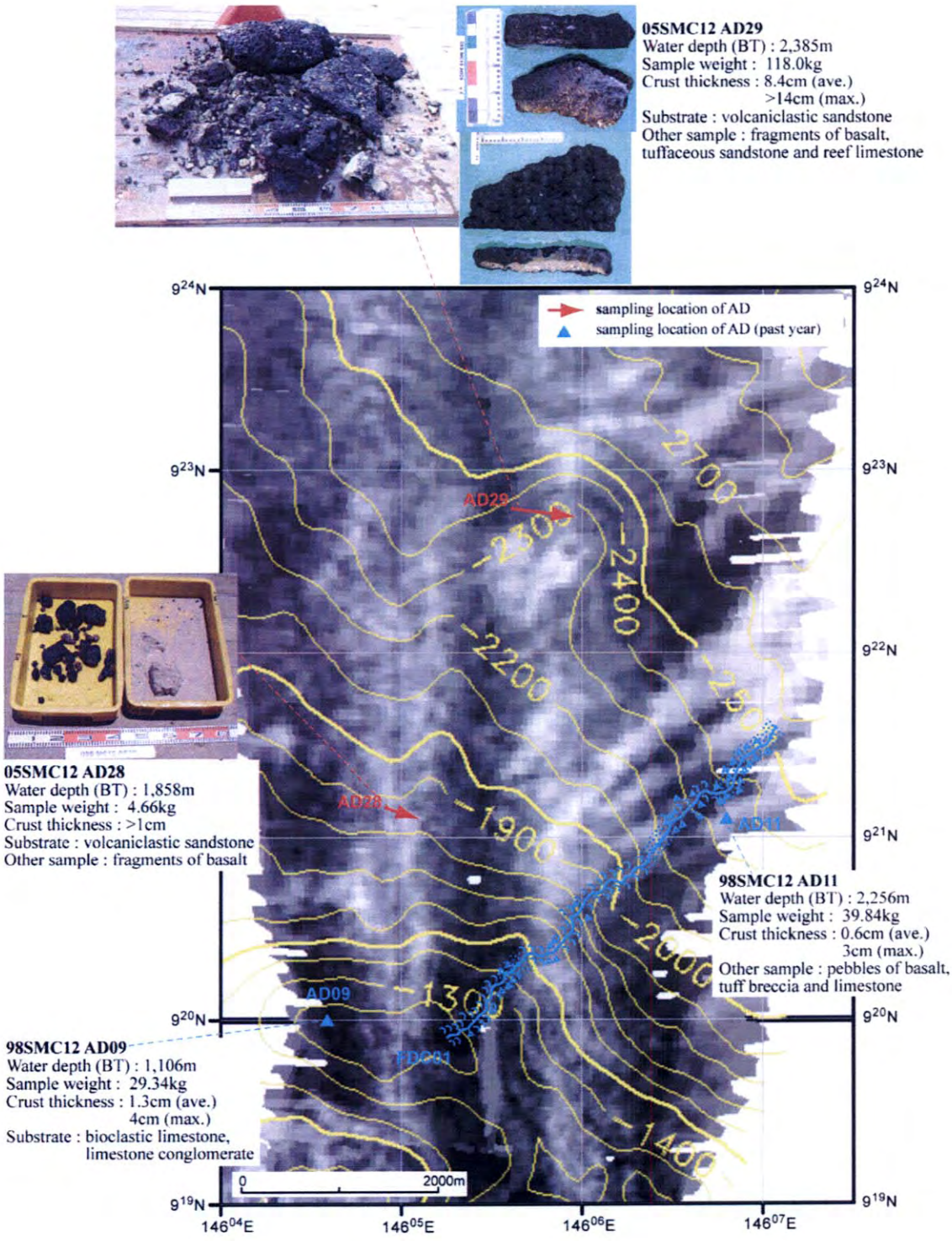


Figure 3-1-6 Acoustic Reflection Intensity and Photograph of Samples (05SMC12AD28-AD29)

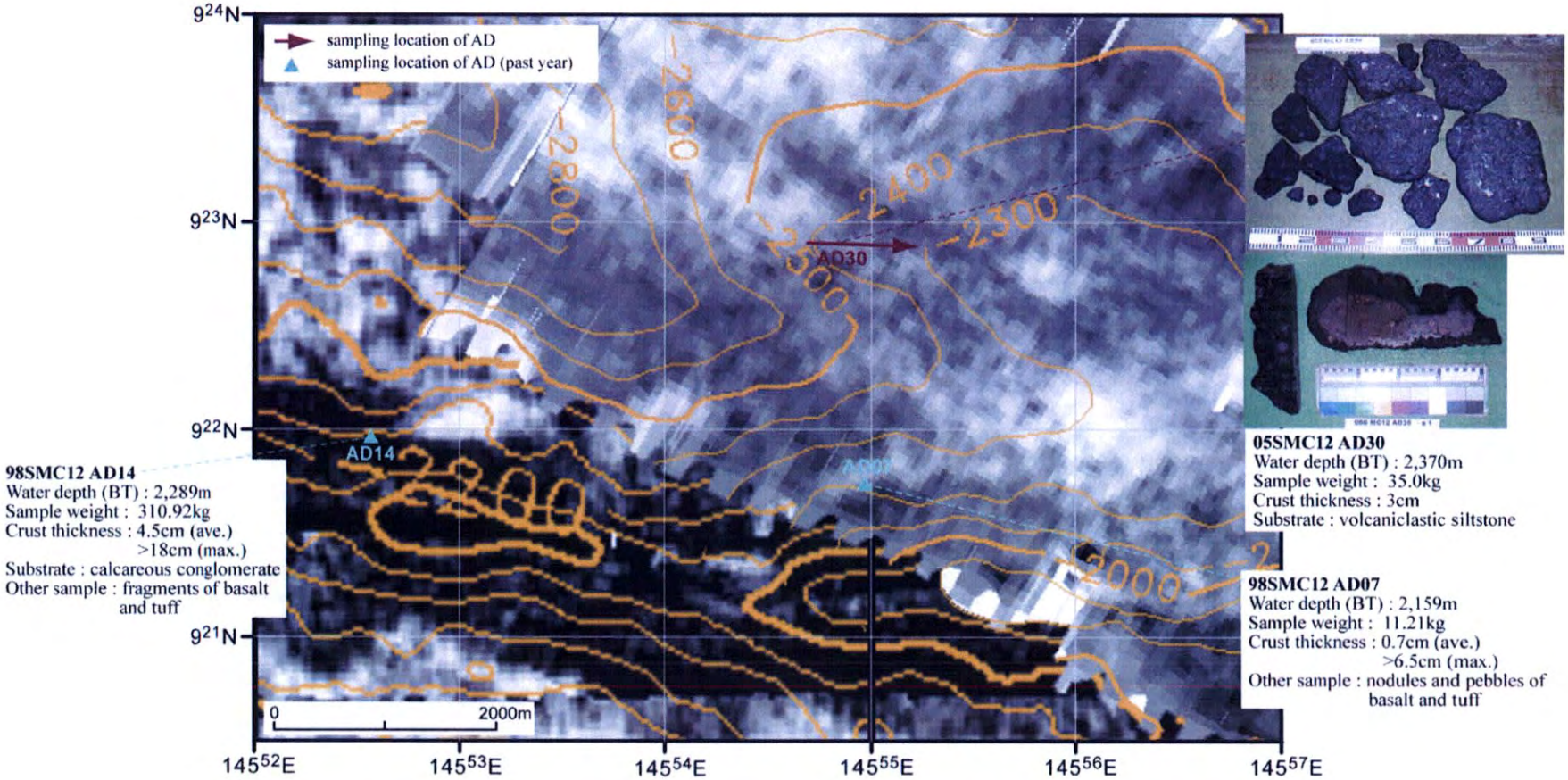


Figure 3-1-7 Acoustic Reflection Intensity and Photograph of Samples (05SMC12AD30)

(2) AD Sampling

The 16 sites of AD sampling with variable topographic natures and depths in Seamount MC12 were decided within the area of high reflection intensity considering results of FDC survey of this year and AD sampling of previous year (Figure 3-1-1).

From the results of AD sampling, the following sites are summarized concerning occurrences of manganese crust in the east-west trending seamount.

1) The samples collected by AD sampling are similar to and not so much different from what has been expected by seafloor observation by FDC. Consequently, based on the information of seafloor observation, it was possible to collect samples by AD corresponding to various aspects of topography and of bedrock of the seafloor.
2) Comparison of the samples collected on the north and south slopes of east-west trending ridge shows that manganese crust on the south slope is less aboundant than that on the north slope. The manganese crusts of the south slope are mostly thin and more or less coating on the surface of the bedrock. While, the manganese crust of the northern slope is thick and becomes thicker with increase of water depth in accordance with the results of the previous year.
3) In the area shallower than about 1,500m depth, the occurrences of manganese crust tend to be poor.

3-1-4 Laboratory Works

For understanding the nature of the bedrock, microscopic observation of thin section, whole rock chemical analyses, X-ray diffraction analyses and fossil studies were conducted. Chemical analyses, microscopic observation and X-ray diffraction analyses were conducted for roughly evaluating manganese crust resources (Table 2-1, detailed description in Appendix 5).

(1) Characteristics of Bedrock

The upper part of Seamount MC12 basically consists of limestone and the lower part consists of volcanic rocks and they are covered by unconsolidated sediments.

The results of microscopic observation (four samples), whole rock chemical analyses (four samples), X-ray diffraction analyses (two samples) of the volcanic rocks showed that the volcanic rocks are slightly altered phyric basalt classified into within- plate alkali basalt. The K-Ar dating conducted in previous year showed that the ages of these basaltic rocks were 71.1±3.6Ma.

The studies of microfossils (foraminifera and calcareous nannoplankton: six samples) and fossils (five samples) of the limestone revealed a mixed occurrences of Cretaceous,

Paleogene and Quaternary fossils suggesting possible resedimentation episode during the formation of these limestone. However, approximate ages of these samples are Eocene to Miocene.

Based on the microfossil studies (two samples) of unconsolidated sediments covering the bedrocks, these unconsolidated sediments were formed during Quaternary in the lower bathyal zone.

(2) Characteristics of Manganese Crust

The manganese crust shows massive to spotted and colloform textures based on microscopic observation of polished section. Fragments of rocks and minerals less than 0.03mm across tend to increase toward lower part of manganese crust.

X-ray diffraction studies of manganese crust (five samples) shows that the main constituent of manganese crust is vernadite (δ –MnO_2) of hydrogenetic origin. The hydrogenetic nature of manganese crust are also observed in results of chemical analyses plotted on cation ratios of (Cu+Ni)x10-Fe-Mn and chondrite REE normalized pattern.

(3) Thickness and Grade of Manganese Crust

Chemical analyses of 32 elements are conducted for manganese crust collected by AD sampling. Among these elements, Co, Ni and Pt are chosen as key elements for considering the potentiality of manganese crust resources.

When more than one analytical results were obtained at one AD sampling site, the chemical composition of each AD sampling site was calculated by weighted average using thickness of manganese crust. The average thickness and grade of manganese crust at each sampling site of this year and previous year are shown in Table 3-1 and Figure 3-1-1.

3-1-5 Discussion

(1) Diversity of Manganese Crust

1) Distribution and Thickness of Manganese Crust

The AD sampling of this year was conducted along and near FDC line based on the information of seafloor observation.

The FDC02 line runs along ridge with high acoustic reflection intensity. The occurrence of manganese crust shallower than 1,562m depth (AD20) is less than 1cm thick. Deeper than this point, manganese crust increase its thickness with increase of depth, such as 4.0cm thick at 1,772m depth (AD17), 4.9cm thick at 1,873m depth

(AD19), 9.1cm thick at 2,004m depth (AD16), reaching the maximum of 10.4cm at 2,437m depth (AD15).

Along the FDC03 line in the valley, on the other hand, even in the area of high reflection intensity, talus deposits and unconsolidated sediments filling the open spaces of talus deposits are observed and the occurrences of bedrock covered by manganese crust are rare.

Summarizing the 30 sites, 14 sites of previous year and 16 sites of this year, of AD sampling, the thickness of manganese crust varies from 10.4cm at maximum (AD15) to thin film of coating. The manganese crusts of less than 1cm thick is obtained at 17 sites and that most of which are located either shallower than 1,500m depth or on the south facing slope of Seamount MC12. While on the north slope of the seamount, relatively thick (more than 3cm) manganese crust is obtained at most of the AD sampling sites.

Preferable locations of thick manganese crust are the north facing slope of 1,500m to 2,400m depth, and ridge topography is also considered to be preferable factor development for thick manganese crust.

2) Ore Grade of Manganese Crust

The statistical analyses of three key elements (Co, Ni and Pt) were carried out for 13 sites of AD sampling which thickness of manganese crust is greater than 1cm thick (Table 3-1).

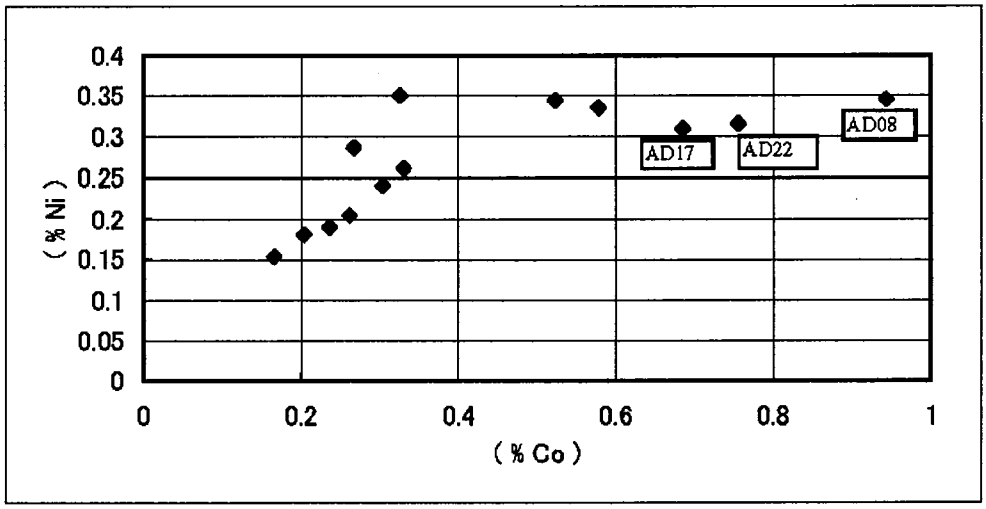
As shown in scattered diagram of correlation (Figure 3-1-3), correlation between two elements shows good positive relation. Pt enrichment feature at three sampling sites (AD08, AD17 and AD22) is observed. These three AD sites are located within a narrow range of 1,736 to 1,822m depth.

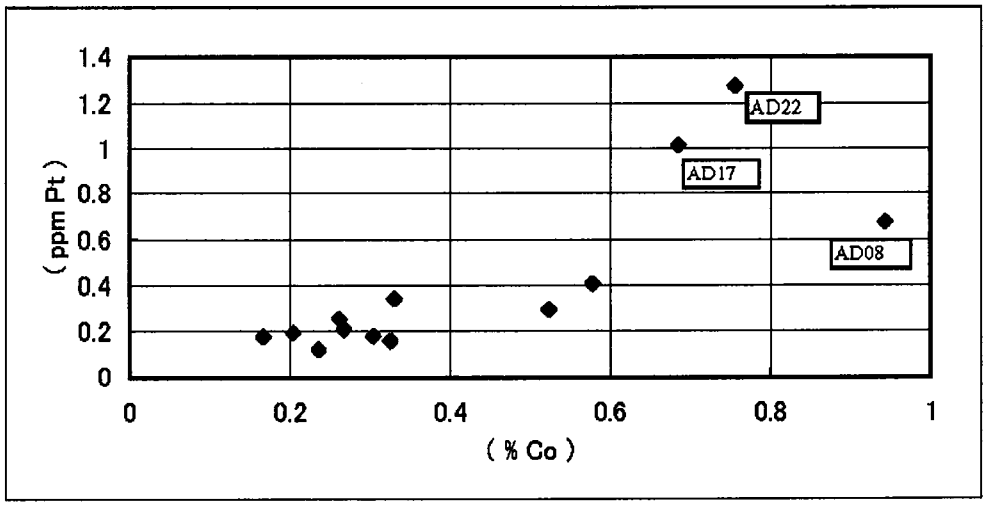
As for the relation between grade and thickness of manganese crust, the manganese crusts more than 6cm thick are generally lower in three key elements of Co, Ni and Pt compared with those being less than 6cm thick. The statistics of Co, Ni and Pt elements are clarified that these three elements show positive correlation relation, Pt is possibly enriched in the manganese crust of around 1,800m depth, and thicker manganese crusts are relatively lower grade in these elements.

Table 3-1 Analytical Results of Manganese Crust of Seamount MC12

	Sampling No.	Sampling Water Depth (m)	Manganese Crust Type	Thickness min/max (cm)	Tickness Average (cm)	Substrate	Condition of Surface	Analyzed Sample Part	Co (%)	Ni (%)	Pt (ppm)
1	98SMC12AD03	1,903	cobble	0.1 / 15	9.3	limestone	botryoidal	bulk	0.27	0.29	0.21
2	98SMC12AD05	1,218	cobble	0.1 / 5	2.6	limestone	botryoidal	bulk	0.58	0.34	0.41
3	98SMC12AD06	2,474	crust	0.1 / 19	10.1	hyaloclastite	botryoidal	bulk	0.17	0.15	0.18
4	98SMC12AD08	1,736	crust	0.5 / 7	4.5	tuff	botryoidal	bulk	0.94	0.35	0.67
5	98SMC12AD09	1,106	cobble	0.1 / 4	1.3	reef limestone	smooth	bulk	0.52	0.34	0.30
6	98SMC12AD14	2,289	crust	1.2 / 18	4.5	-	botryoidal	bulk	0.26	0.20	0.25
7	05SMC12AD15	2,437	crust	7 / 14	10.4	volcaniclastic rock	botryoidal, coke-like	bulk	0.20	0.18	0.20
8	05SMC12AD16	2,004	crust	8 / 11	9.1	calcareous conglomerate	botryoidal	bulk	0.24	0.19	0.12
9	05SMC12AD17	1,772	fragment	4 / 4	4	-	coke-like	bulk	0.69	0.31	1.02
10	05SMC12AD19	1,873	crust	3 / 7	4.9	sandstone	botryoidal	bulk	0.30	0.24	0.18
11	05SMC12AD22	1,822	fragment	3.5 / 3.5	3.5	-	coke-like	bulk	0.76	0.32	1.28
12	05SMC12AD29	2,385	crust	3.5 / 14	8.4	calcareous sandstone	coke-like	bulk	0.33	0.26	0.34
13	05SMC12AD30	2,370	crust	2.5 / 3	3	siltstone	botryoidal	bulk	0.33	0.35	0.16
					1.1～10.4 (5.8)				0.35	0.24	0.33

The data of the crust being thicknesss more than 1 cm and cobalt grade more than 0.1% are listed.





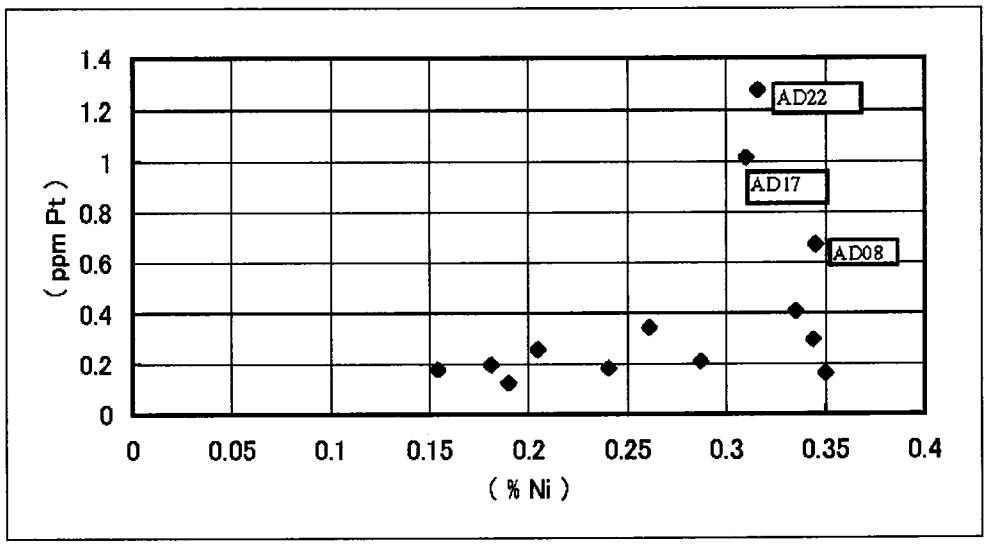


Figure 3-1-8 Distribution of Major Elements of Seamount MC12

(2) Roughly estimation of Manganese Crust Resources

According to the previous survey, Seamount MC12 is a ridge seamount with summit of 1,141m depth, extending 60km long in east-west direction with the maximum width of 20km. The area of high acoustic reflection intensity of seamount being shallower than about 2,500m depth is considered to be covered by manganese crust.

The systematic survey combining FDC seafloor observation and AD sampling of this year indicated the diversity of occurrences of manganese crust affected by the factors such as direction of slopes, water depth and then the manganese crust with constant thickness did not cover the whole area of high reflection intensity slope.

The occurrences of manganese crust differ according to location of slopes, such as topography of rising ridge or concaved valley. Relatively thick manganese crust tends to occur on the rising ridge. The thickness of manganese crust varies significantly from thin coating on the surface of bedrock to the maximum thickness of 10.4cm. The manganese crusts more than 1cm thick are considered to occur mainly in the area of north facing slope and their thickness seems to increase with water depth. The Pt enriched manganese crust tends to occur in the particular area of around 1,800m depth.

The 13 sites of AD sampling show the manganese crust more than 1cm thick. The average thickness of each site varies from 1.1cm to 10.4cm. The thickness weighted average grades of Seamount MC12 are 0.35%Co, 0.24%Ni and 0.33ppmPt. These manganese crusts are roughly distributed in the area of about 100 km^2 of ridge topography on the north facing slope about 1,500m to 2,500m depth.

Seamount MC12 is huge in size, hence a vast amount of resources of manganese crust is expected. However, due to the diversity of manganese crust distribution, more detailed survey is necessary for estimation of resources (Figure 3-1-9).

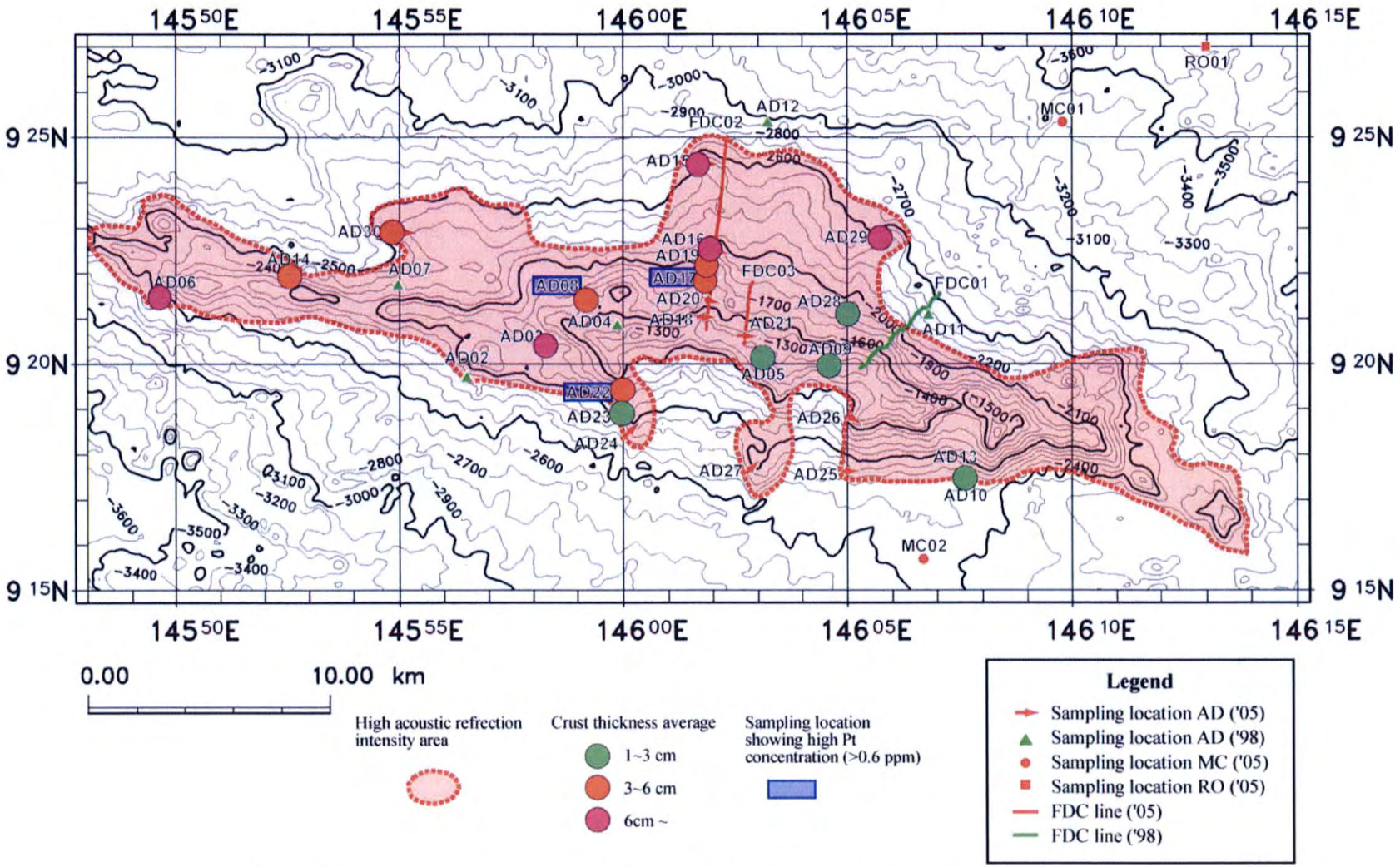


Figure 3-1-9 Compilation of Survey Results of Seamount MC12

3-2 Seamount MC13

3-2-1 Outline of Seamount MC13

Seamount MC13 with small flat summit of 1,656m depth rises 2,200m high from the 4,000m deep sea plateau locating in the area of 45km in east-west and 45km in north-south. Reef limestone occurs in the summit area. Steep slopes similar to fault scarp are observed in northeastern edge of the seamount

3-2-2 Survey Results of Previous Years

In the previous survey in 1998, bathymetric survey by MBES, seafloor observation by FDC and samplings by AD, CB and LC were conducted at Seamount MC13 (Table 4-1).

The bathymetric survey showed the area of high acoustic reflection intensity in the summit and its marginal area shallower than 2,500m depth. Manganese crust was collected by AD and CB in the areas. The thicknesses of manganese crust are a few cm on the summit and 8cm in eastern part of the summit. Fragments of manganese crust 10 to 14cm across were collected on the north and east slopes of the summit area. The average grade of 0.37%Co, 0.29%Ni and 0.22ppmPt were obtained from the five samples of seamount MC13. Substrates of the manganese crust were reef limestone, hyaloclastite and basalt.

3-2-3 Survey Results of This Year

Since priority of the survey in this year was given to Seamount MC12 due to better exposure of bedrock in Seamount MC12, the work of Seamount MC13 was limited to seafloor observation of one line by FDC and two sites of AD sampling. The seafloor observation by FDC was conducted to obtain the information about occurrence of manganese crust and characteristics of bedrock in the area more than 3,000m depth and AD sampling was conducted along the FDC line in previous survey (Table 1-1 and Figure 3-2-1).

(1) Seafloor Observation (Figure 3-2-1)

05MC13FDC02: from the foot of seamount at 3,120m depth downing to the abyssal area at 3,880m depth, 1.4nm long

From 3,120m to 3,140m depth, flat area totally covered by unconsolidated sediments was observed. A slope started approximately at 3,140m depth and the bedrock appeared to be covered by manganese crust with botryoidal surface occured at average outcrop rate of 50% until 3,170m depth.

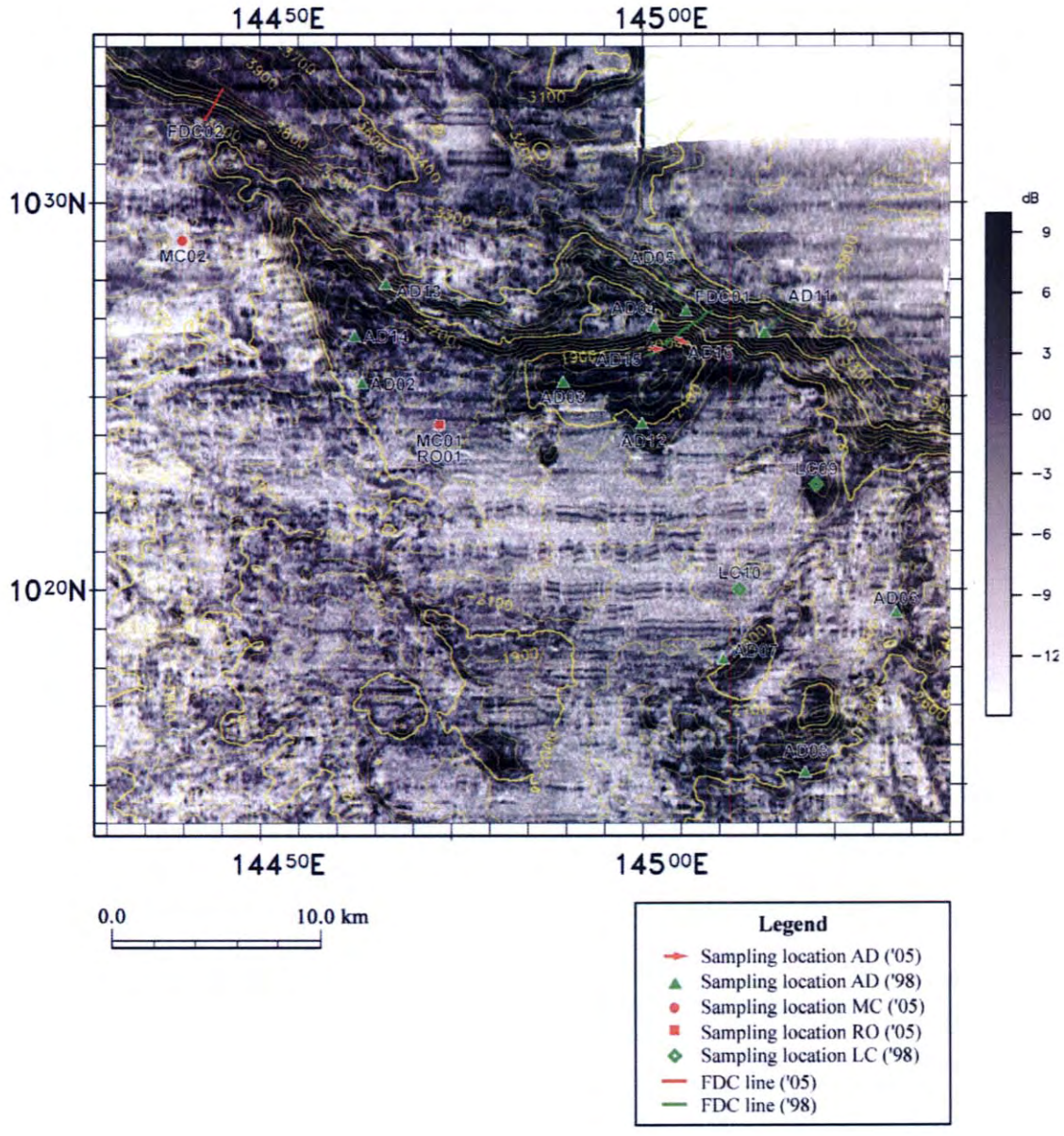


Figure 3-2-1 Bathymetric Map、Acoustic Reflection Intensity Distribution and Location Map of Sampling Sites (Seamount MC13)

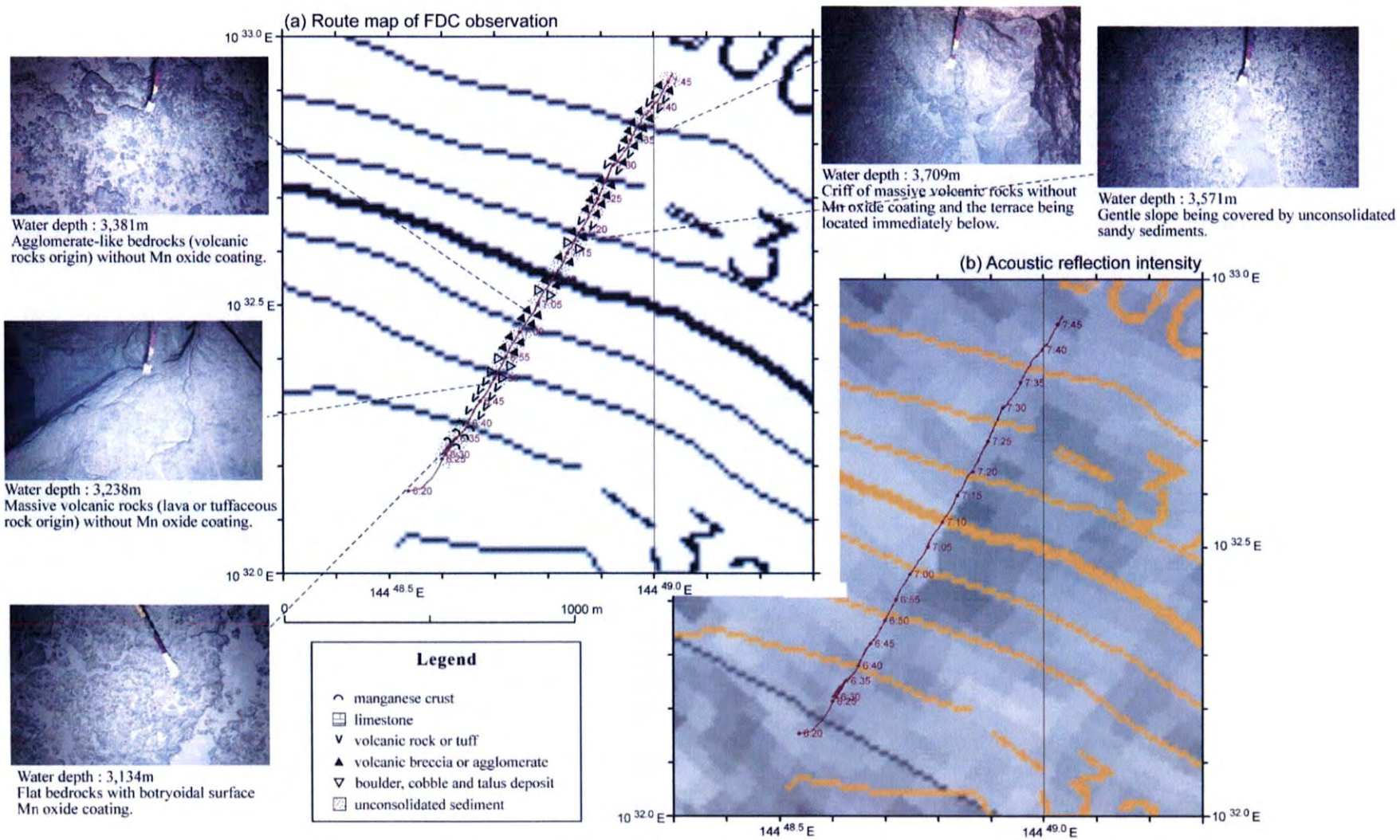


Figure 3-2-2 Seafloor Aspect and Acoustic Reflection Intensity (05SMC13FDC02)

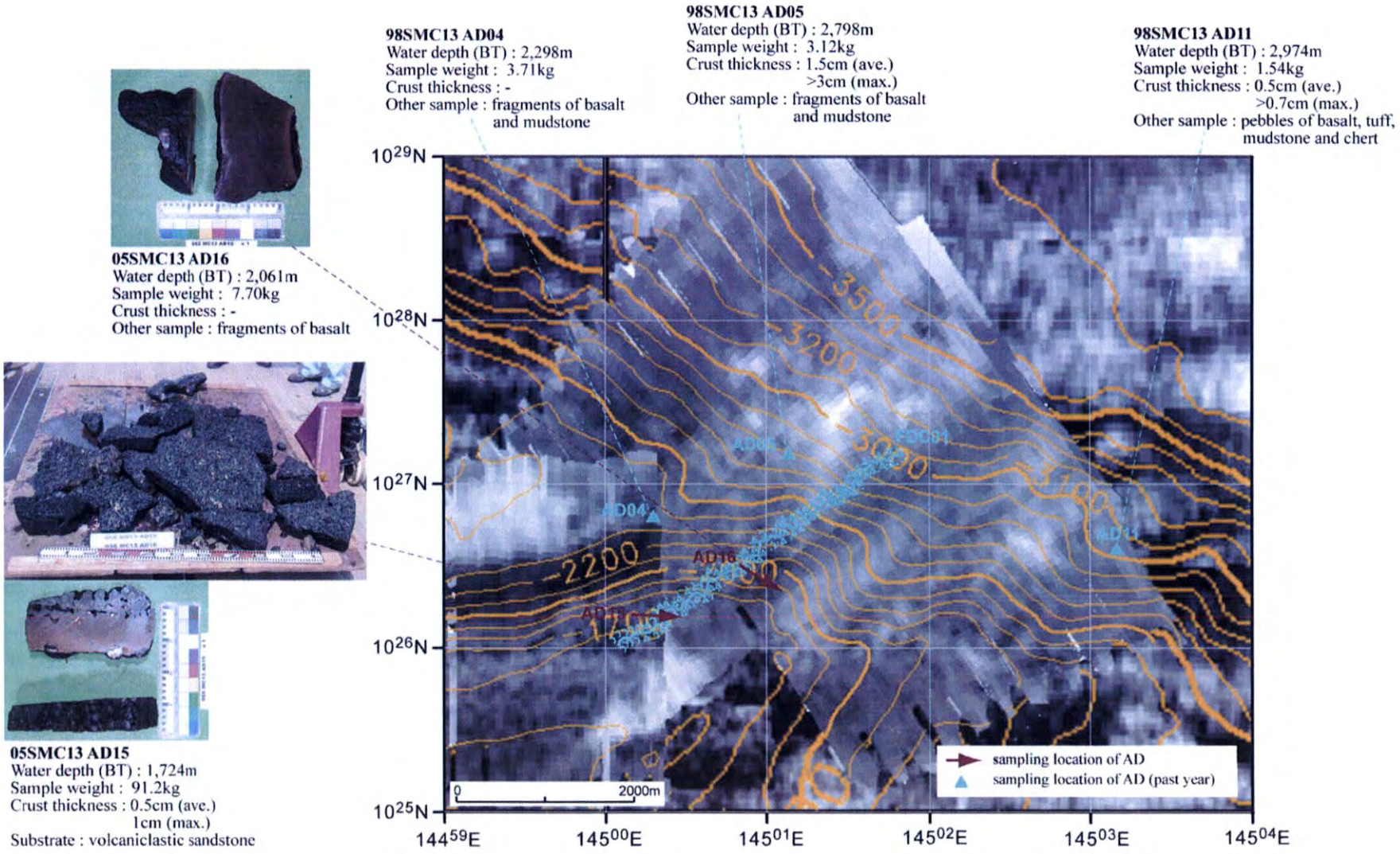


Figure 3-2-3 Acoustic Reflection Intensity and Photograph of Samples (05SMC13AD15-AD16)

From 3,170m to 3,880m depth, set of steep cliffs and flat is observed repeatedly on the slope. The flats are covered by unconsolidated sediments. Some of the cliffs show gentle slope being occupied by talus deposits consisting of volcanic breccia and agglomerate. Because of the unconsolidated sediments covering the flats, the average outcrop rate is 50%. A lack of botryoidal texture on the surface of pyroclastic rocks, manganese crust seems to be not distributed in this area. A flat area entirely covered by unconsolidated sediments starts from 3,880m depth.

(2) Results of AD Sampling

The AD sampling was conducted at two sites according to the results of seafloor observation in the previous survey. One site (AD15) was near the summit where manganese crust with botryoidal surface was observed by seafloor observation and the other site (AD16) was just below AD15 where talus deposits occurred (Figure 3-2-1).

3-2-4 Laboratory Works

Microscopic observation of thin section, whole rock chemical analyses, X-ray diffraction analyses and fossil studies were conducted for understanding the nature of the bedrock. Manganese crust samples were assayed for roughly evaluating manganese crust resources (Table 2-1, detailed description in Appendix 5).

3-2-5 Discussion

(1) Characteristics of Bedrock

Upper part of Seamount MC13 consists of limestone and the lower part consists of volcanic rocks. They are covered by unconsolidated sediments from one locality to another.

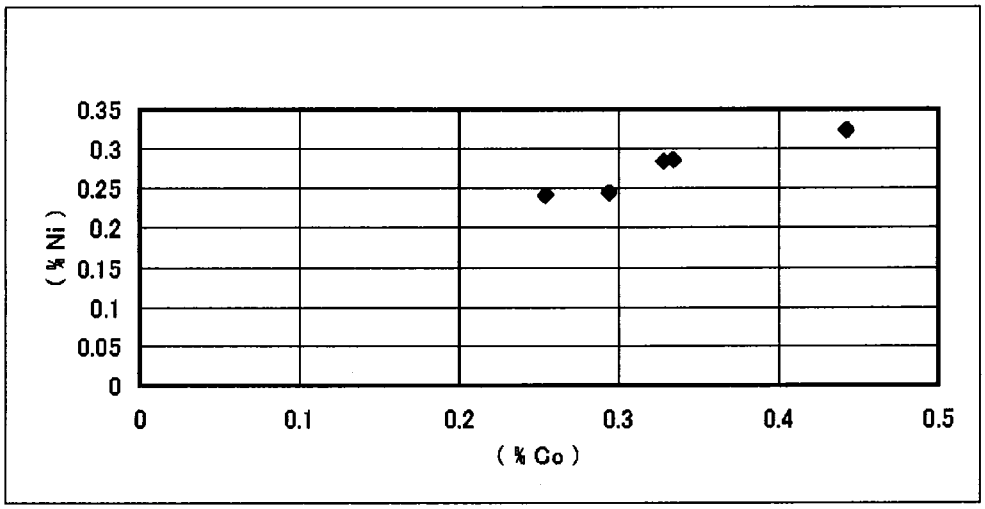
The results of microscopic observation and whole rock chemical analyses of the volcanic rock revealed that the volcanic rock is relatively fresh clinopyroxene basalt showing chemical nature similar to oceanic island basalt of tholeiitic nature. The K-Ar dating conducted in previous year showed that the ages of these basaltic rocks were and 56.8±2.8Ma.

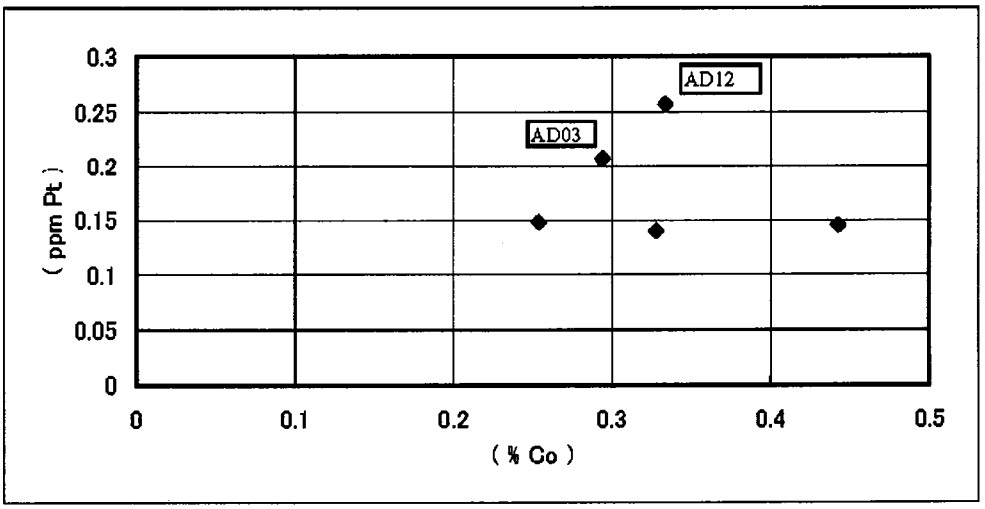
The studies of microfossils (foraminifera and calcareous nannoplankton) and fossils of the limestone suggest that the geological age of the limestone is Eocene. Based on the microfossil studies of unconsolidated sediments covering the bedrocks, these sediments were formed during late Pliocene to Quaternary in the lower bathyal zone.

Table 3-2 Analytical Results of Manganese Crust of Seamount MC13

	Sampling No.	Sampling Water Depth (m)	Manganese Crust Type	Thickness min/max (cm)	Tickness Average (cm)	Substrate	Condition of Surface	Analyzed Sample Part	Co (%)	Ni (%)	Pt (ppm)
1	98SMC13AD02	2,299	crust	0.1 / 2.5	1.1	mudstone	botryoidal	bulk	0.25	0.24	0.15
2	98SMC13AD03	1,750	cobble	<0.01 / 12	6	phosphorite	botryoidal	bulk	0.29	0.24	0.21
3	98SMC13AD06	2,347	cobble	<0.01 / 10.5	5	limestone	granule	bulk	0.44	0.32	0.15
4	98SMC13AD07	2,043	cobble	<0.01 / 10	3.2	limestone	botryoidal	bulk	0.33	0.28	0.14
5	98SMC13AD12	1,975	cobble	<0.01 / 14	4	-	granule	bulk	0.33	0.29	0.26
					1.1~6.0 (3.9)				0.34	0.28	0.19

The data of the crust being thicknesss more than 1cm and cobalt grade more than 0.1% are listed.





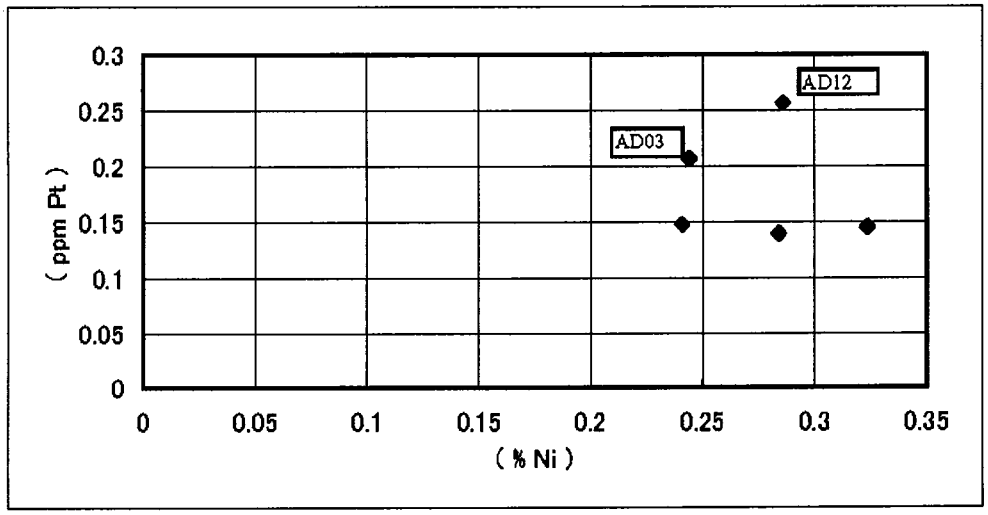


Figure 3-2-4 Distribution of Major Elements of Seamount MC13

(2) Characteristics of Manganese Crust

Considering the characteristics of manganese crust at 16 sites of AD sampling in Seamount MC13 (two sites in this year and 14 sites in previous survey), the thickness of manganese crust varies from thin coating to 6.0cm thick (AD03). Most of those did not reach to 1cm thick. The five sampling sites in the flat summit of 1,656m depth were sampled manganese crust more than 1cm thick.

The analytical results of Co, Ni and Pt elements of the manganese crust with more than 1cm thick at five AD sites show similar nature to those of Seamount MC12 (Table 3-2). The three key elements show positive correlation. Pt enrichment feature at two sampling site (AD03 and AD12) is observed. These two sites are located in 1,750m and 1,975m depths respectively (Figure 3-2-3).

(3) Roughly estimation of Manganese Crust Resources

The flat summit area of Seamount MC13 and its surrounding area are consider to be potential areas of about 70 km^2 for manganese crust. Based on five AD sampling sites with the manganese crust more than 1cm thick, the average thickness of each site varies from 1.1cm to 6.0cm thick and the thickness weighted average grades of Seamount MC13 are 0.34%Co, 0.28%Ni and 0.19ppmPt.

Seamount MC13 is huge in size, hence a vast amount of resources of manganese crust is expected. However due to the diversity of manganese crust distribution, more detailed survey is necessary for estimation of resources (Figure 3-2-4).

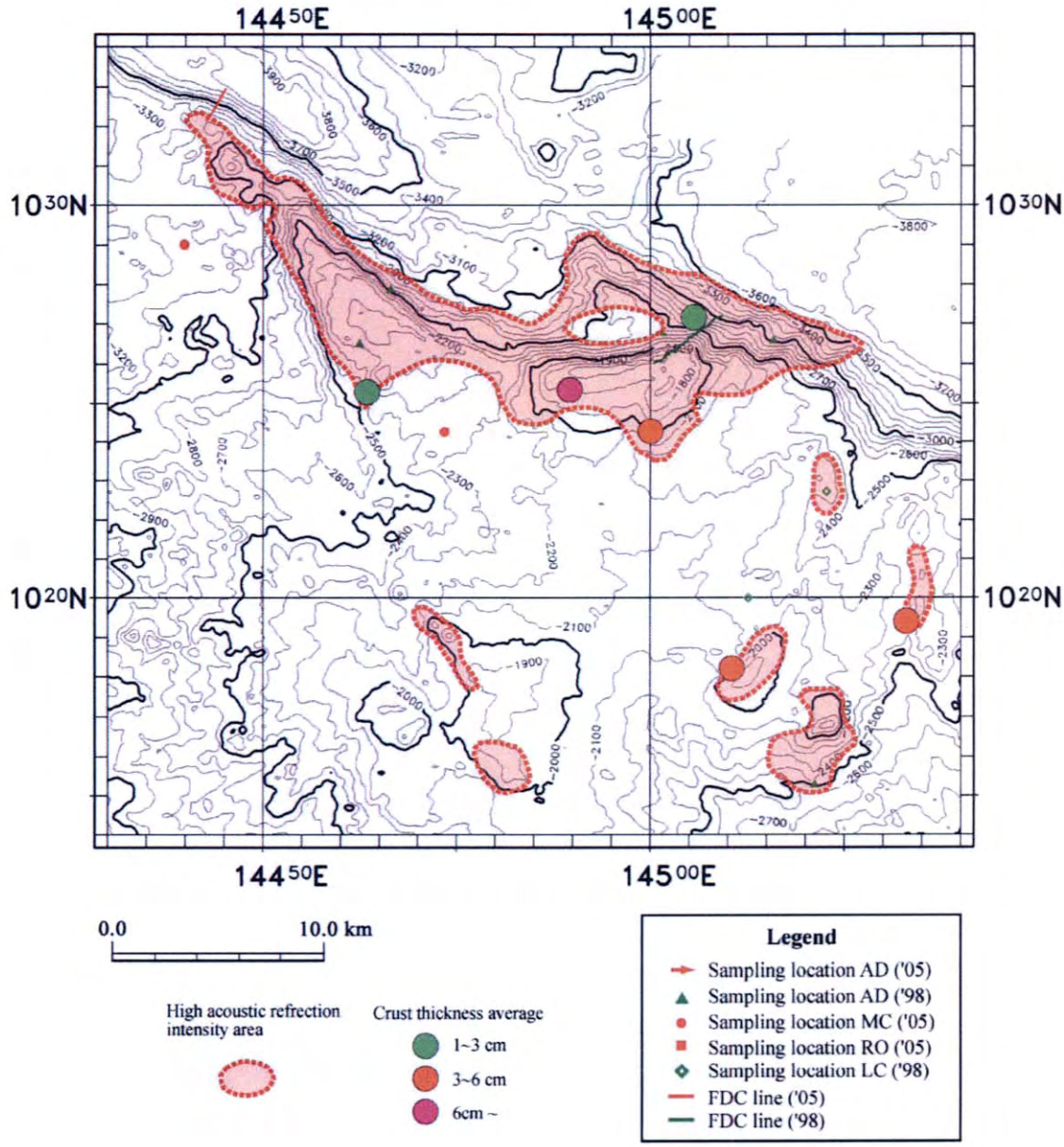


Figure 3-2-5 Compilation of Survey Results of Seamount MC13

3-3 Environmental Survey

3-3-1 Survey Results

In the water quality and bacterioplankton survey, water temperature and salinity showed similar patterns of vertical distribution in both stations of MC12 and MC13. In these stations, formation of a mixed layer near 100m depth and a thermocline between 100m to 300m depth were observed. Moreover, very minimal change in the temperature and salinity were found from 300m depth and in deeper layers. As regards to the nutrients, PO_4-P and NO_3-N had similar pattern of vertical distribution in both stations. Concentrations of these nutrients were low from the surface to 100m and increasing deeper to 500m and became almost stable from thereon toward the deeper layers. As regards to SiO_2-Si, its vertical distribution was similar with that of PO_4-P and NO_3-N except that maximum concentration of SiO_2-Si was observed at 1,000m depth. The vertical distribution of bacterioplankton was analogous to that of water temperature wherein decreasing values were observed from 100m depth toward 300m depth and becoming stable more than 300m depth.

Vertical distributions of TOC and T-N were similar between stations 05SMC12MC01 and 05SMC12MC02. Similar patterns were also observed between stations 05SMC13MC01 and 05SMC13MC02 except that TOC and T-N concentrations in the upper layer were lower at 05SMC13MC01 compared with 05SMC13MC02. Station 05SMC13MC01 also showed the lowest water content in all layers compared with other stations. Sedimentary bacteria in station 05SMC13MC01 were remarkably more abundant than the other stations. However, meio- and macro-benthos showed the lowest abundance in this station.

3-3-2 Discussion

Based from the survey on water quality and bacterioplankton, the vertical profile of bacterioplankton abundance was analogous to that of water temperature in both stations. Based from all these results, both stations have similar water column characteristics and maybe thought of as stable environments.

05SMC13MC01 differed from other stations in terms of TOC, T-N and water content. Analysis of the sediments showed that 05SMC13MC01 hosts a large number of sedimentary bacteria but had low abundance of both meio- and macro-benthos. This inverse relationship between the bacteria and abundance of benthic organisms could probably imply that there was a lesser grazing impact on the sedimentary bacteria due to the very low abundance of meiobenthos, thus paving way for the bacteria to increase its population.

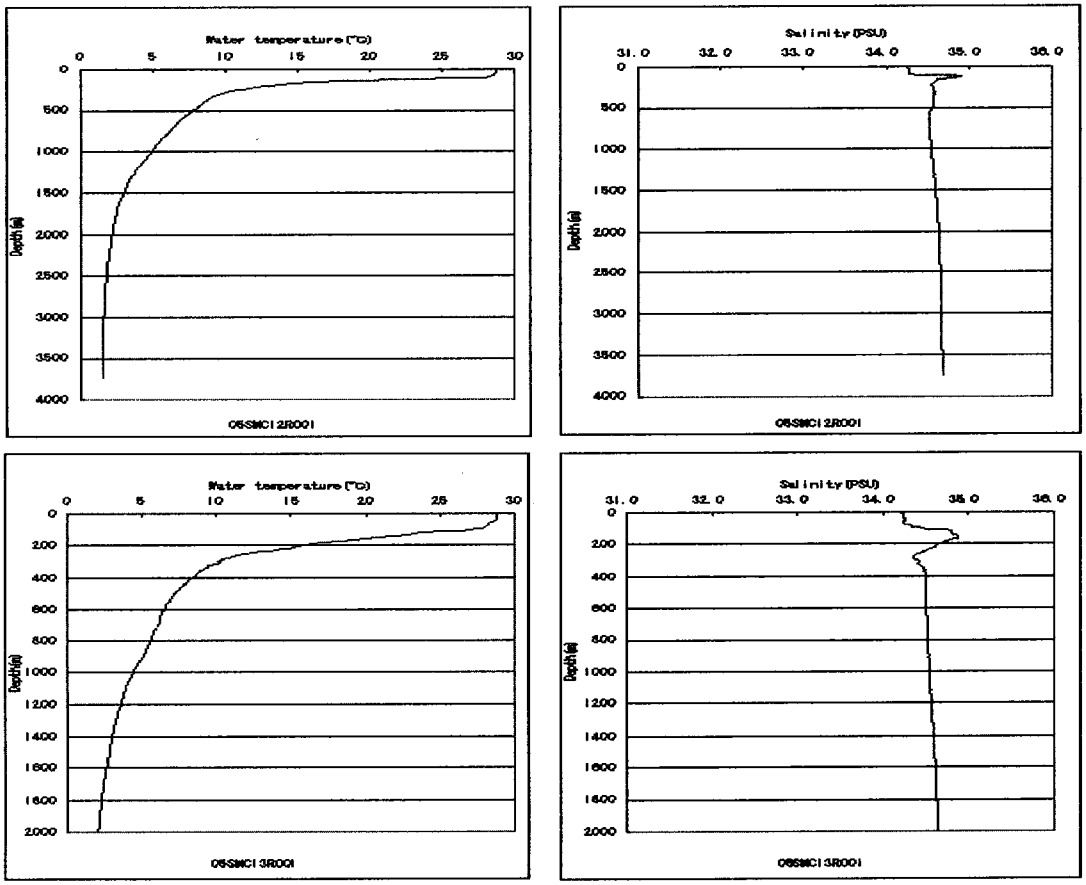


Figure 3－3－1 Vertical Profile of Water Temperature and Salinity

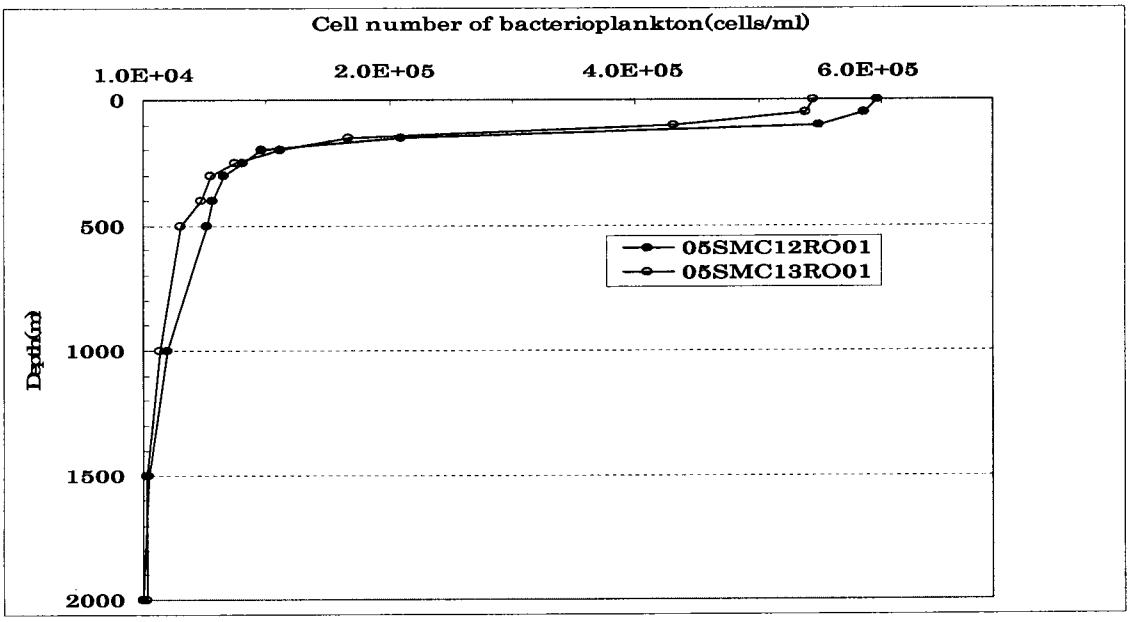


Figure 3－3－2 Vertical Profile of Bacterioplankton

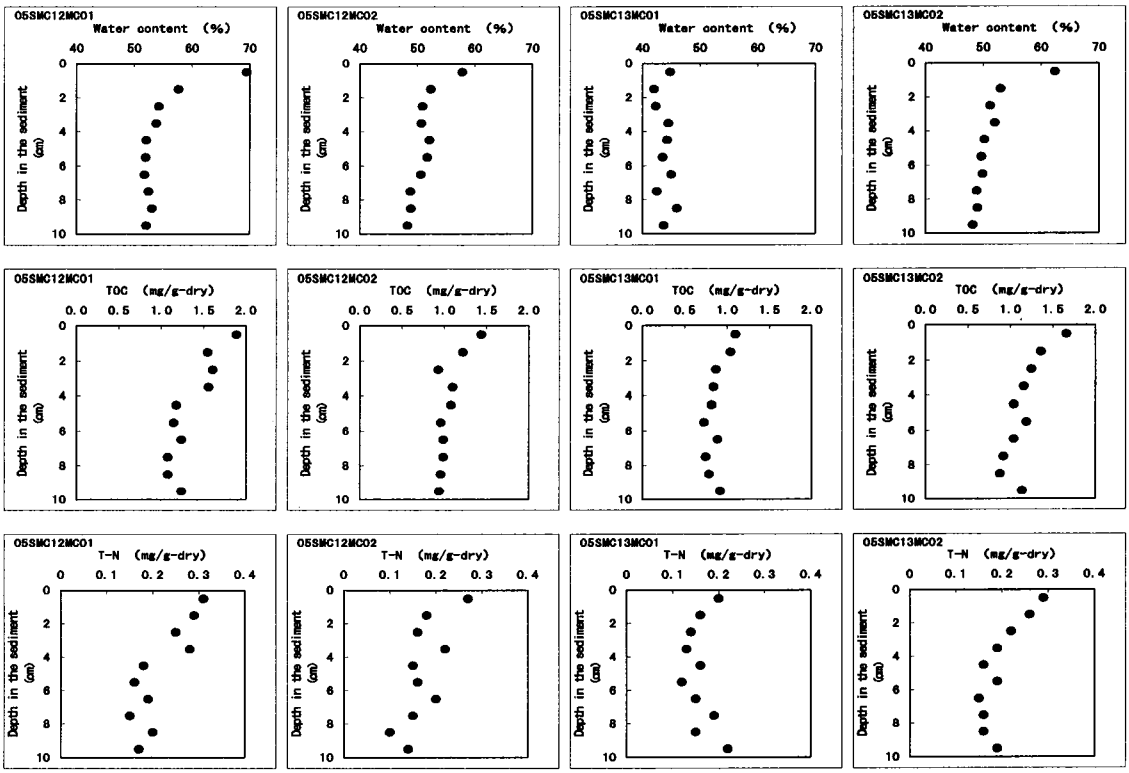


Figure 3－3－3 Vertical Profiles of Sediment Properties

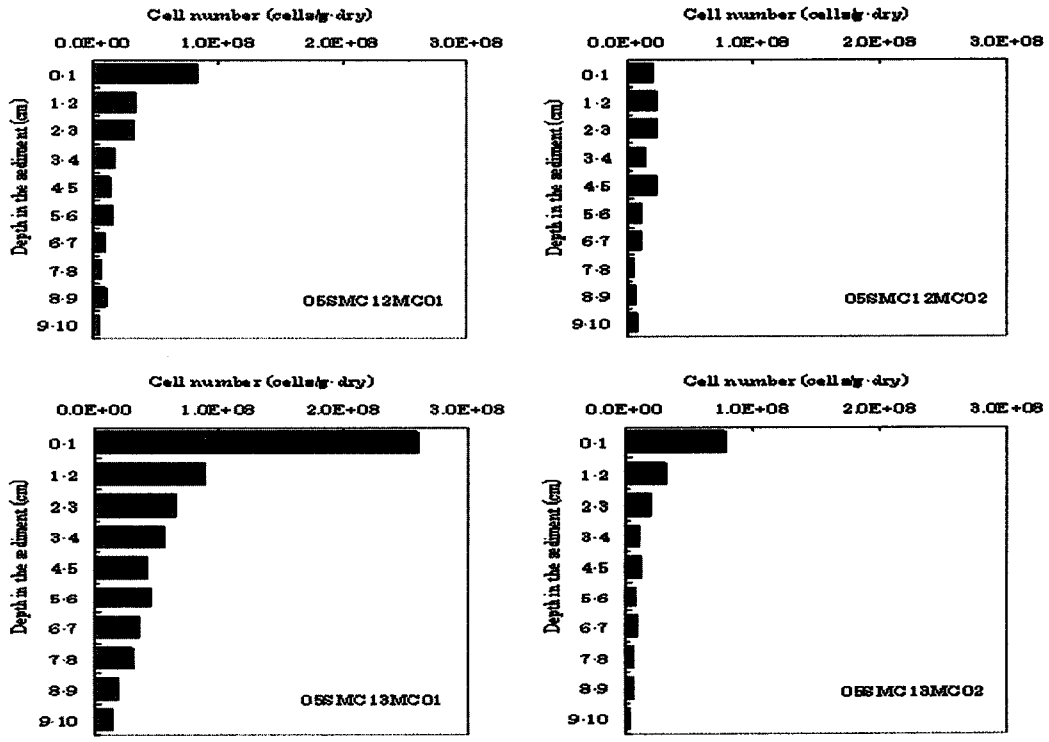


Figure 3－3－4 Vertical Profiles of Sedimentary Bacteria

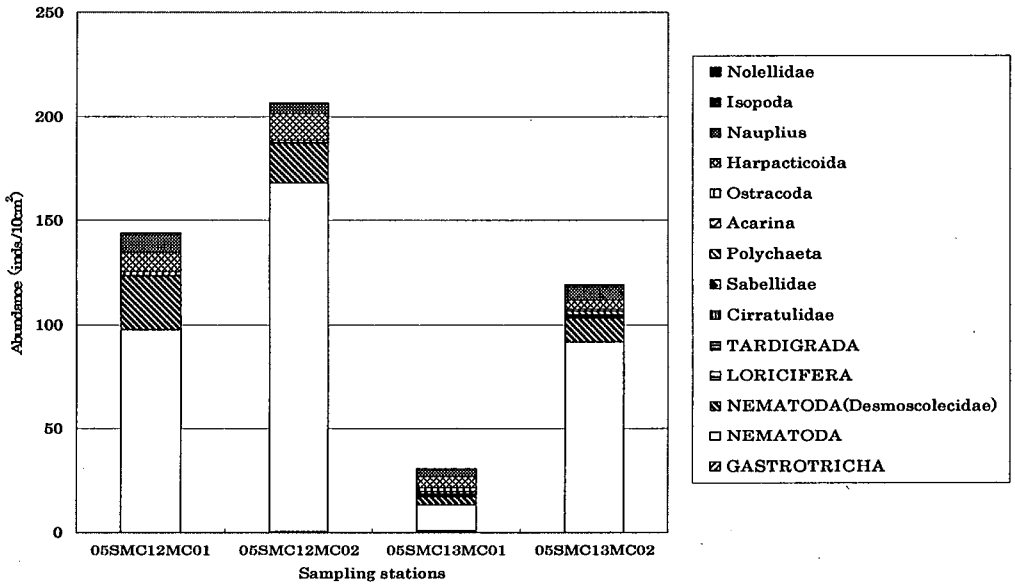


Figure 3－3－5 Abundances of Meiobentos at Each Station

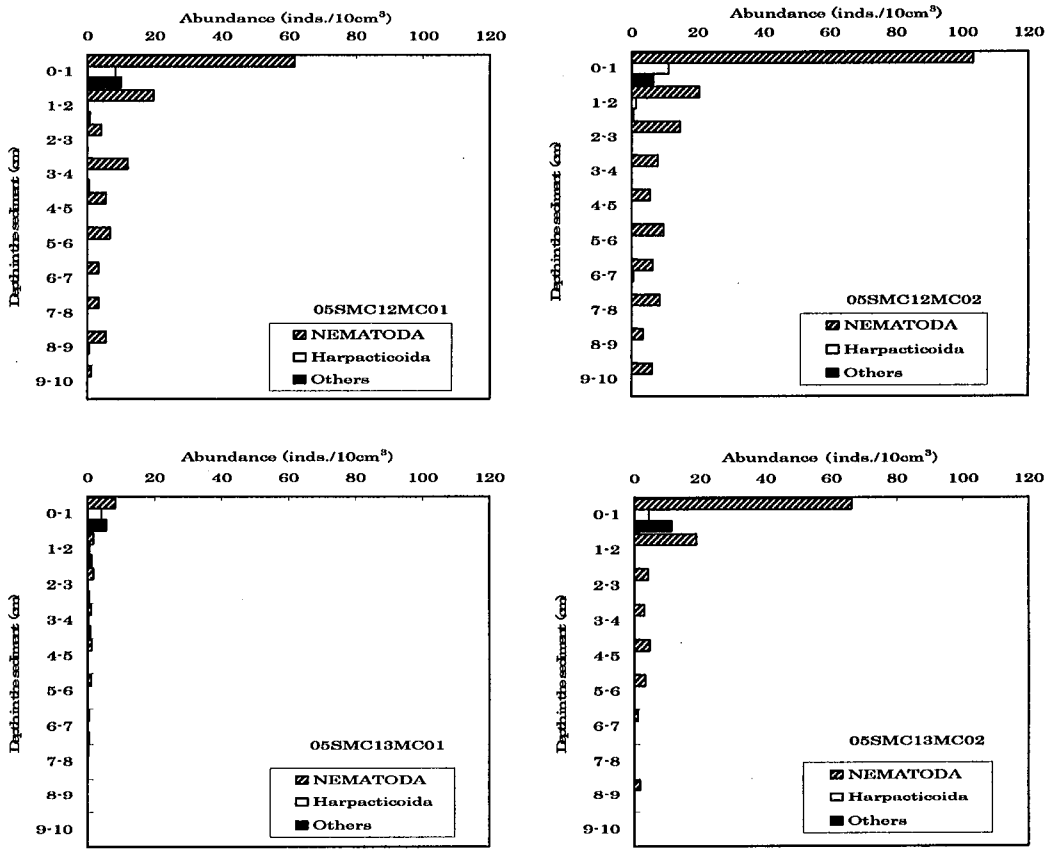


Figure 3－3－6 Vertical Profiles of Meiobentos at Each Station

(Abundance of 「Nematoda」 in figure is the sum of that of 「Nematoda」 and 「Nematoda(Desmoscolecidae) in Table 4-3-1, Appendix 6)

Chapter 4 Conclusions

4-1 Manganese Crust

4-1-1 Seamount MC12

Seamount MC12 is a ridge shape seamount with summit of 1,141m depth extending 60km east-west with 20 km maximum width. The area of shallower than 2,500m depth of the seamount is the area of the extensively high acoustic reflection intensity. The surveys of this year conducted to understand a nature of manganese crust in the high acoustic reflection area. As the result of the survey, manganese crust of constant thickness does not occur entirely the survey area. Rather, diversity of occurrences affected by factors such as direction of slope and water depth was observed.

Among a total of 30 AD sampling sites, 13 AD sampling sites showed development of manganese crust more than 1cm thick. The average thickness of each site varies from 1.1cm to 10.4cm thick and the thickness weighted average grades are 0.35%Co, 0.24%Ni and 0.33ppmPt. These manganese crusts are mainly distributed in the area of ridge topography on the north facing slope at 1,500m to 2,500m depth. Pt enriched manganese crust seem to occur at around 1,800m depth.

Seamount MC12 is a huge in size, hence a vast amount of manganese crust is expected. However, due to the diversity of manganese crust distribution, more detailed survey is necessary for estimation of resources.

4-1-2 Seamount MC13.

Seamount MC13 is the seamount with flat summit of 1,656m depth. Among the total of 16 sampling sites, five AD sampling sites showed the manganese crust more than 1cm thick. The average thickness of each site varies from 1.1cm to 6.0cm thick and the thickness weighted average grades are 0.34%Co, 0.28%Ni and 0.19ppmPt. Seamount MC13 is a huge in size, hence a vast amount of manganese crusts are expected. However, due to the density f manganese crust distribution, more detailed survey is necessary for estimation of resources.

4-1-3 Exploration of Manganese Crust on the Slope of Seamount

Although manganese crust was found on slopes of seamount by the survey, the distribution of manganese crust had not been fully understood, because its occurrences seemed to be complicatedly affected by factors such as natures of the slopes of seamount and water depth.

For planning an efficient AD sampling, the seafloor observation by FDC based on the

acoustic sounding map of the previous year was conducted in the survey of this year for obtaining the information such as topographic natures of seamount slope, situation of bedrock exposure and occurrences of manganese crust respect to water depth prior to the AD sampling.

(1) Seafloor Observation by FDC

Total of three FDC track lines were conducted in the high reflection intensity area detected by the acoustic survey of previous year. Two FDC lines were set parallel on the north facing slope of Seamount MC12. One FDC line was set along ridge and the other was set along the valley. The another FDC line was set on the lower slope of Seamount MC13.

Even though a certain area is shown to be acoustically monotonous, the seafloor observation by FDC in the same area gives more detailed information concerning various features of the sea bottom beyond resolution limit (50m square at 1,500m depth) of MBES acoustic survey, consequently it enable to decide sampling location precisely.

1) Over the ridge, distribution of unconsolidated sediments is controlled by angles of slope. If it is steep, poor distribution of unconsolidated sediments promote growth of manganese crust.
2) In the valley, an abundant accumulation of talus deposits may sometimes be shown by high reflection intensity on the acoustic intensity map.
3) By direct observation of the bedrock, it is possible to acquire information of manganese crust occurrence that can not be expected from the acoustic and bathymetric maps.
4) Combining the information of seafloor observation such as topographic features and occurrences of manganese crust with bathymetric and acoustic reflection maps, it is possible to efficiently determine AD sampling site.
5) It was confirmed by the survey of this year that the distribution of manganese crust was almost restricted in the area shallower than 3,100m depth. It was possible to narrow down the target area based on seafloor observation together with bathymetric and acoustic reflection maps.

(2) AD Sampling

The AD sampling of Seamount MC12 and Seamount MC13 was conducted considering the results of seafloor observation.

In Seamount MC12, the AD sampling sites were selected within high reflection intensity area considering variable topographic natures by FDC observation results and water depths.

The following are summarized from the results of AD sampling in Seamount MC12.

1) The AD sampling based on the information of the seafloor observation showed that the samples collected by AD sampling are similar to what expected by seafloor observation by FDC. Consequently, AD sampling based on the information of seafloor observation is more accurate and efficient compared with the method based only on acoustic intensity and bathymetric maps.
2) Occurrences of manganese crust on the south slope is poorer compared to that on the north slope in accordance with the results of the previous survey. The manganese crust on the north slope becomes thicker with water depth. Thus, the occurrences of manganese crust are not uniform within the area of high acoustic reflection intensity. They show variable occurrences depending on location and water depth of slope.

In Seamount MC13, the samples reflecting the seafloor observation were collected by the AD sampling at two sites. The site (AD15) located near the summit collected manganese crust with botryoidal surface observed by seafloor observation. The other site(AD16) located at immediately beneath of the AD15 site collected talus deposits.

(3) Survey Method of Seamount Slope

The survey of this year conducted in Seamount MC12 and Seamount MC13 clarified that the distribution of manganese crust was explained not only by acoustic reflection and bathymetric maps but also factors such as the direction of slope and water depth. The manganese crust is considered to be not uniformly distributed within an entire area of high acoustic reflection intensity. Following systematic survey scheme is recommended.

1) Reconnaissance Survey
   Extracting areas of bedrock exposure shown by high acoustic reflection intensity (MBES)
   ----------Selecting the semi-detail survey area
2) Semi-detail Survey
   Recognizing the occurrences of manganese crust respect to characteristics of bedrock and small-scale topography (FDC and AD)
   ----------Extracting the area with well developed manganese crust
   Considering the following survey method
3) Detailed Survey
   Conducting sampling (AD) considering topographic features and occurrences of manganese crust
   ---------- Detailed survey of manganese crust distribution area

---------- Estimation of potentiality of resource and test sampling for future mining activities

4-1-4 Recommendation for Future Works

By the previous surveys in the Federated States of Micronesia, 13 areas were studied and among them two areas with the potential, Seamount MC12 and Seamount MC13, were surveyed in this year (Figure 1-1 and Table 4-1).

With in the EEZ of the Federated States of Micronesia, other than the 13 areas of already surveyed, many other seamounts are still left without detailed bathymetric and acoustic sounding surveys. In the future, the survey of these seamounts is recommended to be conducted following the survey scheme given above.

4-2 Environmental Survey

In the water quality and bacterioplankton investigation, water temperature and salinity showed similar patterns of vertical distribution in both seamounts. As regards to the nutrients, PO_4-P and NO_3-N had similar pattern of vertical distribution in both seamounts. As regards to SiO_2-Si, its vertical distribution was similar with that of PO_4-P and NO_3-N except that maximum concentration of SiO_2-Si was observed at 1,000m depth.

Based from all these results, both stations have similar water column characteristics and maybe thought of as stable environments.

Vertical distributions of TOC and T-N were similar between stations 05SMC12MC01 and 05SMC12MC02. Similar patterns were also observed between stations 05SMC13MC01 and 05SMC13MC02 except that TOC and T-N concentrations in the upper layer were lower at 05SMC13MC01 compared with 05SMC13MC02. Station 05SMC13MC01 also showed the lowest water content in all layers compared with other stations. Sedimentary bacteria in station 05SMC13MC01 were remarkably more abundant than those in the other stations. However, meio- and macro-benthos showed the lowest abundance in this station.

Based from the results of sediment properties and benthic organisms survey it may be assumed that benthic environment of station 05SMC13MC01 may be different from that of other station thus, a different population of benthic organism exist in this area.

Even though both stations 05SMC13MC01 and 05SMC13MC02 belong to Seamount MC13, their benthic environmental characteristics were different. These differences may be attributed to the ocean current and their respective topography.

Table 4-1 Survey Achievement of SOPAC Project (The Federated States of Micronesia)

Survey	Method	Unit	H9FY (1997)	H10FY (1998)	H17FY (2005)			Total
			MC01-10	MC02, MC11-	MC12	MC13	Sub-total	
Bathymetric Survey	NBS	nm	6,346.0	2,329.4	250.4	51.7	302.1	8,977.5
	SBP	nm	6,346.0	2,329.4	250.4	51.7	302.1	8,977.5
	MBES	nm	6,346.0	2,329.4	250.4	51.7	302.1	8,977.5
	SSS	nm	18.6	17.4	-	-	-	36.0
Temp. Depth	TD	Point	-	40	-	-	-	40
Conductivity, Temp	CTD	Point	8	4	4	3	7	19
Seafloor obervation	FDC	Line No.、nm	7, 32.40	10, 39.10	2, 10.93	1, 2.59	3, 13.52	20, 85.02
Sampling	LC	Point	24	9	-	-	-	33
	AD	Point	9	32	16	2	18	59
	CBD	Point	95	1	-	-	-	96
	RO	Point	-	-	1	1	2	2
	MC	Point	-	-	2	2	4	4
X-ray defferaction amalysis		No. of Spls	30	-	7	1	8	38
Obervation of thin section of ore		No. of Spls	3	7	12	-	12	19
Chemical analysis of ore		No. of Spls	163	69	32	1	33	265
Obervation of thin section		No. of Spls	52	-	4	2	6	58
Whole rock analysis		No. of Spls	19	4	4	1	5	28
Fossil determination of unconsolidated material		No. of Spls	32	1	2	2	4	37
Microfossil determination		No. of Spls	-	9	6	2	8	17
Fossil determination		No. of Spls	32	-	5	-	5	37
K-Ar age determination		No. of Spls	13	2	-	-	-	15
Be age determination		No. of Spls	3	-	-	-	-	3
C14 age determination		No. of Spls	-	2	-	-	-	2

Table 4-2 Summary of SOPAC Project (The Federated States of Micronesia)

No.	Area	Water depth of top (m)	Areal dimension (㎢)		Crust thickness (mm)		Average grade			Survey works				Remarks
			Summit	Slope	Average	Maximum	Co (%)	Ni (%)	Pt (ppm)	AD	CBD	LC	FDC	
1	MC01	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0	0	0	0	Selected by previous survey data, but it was not surveyed
2	MC02	1,080	1,134	2,257	21.0	50.0	0.35	0.33	0.50	1	2	4	0	Crust distribution is limited, but relatively thick.
3	MC03	510	625	7,051	8.0	47.0	0.48	0.36	0.33	4	8	4	1	Distribution of thick crusts is limited, but water depth is shallow.
4	MC04	100	0	3,798	1.0	20.0	0.47	0.32	0.23	0	18	3	1	Water depth is shallow, but crust is thin.
5	MC05	190	504	4,730	1.0	1.0	N.A.	N.A.	N.A.	0	8	1	0	Crust is not well developed.
6	MC06	740	0	1,496	3.0	20.0	0.47	0.36	0.28	0	8	0	0	Crusts is relatively thin, but Co, Ni grade are high, and water depth is shallow.
7	MC07	1,423	278	1,548	5.0	14.0	0.48	0.31	0.19	4	6	5	1	Crust develpoment was observed by FDC but it is not collected.
8	MC08	1,583	216	2,069	20.0	90.0	0.36	0.32	0.37	0	16	3	1	Co grade is low, but it is thick, seamount is large.
9	MC09	1,096	154	2,610	7.0	23.0	0.49	0.30	0.14	0	12	1	1	Seamount is in deep with rugged topography. Crust is relatively thin but Co grade is high.
10	MC10	1,442	1,401	4,523	20.0	155.0	0.33	0.30	0.27	0	17	3	1	Co and Ni grades are low, but crusts are thick. Exposure ratio is high. Seamount is large, thus resources are large.
11	MC11	1,777	94	1,716	36.1	55.0	0.61	0.43	0.26	5	0	1	1	Co and Ni grade are high. Thick crust is distributing.
12	MC12	1,141	35	1,866	40.0	190.0	0.38	0.27	0.27	13	0	1	1	Very thick crusts are distributing.
13	MC13	1,656	825	1,608	45.2	140.0	0.37	0.29	0.22	11	0	3	1	Very thick crusts are distributing.

(After JICA・MMAJ report in 1998 and 1999)

AD : Armed dradge CBD : Chain backed doredge LC : Large corer FDC : Finder-installed deep-sea camera

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