence of Antarctic bottom current and erosional environment of the seafloor with low rate of sedimentation (hiatus) iii.depth of sea floor being near the CCD or slightly deeper. Exon (1983) and Cronan (1984) and Cronan et al. (1986) drew out a series of conclusions as the major environmental condition of abundant occurrence of manganese nodules based upon the results of manganese nodules surveys conducted as the CCOP/SOPAC surveys in the Southwest Pacific Ocean surrounding the survey area. They are; i. biologic productivity is greater than 50 $\cdot$ cm^{-2} $\cdot$ y^{-1}, ii. water depth is near the CCD or slightly deeper, iii. no existence of turbidite of rapid deposition product supplied from islands or seamounts. Taking consideration of these, comparison of bottom sediments between Niue and Cook Islands are made.

(1) Productivity

According to the fossil inspection, the occurrence of radiolarian fossils is scarce in the bottom sediments of the Cook Islands area, suggesting low productivity. In the bottom sediments of the Niue area, on the other hand, almost all samples include radiolarian fossils and ichtyolith fossils, and foraminifer fossils were found at water depth as deep as 4,700m. The occurrences of radiolarian fossils in the Niue area suggest lower productivity in the southern area.

(2) Antarctic Bottom Current

The temperature data measured by CTD (conductivity/temperature/pressure measuring system) show that sea floor temperature of both areas is lower than 1.5℃ (Figure 4-3-1). Particularly in the Niue area, deep-sea water temperature measured at 03S1827SC01 point by CTD mounted on the spade corer showed about 1.0℃ at depths deeper than 4,500m, and temperature remained same toward deeper depths. From this, benthic front at this point (17° S, 169° W; water depth 5,135m) was assumed to be about 4,500mdeep (Figure 4-3-1). The temperature profile of seawater similar to that of 03S1827SC01 was obtained in the South Pacific where Antarctic Bottom Current was confirmed (Craig et al. 1972), This suggest the existence of the Antarctic Bottom Current in the Niue area. The Niue area is located at the western edge of Antarctic Bottom Current flow (South Pacific Basin-Samoa Basin-Samoa Passeage) as shown by

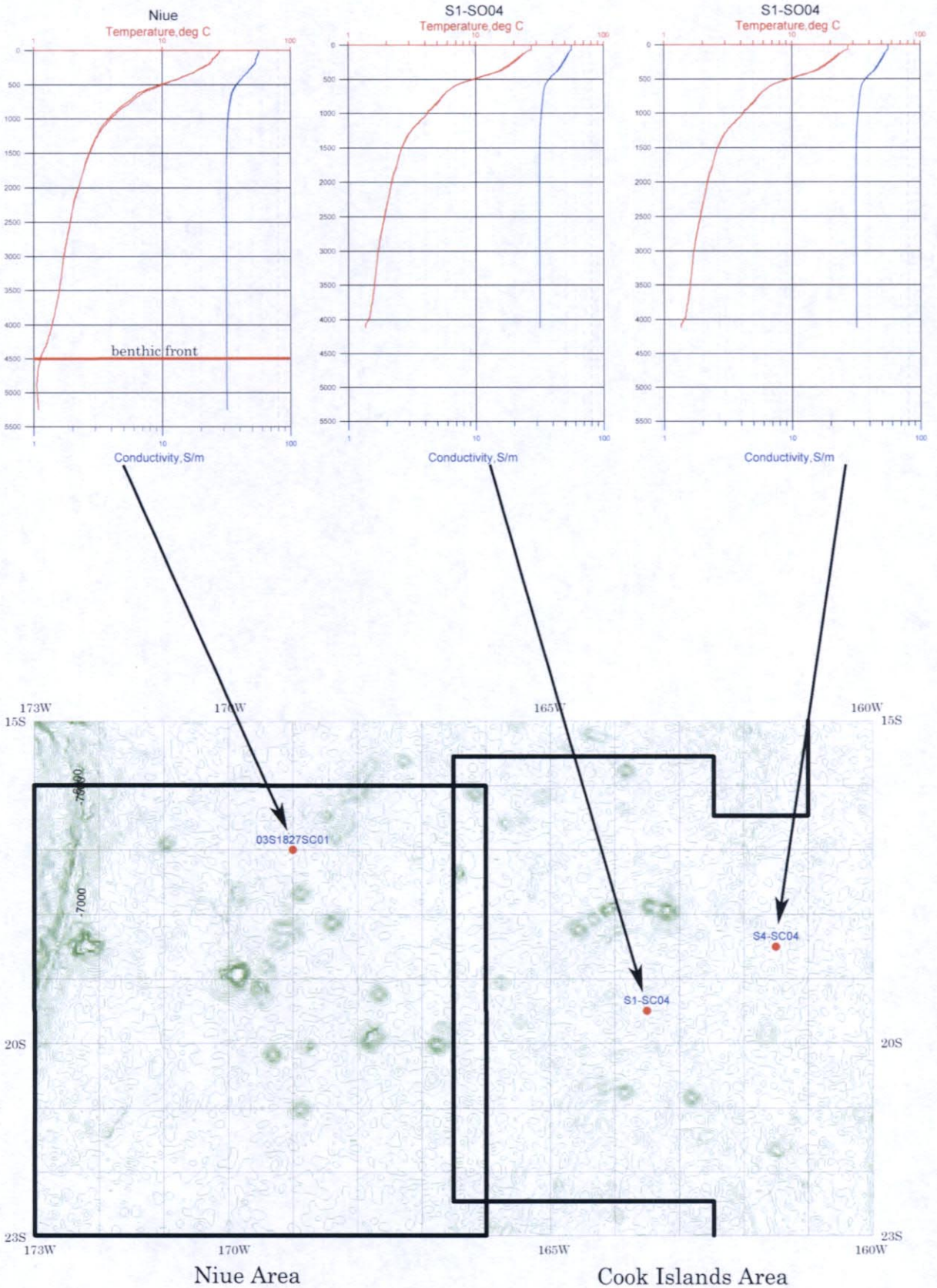

Fig. 4-3-1 Seawater temperature and Conductivity of Niue and Cook Islands Area

Pautot and Melguen (1979), and the temperature profile of the seawater obtained at 03S1827SC01 supports this idea. In Cook Islands area benthic front was not clearly observed on the temperature profile and the Antarctic Bottom Current was not confirmed.

(3) Water Depth and Depositional Environment

Water depth of the Niue area is as deep as more than 5,000m to 5,500m, and occurrence of microfossils suggests that the carbonate compensation depth (CCD) is about 4,800m to 5,000m deep. On the other hand, in almost of the Cook Islands area water depth is deeper than 5,000m and the depth increases toward west, reaching the maximum of 5,400m, but CCD in the area was assumed to be 5,050m deep, about the same depth with the Niue area. From the comparison of chemical composition of bottom sediments, the sediments of the Niue area are characterized by comparatively rich amount of volcaniclastic grains.

Biologic productivity of both area does not show big difference, and from the view point of the existence of the Antarctic Bottom Current, the Niue area is more preferable site for high abundance of manganese nodules rather than the Cook Islands area, however the fact is adverse. Among above stated particular conditions for the developments of manganese nodule, difference of depositional environment seems the most important factor for the occurrence of manganese nodules. The depositional environment of the Niue area, including comparatively rich amount of volcaniclastic materials, does not support an existence of clear hiatus, which is necessary for growth of manganese nodule. Contrary to this, in the Cook Islands area, seafloor topography shows many ups and downs (micro topography is well preserved without sedimentation), suggesting existence of hiatus.