Chapter 3 Results of the Survey

3-1 Seafloor Topography

The Gilbert Islands is situated in the area from latitude 3°S to 3°N, longitude from 173°E to 177°E, and form a row of islands(seamounts group) consisting of 16 atolls, and they extend from the northernmost Makin Island to the southeastern end of Arorae Island. Of the these islands, the North Gilbert Group of north of the equator is aligned in N-S direction, and the South Gilbert Group in NW-SE direction. The northern end is linked to the Radak Chain of the Marshall Islands extending from latitude 6° N to 15° N, and the southern end is linked to the Tuvalu Islands running from latitude of 10°S to 5°S.

In 1991, five seamounts from SE01 to SE05 of the North Gilbert Group had been surveyed. Among five seamounts, SE01 Seamount (4°15' N・ 172°54' E) is located at 80 miles north of Makin Atoll of the northern edge of the Gilbert Islands and belongs to the Gilbert Ridge. The location of SE01 Seamount is shown in Fig. 3-1-1 and the track lines of the acoustic sounding surveys are shown in Appendix Fig. 1.

(1) Topographic Classification of Seafloor

Seamounts are topographically subdivided into summit and slope, and defined as shown in Table 3-1-1 and Fig.3-1-2. The statistical figures of each topographic part were given in Table 3-1-2.

Table 3-1-1 Topographic Subdivision of Seamount

Classification		Topographic Feature
Summit	Central Part	Central area of summit with flat to gentle slope
	Marginal Part	Transition zone from central part of summit to upper part of slope
Slope	Upper Part	Steeply inclined upper part of slope
	Middle Part	Zone between upper part and lower part of slope
	Lower Part	Gently inclined lower part of slope
Foot of Sea Mountain		Transition zone from lower part of slope to the ocean floor

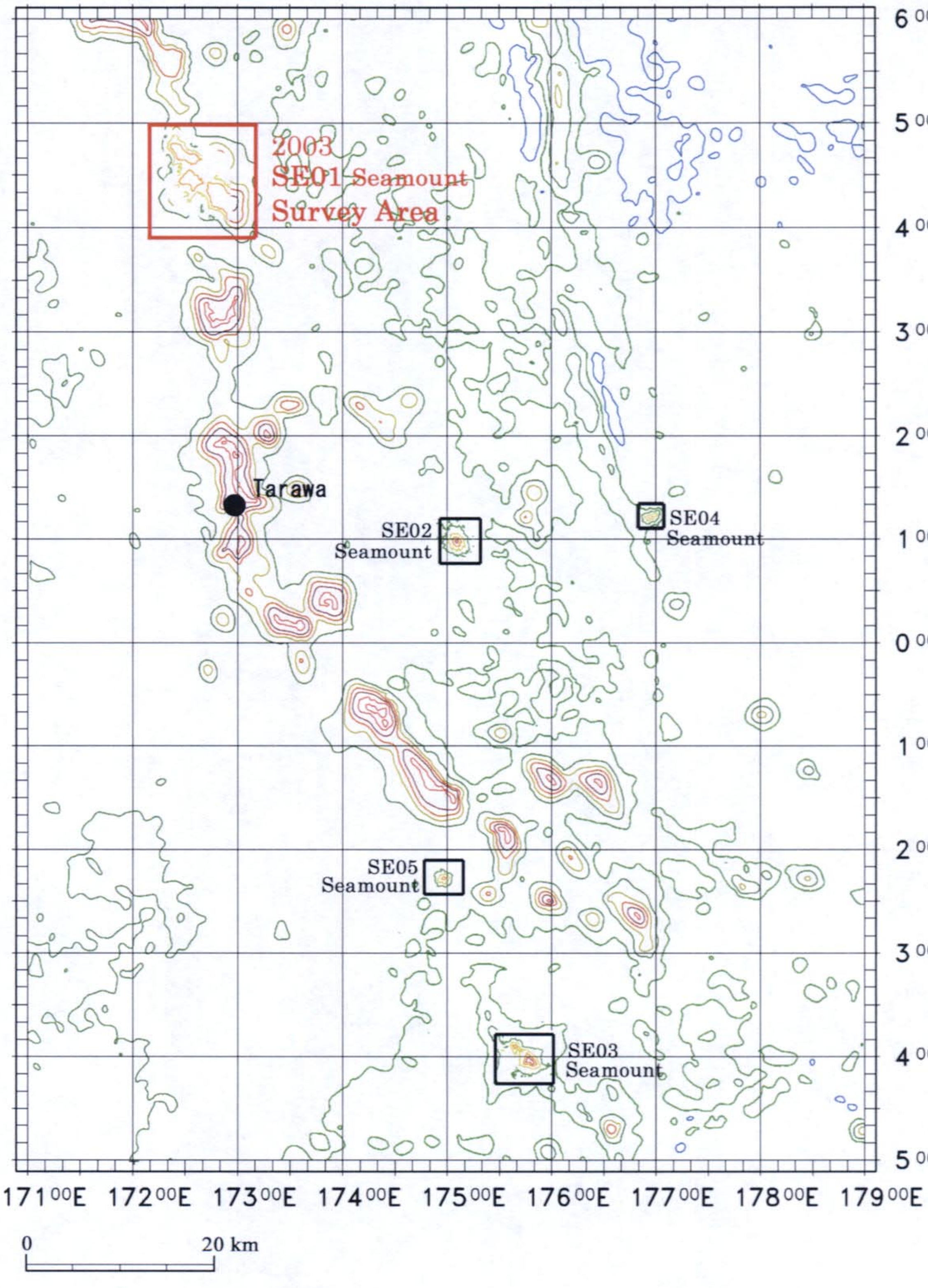


Fig. 3-1-1 Location Map of SE01 Seamount

Table 3-1-2 Topographic Subdivision of SE01 Seamount and Slope Angle

(1) SE01 Seamount Total Area

Topographic Division	Water Depth Range	Slope Area	Gradient			Frequency distribution of gradient (%)			
			Average	Min.	Max.	0-10°	10-20°	20-30°	>30°
	(m)	(k m²)	(°)	(°)	(°)	(%)	(%)	(%)	(%)
Summit	<1500	1,036.30	3.3	0.0	38.8	92.0	5.9	1.9	0.2
Upper Slope	1500-2500	1,328.09	14.4	0.0	54.7	34.2	41.2	20.0	4.5
Middle Slope	2500-3500	1,783.73	11.8	0.0	49.4	45.8	41.2	12.0	1.0
Lower Slope	>3500	1,365.70	6.4	0.0	45.2	80.5	17.1	2.2	0.3

(2) Northwest Seamount (surveyed in 2003)

Topographic Division	Water Depth Range	Slope Area	Gradient			Frequency distribution of gradient (%)			
			Average	Min.	Max.	0-10°	10-20°	20-30°	>30°
	(m)	(k m²)	(°)	(°)	(°)	(%)	(%)	(%)	(%)
Summit	<1500	190.86	5.7	0.1	30.3	80.2	13.7	5.9	0.1
Upper Slope	1500-2500	361.62	14.7	0.8	33.9	31.5	43.4	22.8	2.3
Middle Slope	2500-3500	412.32	13.2	0.2	35.7	36.8	43.6	19.1	0.5
Lower Slope	>3500	294.12	7.2	0.1	33.9	72.5	24.1	3.1	0.3

(3) Center Seamount (surveyed in 2003)

Topographic Division	Water Depth Range	Slope Area	Gradient			Frequency distribution of gradient (%)			
			Average	Min.	Max.	0-10°	10-20°	20-30°	>30°
	(m)	(k m²)	(°)	(°)	(°)	(%)	(%)	(%)	(%)
Summit	<1500	150.67	5.7	0.2	31.1	83.7	12.1	4.1	0.1
Upper Slope	1500-2500	392.59	11.4	0.1	37.2	46.9	42.7	9.4	1.0
Middle Slope	2500-3500	377.97	9.4	0.3	37.5	63.9	29.2	6.4	0.5
Lower Slope	>3500	215.58	5.3	0	33.4	90.1	8.0	1.8	0.1

(4) Southeast Seamount (surveyed in 1991)

Topographic Division	Water Depth Range	Slope Area	Gradient			Frequency distribution of gradient (%)			
			Average	Min.	Max.	0-10°	10-20°	20-30°	>30°
	(m)	(k m²)	(°)	(°)	(°)	(%)	(%)	(%)	(%)
Summit	<1500	692.5	2.1	0	29.1	97.2	2.4	0.3	0.0
Upper Slope	1500-2500	616.95	15.2	0	54.7	31.4	39.3	24.0	5.3
Middle Slope	2500-3500	1032.5	11.5	0.1	49.4	45.6	44.3	9.5	0.7
Lower Slope	>3500	828.77	6.3	0	45.2	80.6	17.6	1.6	0.1

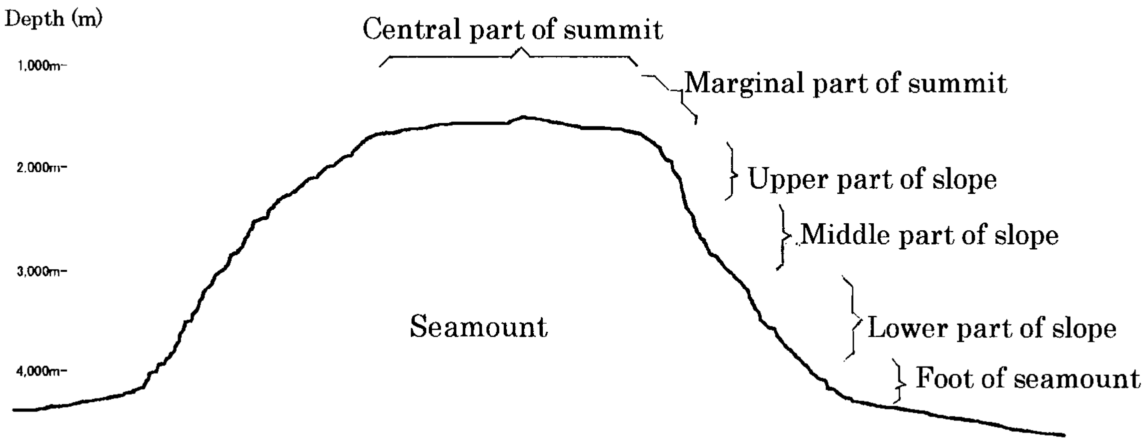


Fig. 3-1-2 Schematic Model of Seamount Subdivision

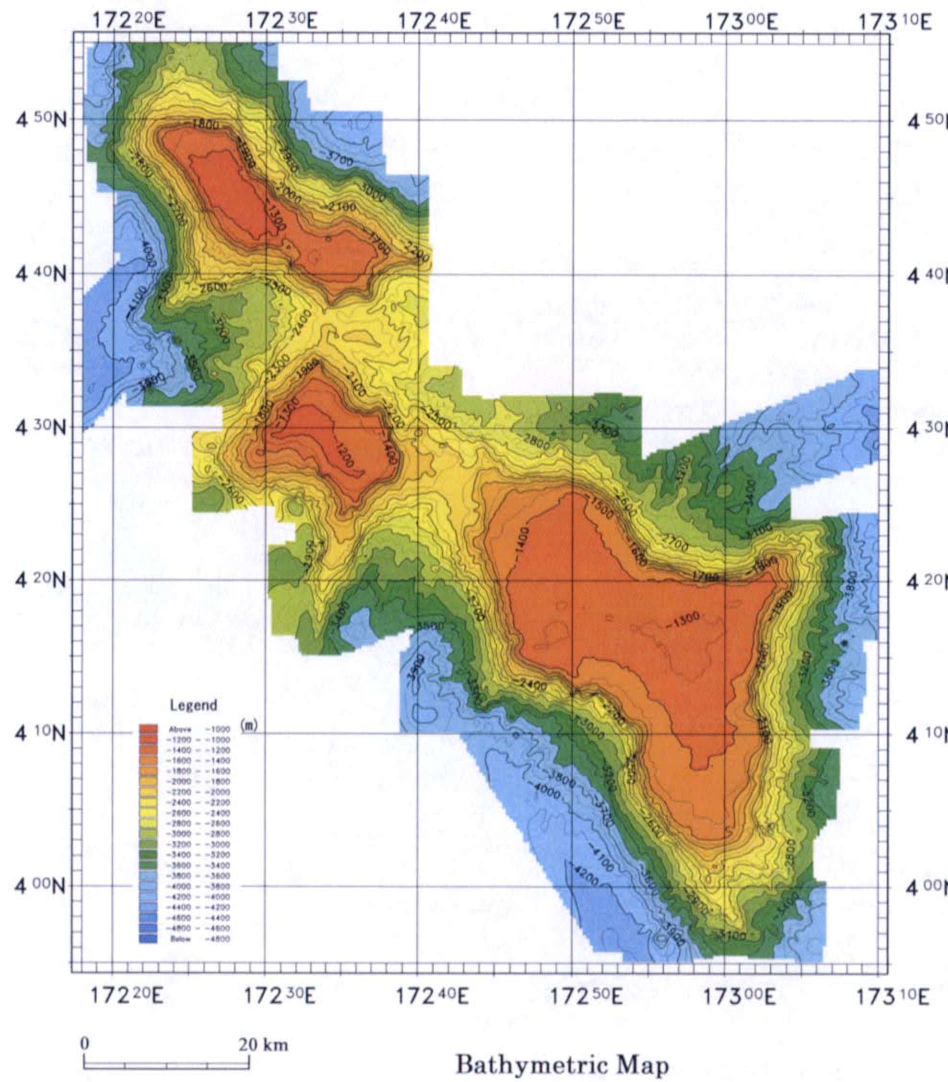
(2) Outline of Topography

The bathymetric map and shaded relief map of SE01 Seamount are shown in Fig. 3-1-3, and three-dimensional bathymetric map is shown in Fig. 3-1-4. The topographic characteristics of the SE01 Seamount are given in Table 3-1-3.

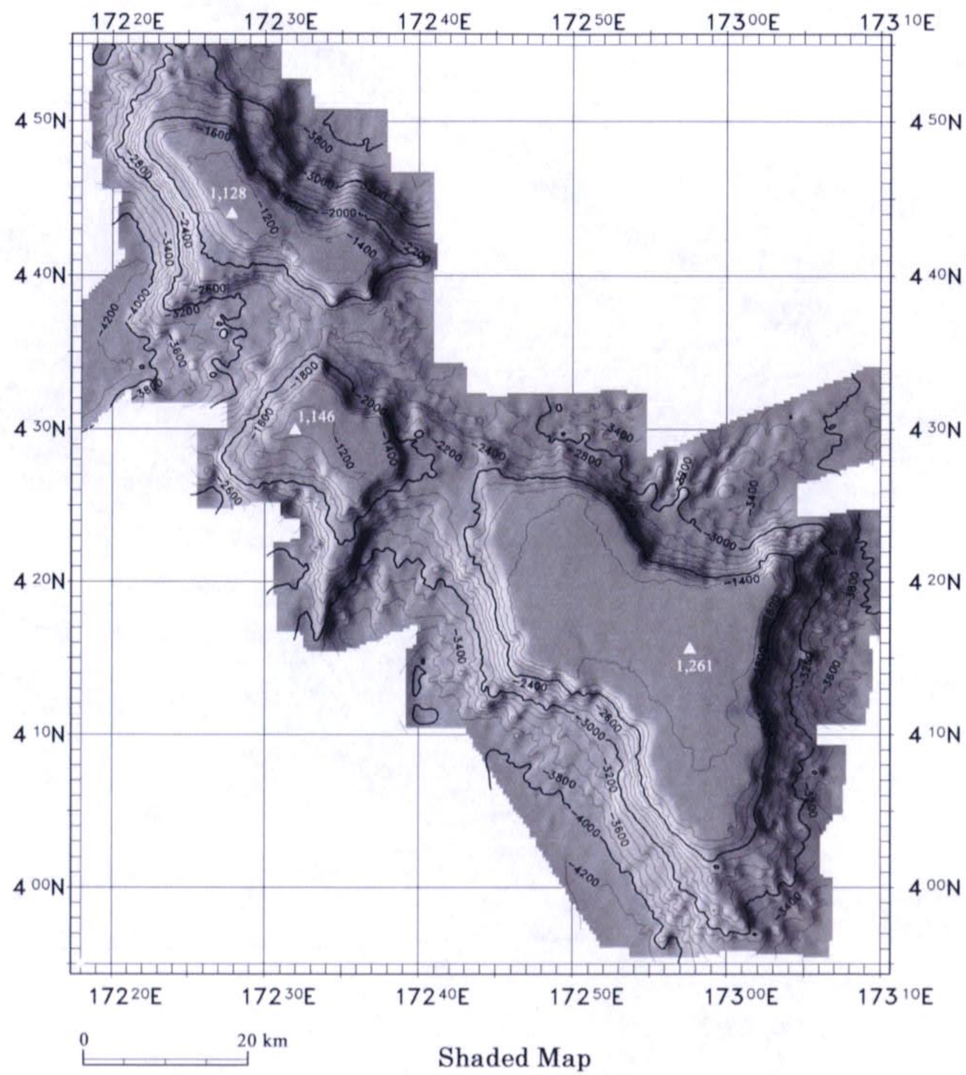
In 1991, only southeastern area of the SE01 Seamount was surveyed, and the rest of it, the northwestern area, was surveyed in this year (2003). The results of the survey of year 2003 revealed that two seamounts existed in the northwestern area, and thus the SE01 Seamount consists of three seamounts, two of them (Northwest Seamount and Center Seamount) are in the northwestern area and another (Southeast Seamount), previously surveyed, is in the southeastern area.

Among them, Southeast Seamount of the southeastern area is the largest flat-summit seamount (guyot). It has elongated shape and the direction of longer axis is N40° W, same as general trend of SE01 Seamount. The seamount rises 2,900m high from the base of the seafloor of 4,100m deep, and the area of the summit shallower than 1,500m deep is 690 k ㎡ (46 ×15km) .

The two seamounts, Northwest and Center Seamounts, found by the survey of year 2003 in the northwest and center 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



Bathymetric Map



Shaded Map

Fig. 3-1-3 Bathmetric Map and Shaded Map of SE01 Seamount

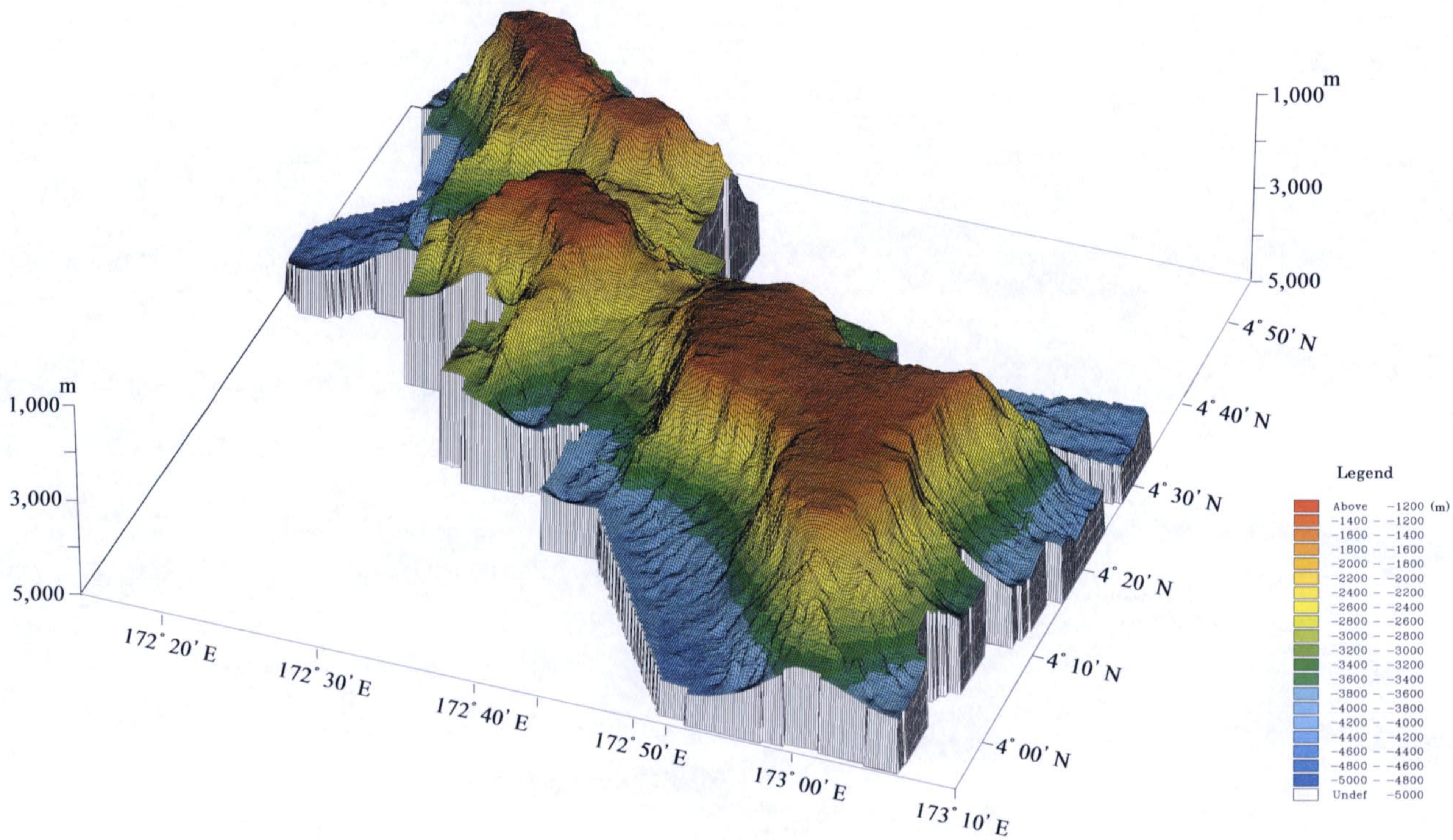


Fig. 3-1-4 3 - D Bathymetric Map

Table 3-1-3 Topographic Characteristics of SE01 Seamount

Location latitude 4° 20′ N, Longitude 172° 40′ E Type Flat-topped seamount (Guyot) Dimension 110km(long baxis) × 10 to 25km(short axis) Water Depth 1,128m to 4,400m deep Summit Area 1,036 km^2 Slope Angle Upper Part 14.4° (max. 54.2°) Middle Part 11.89° (max. 51.4°) Lower Part 6.4° (max. 59.0°) Others ・ Flat-topped seamount seated in the northwestern edge of the Gilbert Rise ・ Direction of long axis: N40° W ・ Composite seamount of three bodies, northwestern, central, and southeastern seamount. Depth of water of saddle portion of three seamounts is approximately 2,200m deep. ・ Summit becomes shallower from southeast to northwest, 1,128m, 1,145m, and 1,261m. ・ Summit area is, 692 km^2(southeast), 190km^2 (northwest), and 150km^2 (central). ・ The gentle, dome-shaped summit stands from the shoulder (1,500m deep). Surface is covered with unconsolidated sediments and no definite ups and lows and smooth.	SBP records ・ Type-T covers whole the summit area. ・ All of three seamounts are covered by acoustically transparent-layer from the summit to the upper part of slope (shoulder). ・ Layer thickness of the summit is, 10m to 50m at the northwest, 20m to 70m at the central, and maximally 150m at the southeast summit. ・ Acoustically transparent layer shows striped pattern layer appearance suggesting high reflectance, coarse sediments. MBES Acoustic Intensity Image ・ Pale color at the whole summit area, concordant with SBP records. ・ Presumably unconsolidated sediments at the summit. ・ Previously surveyed southeastern area lacks MBES data, but presumably similar summit condition to other two seamounts (from SBP records). ・ Wide distribution of unconsolidated sediments at the foot of seamount deeper than 4,000m deep. ・ Limited rock outcrops around the saddle between two seamounts and the slope deeper than the upper part of slope. Ridges and valleys are reflected on the image pattern. Area of exposed rock at the summit area Northwestern part 53 km^2 Central part 28 km^2

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.

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-like 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 as shown later by SBP records and MBES images.

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°. Locally there are slopes showing steep gradient, reaching the maximum of 55°. The middle slope is slightly gentler than the upper slope, ranging from 11° to 13°, and the slope of the seamount deeper than 3,500m is more gentle, 5°to 7°and it merges to the foot of seamount.

3-2 Circumstances of seafloor

(1) SBP Survey

The reflection patterns of SBP records of the SE01 Seamount were classified into two types, Type-O and Type-T. The typical examples of each type are shown in Fig. 3-2-1.

i. Type-O: The reflection patterns of this type consist entirely of acoustically opaque layers.
This type is observed mainly on steep slops in the marginal part between summit and slope area in the SE01 Seamount. This type generally reflects the exposure of bedrocks with or without manganese crust. In some cases, this type may include the area covered by thin unconsolidated sediments.

ii. Type-T: The reflection pattern of this SBP type shows two-layers structure, consisting of acoustically transparent layer and opaque layer. The uppermost part of the transparent layer is often accompanied by stripes of opaque layers. This type corresponds to the distribution of unconsolidated sediments (foraminifer sand, calcareous ooze, etc.). It is observed in the flat summit area and the cols between two seamounts.

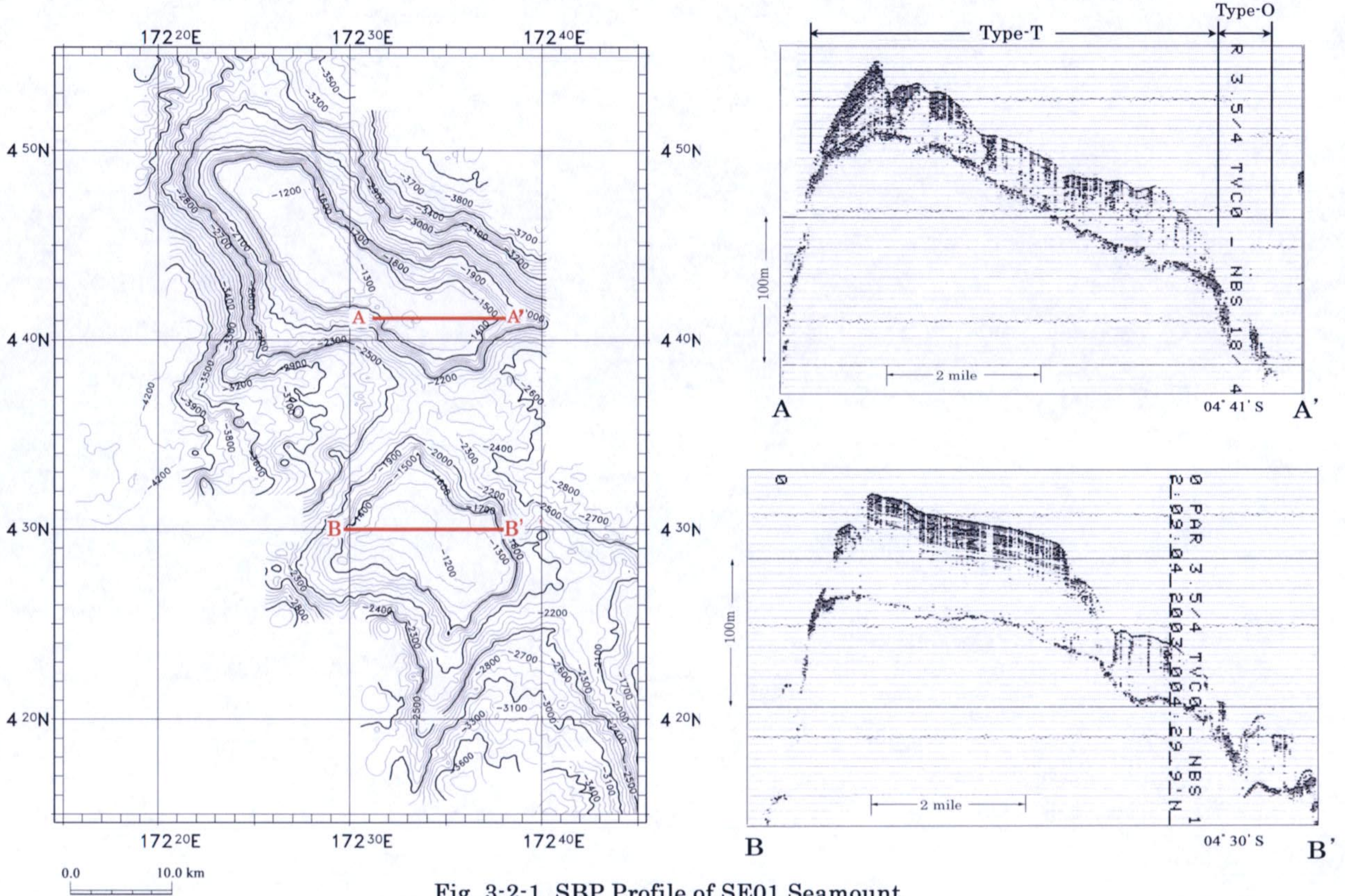


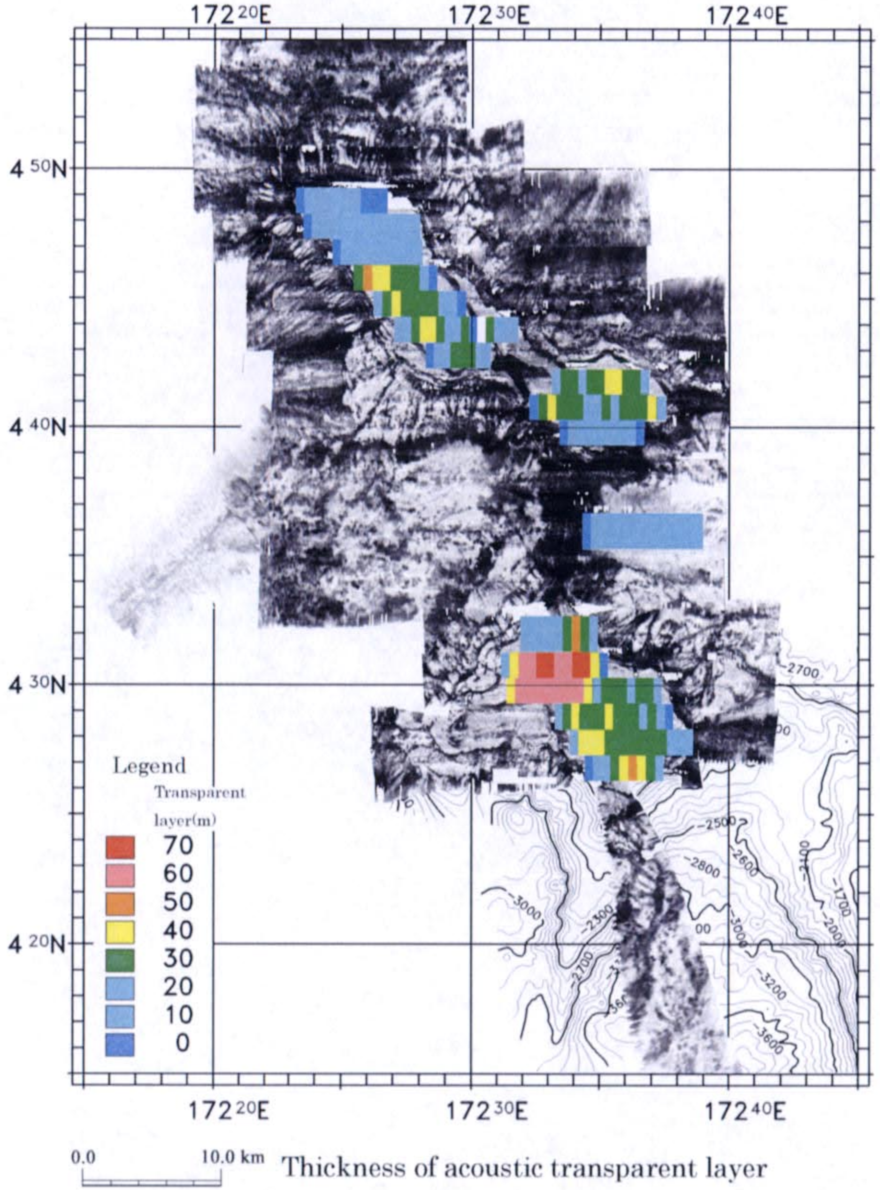
Fig. 3-2-1 SBP Profile of SE01 Seamount

The distribution of Type-T and the thickness of acoustically transparent layer in SE01 Seamount were read from the SBP records. The thickness of acoustically transparent layer is shown on the map of Fig. 3-2-2 and the SBP profiles are given in Appendix Fig. 2. The thickness shown in Figure 3-2-2 is a thickness of layer from the top to the boundary of basement including the uppermost layers with striped pattern. In the figure, the distribution of MBES acoustic reflection intensity, which is mentioned later, is also shown. 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 (The SBP records of 1991 actually shows SBP profile of three layers structure consisting of transparent, semi-transparent, and opaque layers. The SBP used in 1991 had different data detection methods from the one now using, and this three layers stricture type is considered to be included in Type-T according to the classification of this year). 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 in the summit of Northwest Seamounts and 20m to 70m in summit of the 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 on summit area, foraminifer sands are obtained.

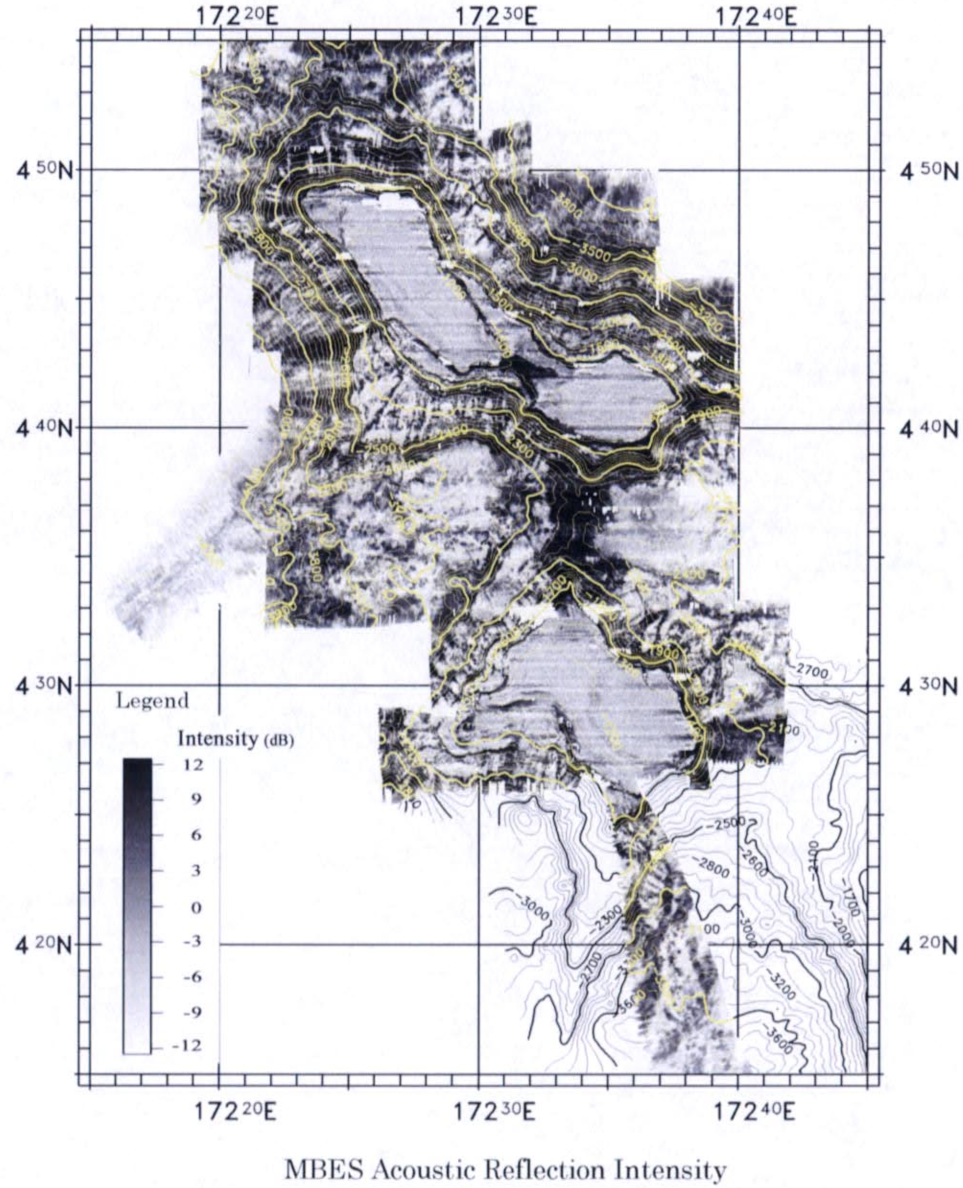
(2) MBES Acoustic Survey

The acoustic reflection intensity of MBES, generally, reflects the material distributed on surface of sea bottom, and different level of reflection is obtained depending on materials of the seafloor, such as exposed rocks or unconsolidated sediments. Exposed rocks show strong reflection intensity, thus the area composed of exposed rocks is shown as dark color (black) on the MBES image. On the contrary, weak reflection intensity coming from sediments such as unconsolidated sediments is shown as pale color (white) on the image. The intensity varies affected by other parameters such as grain size, extent of compaction of sediments. When manganese nodules are distributed on unconsolidated sediments, the area is shown as intermediate color (gray) on the MBES image. The MBES acoustic reflection intensity image of the Northwest and Center Seamounts is shown in Fig. 3-2-2.

The distribution of MBES acoustic reflection intensity of the SE01 Seamount conforms well to the results of SBP. That is, the whole summit areas, where Type-T of



Thickness of acoustic transparent layer



MBES Acoustic Reflection Intensity

Fig. 3-2-2 Thickness of Acoustic Transparent Layer and MBES Acoustic Reflection Intensity

SBP is predominantly distributed, 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 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, the 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 of 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 Central 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.

3-3 Geology of SE01 Seamount

The sampling location and sampling results of AD and MC conducted in the northeastern part of SE01 Seamount in year 2003 are shown together with results of previous year in Figs. 3-3-1 and 3-3-2.

(1) Outline of the Sampling Results Conducted in 1991

In 1991, Arm Dredge (AD) sampling and seafloor observation by Finder-installed Deep-sea Camera (FDC) were conducted in the southeastern part of the SE01 Seamount. The outline of this survey is given bellow.

In the previous survey, sampling by AD was conducted at eight sampling points (Table 3-3-1) and seafloor observation by FDC was done along a single track-line (Fig. 3-3-3). The AD sampling conducted at eight sampling points resulted in collecting a

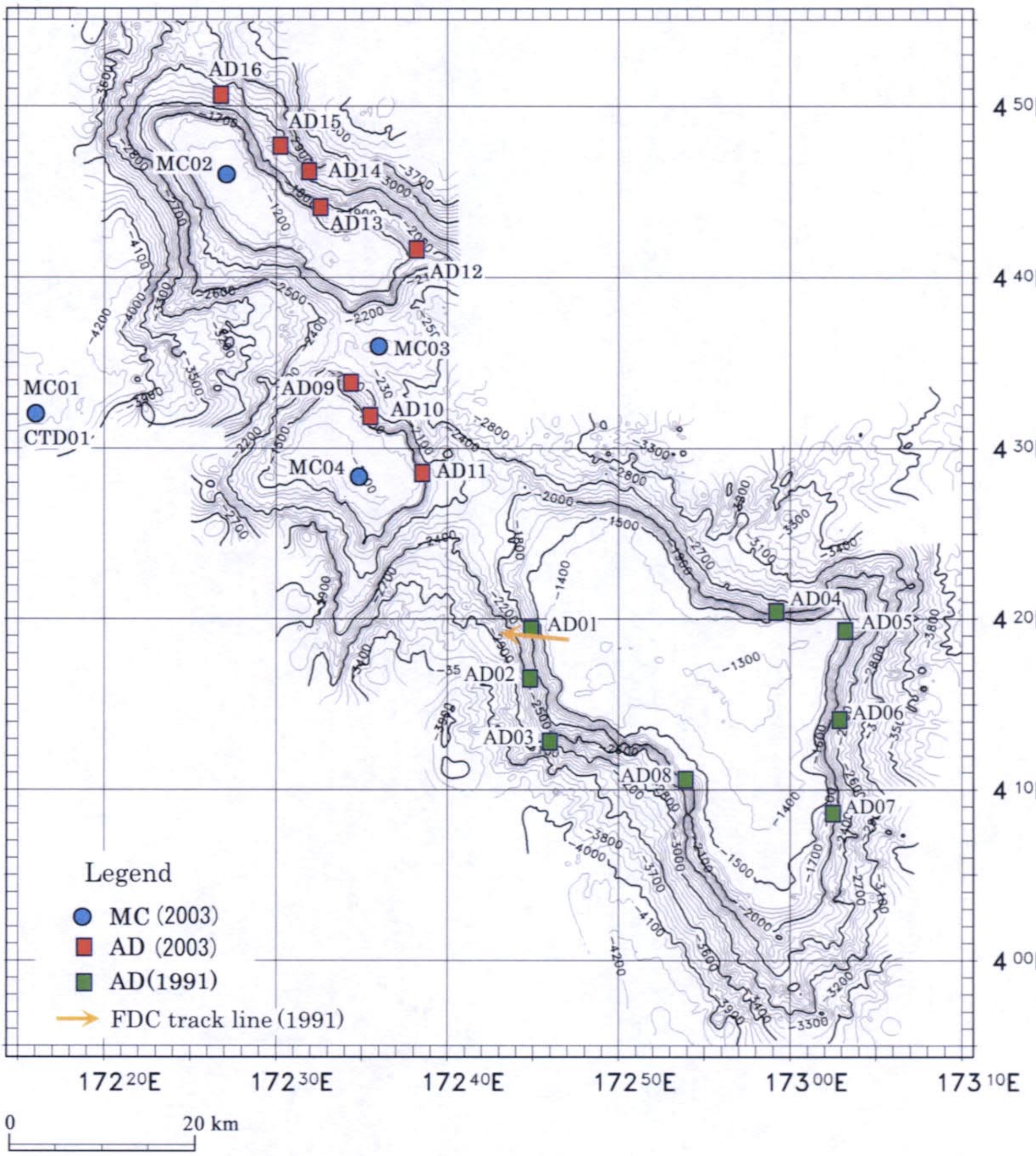
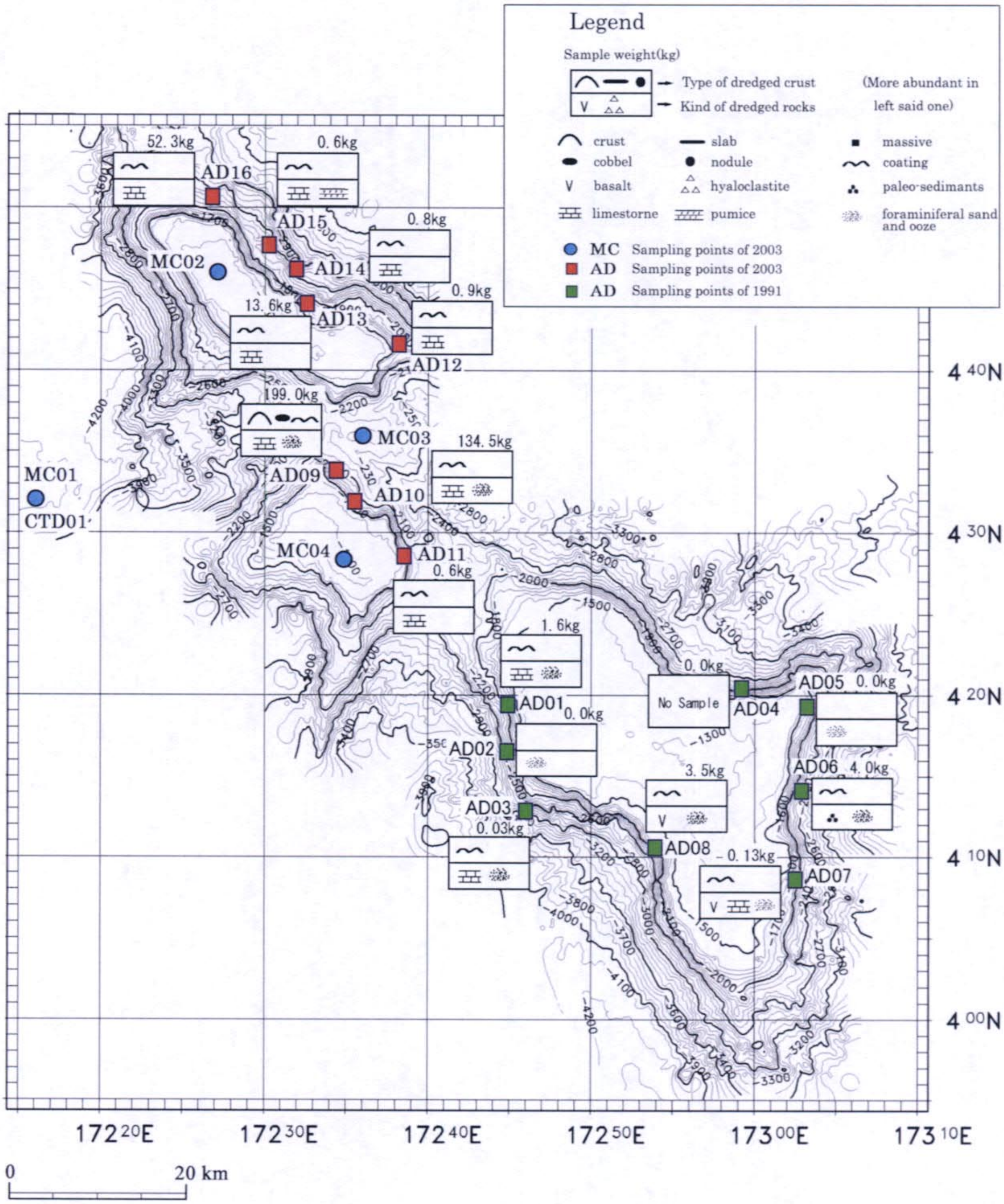


Fig. 3-3-1 Locality map of Sampling points



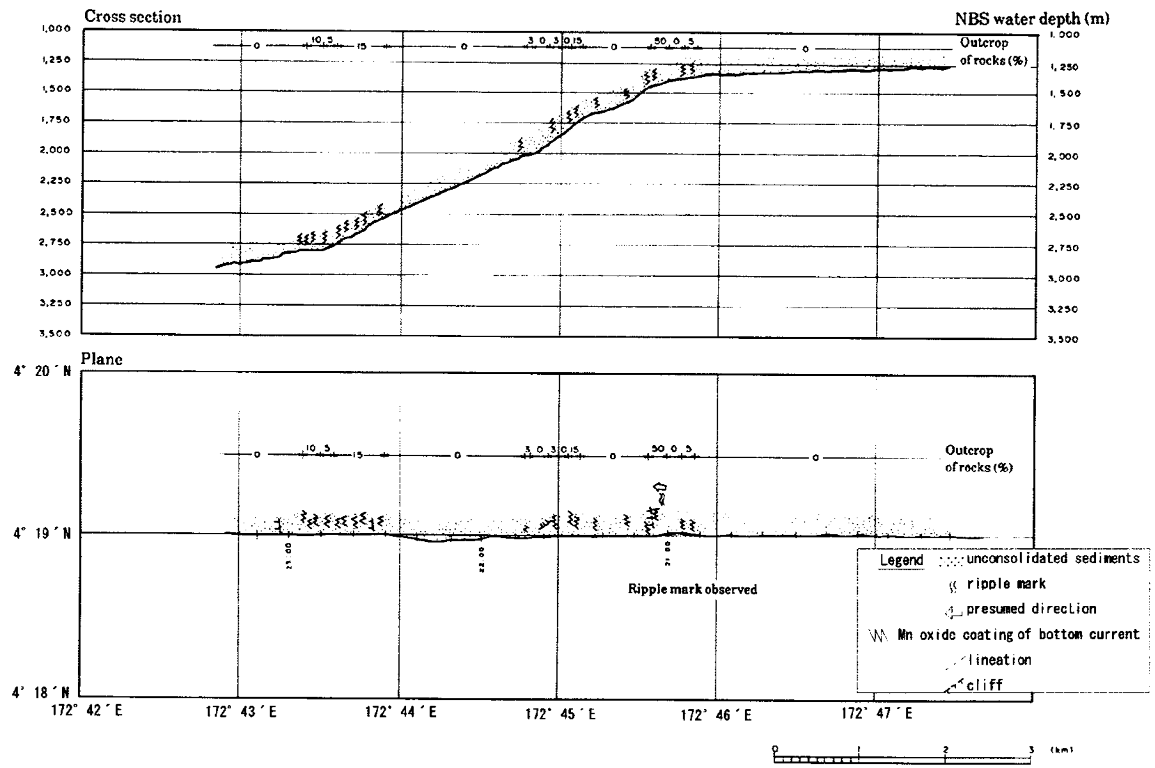
Sample Number		Thickness(mm) Max.	Min.	Ave.	Sample Weight(kg)	Average Grade(%) H_2O	Co	Ni	Cu	Mn	Fe
AD09	Crust	40	35	35	26.5	34.71	0.97	0.56	0.02	29.39	15.72
	Cobble	25	5	20	26.0	33.16	1.51	0.82	0.04	32.70	13.05

Fig. 3-3-2 Geology and Cobalt Crust Distribution in SE01 Seamount

Table3-3-1 Records of AD Sampling (1991)

No.	Sampling	Date (Local time)			Position Lat. Lon.	dir. of towing (°)	Depth (m)	Distance of Towing (nm)	Lithology of collected samples	Total weight (kg)
1	91SE01AD01	BT	16-Sep-91	9:30	4° 19.131'N 172° 45.271'E	146.6°	1,640	0.4	Limestone	1.6
		BR	16-Sep-91	11:10	4° 18.789'N 172° 45.498'E		1,570			
2	91SE01AD02	BT	16-Sep-91	12:55	4° 16.452'N 172° 44.919'E	18.0°	2,331	0.01	–	0.0
		BR	16-Sep-91	13:51	4° 16.466'N 172° 44.916'E		2,318			
3	91SE01AD03	BT	16-Sep-91	16:09	4° 12.931'N 172° 45.952'E	65.0°	2,889	0.7	Pebbles of Basalt	0.03
		BR	16-Sep-91	16:47	4° 13.213'N 172° 45.345'E		2,728			
4	91SE01AD04	BT	17-Sep-91	6:43	4° 20.406'N 172° 59.062'E	248.9°	2,040	0.4	–	0.0
		BR	17-Sep-91	7:14	4° 20.271'N 172° 58.711'E		1,895			
5	91SE01AD05	BT	17-Sep-91	9:05	4° 18.952'N 173° 03.127'E	245.6°	1,560	0.4	–	0.0
		BR	17-Sep-91	9:33	4° 18.785'N 173° 02.758'E		1,410			
6	91SE01AD06	BT	17-Sep-91	11:46	4° 13.234'N 173° 02.847'E	210.6°	2,513	0.4	Fine-grained sandstone	4.0
		BR	17-Sep-91	12:15	4° 12.885'N 173° 02.641'E		2,454			
7	91SE01AD07	BT	17-Sep-91	14:22	4° 08.499'N 173° 02.625'E	233.1°	1,862	0.5	Pebbles of Basalt Limestone	0.1
		BR	17-Sep-91	14:55	4° 08.198'N 173° 02.223'E		1,792			
8	91SE01AD08	BT	17-Sep-91	17:39	4° 10.877'N 172° 53.405'E	3.6°	1,980	0.2	Basalt Volcanic breccia	3.5
		BR	17-Sep-91	18:15	4° 11.064'N 172° 53.416'E		1,750			
						合 計		3.0		9.2

BT: Bottom Touch ; BR: Bottom Release



Date	Track Line No.	a Launch Time b On sea-floor c Off sea-floor d Haul-in time	Location		Depth (m)	Survey Duration (hrs) (a ~ d)	Observation duration (hrs) (b ~ c)	Observation length (mile)
			Latitude	Longitude				
9/17 /18	91SE01FDC01	a 18:58 b 19:25 c 23:23 d 00:17	4°18.98'N 4°19.00'N	172° 47.15'E 172° 42.49'E	1,330 2,040	05 : 19	03 : 58	4.7

Notes) 1. Location of "On sea-floor" and "off sea-floor" shown by ship position.
2. Depth shows NBS water depth at ship position.
3. Time means GMT.

Fig. 3-3-3 FDC Route Map of SE01 Seamount(1991) small amount of samples, a total of 9.3kg. These samples consist of basalt, reef limestone, sandstone and unconsolidated sediments (Table3-3-1), and no clear occurrence of cobalt crust was observed from these samples. The results of sampling without cobalt crust samples conform to the results of seafloor observation by FDC conducted in area summit to middle slop of the seamount. According to the observation by FDC, distribution rate of exposed rocks on the seafloor was low, 3% at the center of the summit and 2 to 5 % on upper to middle slope, and the seafloor was covered mostly with unconsolidated sediments. No significant occurrence of cobalt crust was found by FDC and only weak coating of manganese oxides is observed on the surface of exposed rock (Fig.3-3-4). At the edge of summit, ripple mark was observed on the unconsolidated sediments and the direction of bottom current was assumed to be from east to west.

Collected limestone was mostly grayish white, porous reef limestone. Basalt was collected from the southeastern and southwestern sides of the slope by AD (91SE01AD07, AD08). The sample collected on the southeastern slope (AD07) showed dark gray, comparatively fresh, poorly vesicular, fine-grained compact basalt. The other one collected on the southwestern slope (AD08) was reddish brown, fine-grained, compact basalt but fragile in part and showed autobrecciated, amygdaroidal texture. Small amount of sandstone and siltstone were collected on the eastern slope (91SE01AD06), and the rocks were massive, fine-grained, grayish brown, and only thin coating of manganese oxides was observed on the surface (Fig.3-3-4).

(2) Results of Sampling

The results of AD and MC samplings conducted this year are given on Table 3-3-2., and photographs of collected samples by AD are shown in Fig.3-3-5.

The total weight of samples collected by AD at eight sampling points is 402.3kg, and the weight of collected sample is less than 1kg at four sampling points.

Although different area of SE01 Seamount was surveyed this year (2003) from the survey of previous year (1991), following differences were observed between the results of two surveys.

i. The weight of collected samples is much more than that of previous survey.

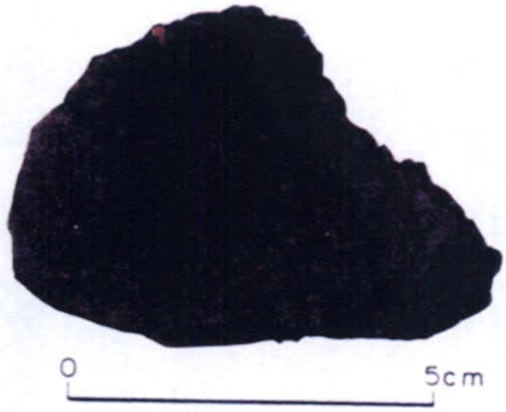
ii. Cobalt crust was collected at 03SE01AD09 in addition to the samples with manganese oxide coating.

iii. Basalt was not collected in the survey of this year.

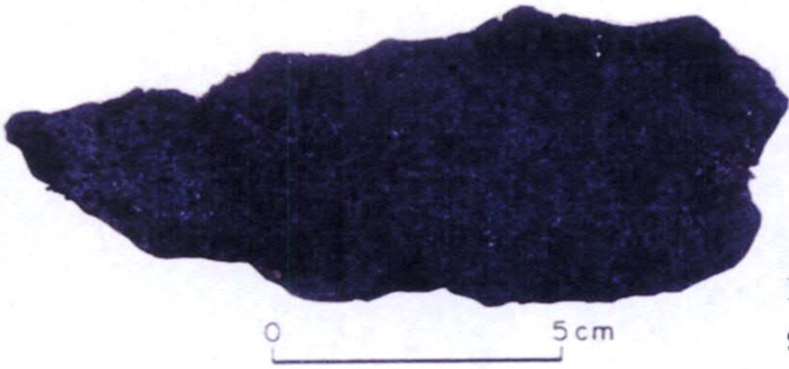
iv. Sandstone was not collected and pumice was collected by the survey of this year.

Although basalt was not collected by the survey of this year, it was commonly collected during the survey of previous year, not only in the southeastern part of SE01

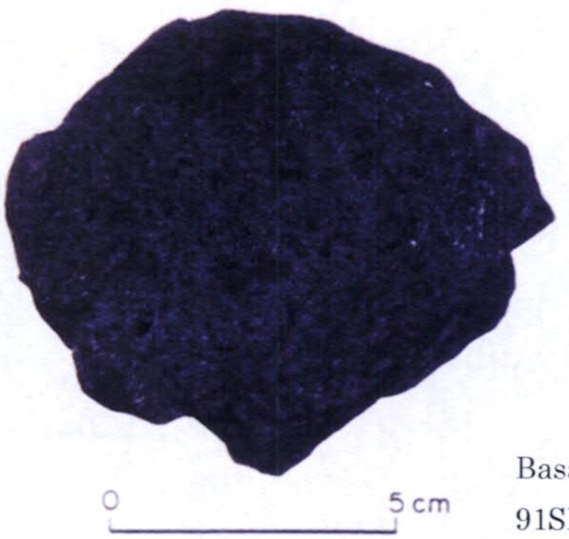
Sandstone with Manganese Oxide Coating 91SE01AD06(A)



Sandstone
91SE01AD06(A)



Basaltic pyroclastic rock
91SE01AD08(B)



Basalt
91SE01AD08(A)

sample No	lithology	Rock Forming Mineral															texture	remarks
		Phenocryst					Groundmass											
		Pl	Cpx	Opx	Ol	Q	Pl	Opx	Ol	Mt	Ap	Epi	Vg	C.Q	Zeo	Lim		
91SE01AD08(A)	basalt	△		△	△		◎	○	○	●	●		◎	●			Flow, Int, Hya	Lim is altered. Vitreous

Pl : Plagioclase Cpx : Clinopyroxene Opx : Orthopyroxene Ol : Olivine Q : Quartz Mt : Iron mineral
Ap : Apatite Epi : Epidote Vg : Glass C.Q : Chalcedony quartz Zeo : Zeolite Lim : Limonite
Flow : Flow structure Int : Intersertal Hya : Hyaloophitic
◎ : Abundant ○ : Common △ : Rare ● : Very Rare

Fig. 3-3-4 Sample Photo of SE01 Seamount (1991)

Table3-3-2 Records of MC and AD Sampling on the SE01 Seamount

No.	Sample name	Date (Local time)			Position Lat. Lon.	dir. of Towing	Depth (m)	Distance of Towing (nm)	Lithology of collected samples	Total weight (kg)
1	03SE01MC01	BT	30-Nov-03	13:00	4°32.016'N 172°16.028'E		4,351		foramniferal sand	
		BR	30-Nov-03	13:05						
2	03SE01MC02	BT	01-Dec-03	8:24	4°46.006'N 172°27.217'E		1,157		foramniferal sand	
		BR	01-Dec-03	8:28						
3	03SE01MC03	BT	01-Dec-03	11:14	4°36.018'N 172°36.024'E		2,184		foramniferal sand	
		BR	01-Dec-03	11:19						
4	03SE01MC04	BT	01-Dec-03	13:49	4°28.404'N 172°34.922'E		1,192		foramniferal sand	
		BR	01-Dec-03	13:54						
5	03SE01AD09	BT	01-Dec-03	15:58	4°33.816'N 172°34.326'E	NE-SW	1,910	0.5	crust 26.5kg cobble-type crust 26kg limestone and others 146.5kg	199.0
		BR	01-Dec-03	17:01	4°33.424'N 172°34.047'E		1,623			
6	03SE01AD10	BT	02-Dec-03	8:33	4°31.804'N 172°35.383'E	NE-SW	1,719	0.4	limestone and others	134.5
		BR	02-Dec-03	9:24	4°31.626'N 172°35.059'E		1,386			
7	03SE01AD11	BT	02-Dec-03	11:23	4°28.562'N 172°38.443'E	E・W	1,430	0.1	limestone fragment	0.6
		BR	02-Dec-03	11:43	4°28.540'N 172°38.385'E		1,375			
8	03SE01AD12	BT	02-Dec-03	14:33	4°41.591'N 172°38.125'E	E・W	1,775	0.3	limestone fragment pumice	0.9
		BR	02-Dec-03	15:01	4°41.516'N 172°37.874'E		1,593			
9	03SE01AD13	BT	02-Dec-03	17:17	4°43.994'N 172°32.550'E	E・W	1,804	0.4	limestone fragment pumice	13.6
		BR	02-Dec-03	18:09	4°43.965'N 172°32.181'E		1,591			
10	03SE01AD14	BT	03-Dec-03	8:47	4°46.152'N 172°31.901'E	E・W	2,681	0.3	limestone fragment pumice	0.8
		BR	03-Dec-03	9:30	4°45.955'N 172°31.665'E		2,452			
11	03SE01AD15	BT	03-Dec-03	11:50	4°47.651'N 172°30.170'E	E・W	2,336	0.5	limestone fragment pumice	0.6
		BR	03-Dec-03	12:31	4°47.423'N 172°29.743'E		2,200			
12	03SE01AD16	BT	03-Dec-03	14:52	4°50.601'N 172°26.761'E	E・W	2,316	0.5	limestone fragment	52.3
		BR	03-Dec-03	15:49	4°50.244'N 172°26.453'E		2,139			
							Total	3.0		402.2

BT: Bottom Touch ; BR: Bottom Release

03SE01AD09

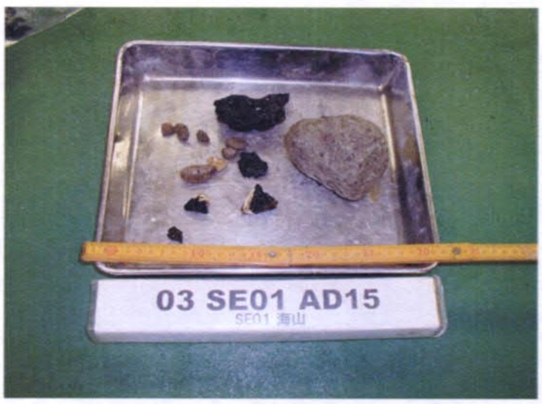
03SE01AD10

03SE01AD11

03SE01AD12

03SE01AD13

03SE01AD14



03SE01AD15

03SE01AD16

Fig. 3-3-5 Sample Photo of AD

Seamount, but also in the other sea mountains, such as SE02, SE03, SE04 and SE05. This suggests that basalt forms the basement of all these sea mountains. Common occurrence of vecicular basalts in these sea mountains is probably explained by eruption of basalt at water depth shallower than present depth.

The fossil identification of limestone encrusted by cobalt crust and unconsolidated sediments collected by MC are given bellow.

(3) Fossil Identification of Limestone

The limestone collected from the SE01 Seamount in previous survey was not encrusted by cobalt crust and fossil identification of the limestone was not conducted.

In the survey of this year, limestone encrusted by cobalt crust was collected by AD on the northwestern slope of the Center Seamount of SE01 Seamount (03SE01AD09). The fossil identification of the limestone given below was conducted for estimation of geological age and sedimentation environment.

Sample no.	Location	Depth of Water
03SE01AD09	4° 33.82′ N, 172° 34.33′ E	1,910m

The results of fossil identification, such as geological age and sedimentation environment, of the limestone are summarized as followings. Detailed results of fossil identification are given in Appendix Data 1.

<u>Sample no. 03SE01AD09 FR01</u>

From the analysis of nannoplankton fossils, the age of sedimentation is assumed to be Late Eocene to Early Oligocene. The foraminifer fossil suggests that the sedimentation environment had changed from pelagic environment far off the shelf to shallow to terrestrial environments, and the age determined by nannoplankton fossils indicates post uplifting age and thus the sedimentation of limestone is assumed to be older than determined geologic time. For the sedimentation environment, foraminifer fossils suggest calm pelagic environment far off the shelf.

Limestone indicates some influence of post depositionnal diagenesis and from the fact it includes neritic or reef benthic foraminifer fossils, it is assumed that bedrock had once deposited under oceanic environment, and after that, it had been raised above the sea surface by uplifting. After the uplifting, the seamount subsidized again and cobalt crust started to grow on the surface of the limestone. The formation of cobalt crust is assumed to start at or after Late Eocene to Early Oligocene

(4) Fossil Identification of Bottom Sediments

Using the sediments samples collected by Multiple Corer (MC), identification of fossils (foraminifer and nannoplankton) was conducted for estimating the geological age and sedimentation environment of bottom sediments (Fig.3-3-1, Table3-3-2). The samples shown below are used for fossil identification.

Sample no.	Locality	Depth of Water
03SE01MC01	4° 32.02′ N 172° 16.03′ E	4,351m
03SE01MC02	4° 46.01′ N 172° 27.22′ E	1,157m
03SE01MC03	4° 36.02′ N 172° 36.02′ E	2,184m
03SE01MC04	4° 28.40′ N 172° 34.92′ E	1,192m

These samples were collected, respectively, at western foot of SE01 Seamount (MC01), on summit of Northwest Seamount (MC02), on col between Northwest and Center Seamounts (MC03) and on summit of Center Seamount (MC04).

The results of fossil identification, such as geological age and sedimentation environment, of the sediments are summarized as followings. Detailed results of fossil identification of the sediments are given in Appendix Document 2.

Sample no. 03SE01MC01 FS01-FS04

From foraminifer fossils analysis, the geologic time of the lowest (deepest) sample is thought to be Late Pleistocene (perhaps older than 0.22Ma). The fossil assemblages of the upper samples, FS01 and FS02, suggests the age of sedimentation to be younger than 0.16Ma (after Late Pleistocene) for these two samples, younger that the lowest one.

The geological ages of younger than 0.25Ma were, also, obtained from calcareous nannoplankton. *Helicoshaera inversa* was found in 03SE01MC01FS02, and from the time plane of its extinction (stratigraphic datum plane 1: 0.16Ma), the time range of FS02 to FS04 is assumed to be 0.16Ma to 0.25Ma.

From the analysis of foraminifer fossils, sedimentation environment of the sediments is considered to be tropical to sub tropical geographic province and the sediments had deposited under the place not so different latitude from present day. Since benthic foraminifer fossils scarcely occur, nutrient saline flux from sea surface to deeper depths is assumed to be poor.

Sample no. 03SE01MC02 FS01- FS04

The samples do not include effective foraminifer index fossil assemblages. Though they do not include individuals of *Globigerinoides rubber* (pink) but assemblages of *Globigerina rubuscens* (pink) and *Bollnella calida* were included, and the age of sedimentation is most probably Late Pleistocene. The age of sedimentation is considered to be younger than 0.16 Ma (after late Pleistocene).

From the inspection of foraminifer fossils, all samples are considered to be younger than 0.25Ma.

The foraminifer fossils suggest sedimentation environment of these sediments to be tropical to sub tropical geographic province, at the latitude not so much different from present day. Since benthic foraminifer fossils scarcely occur, nutrient saline flux from sea surface to deeper depths is assumed to be poor.

Sample no. 03SE01MC03 FS01-FS03

The samples do not contain effective foraminifer index fossil assemblages. By the reason same to the samples of 03SE02MC02FS01-FS04, the geological age of these samples of this sampling point (03SE01MC03) is considered to be younger than 0.16 Ma (after late Pleistocene).

From the inspection of foraminifer fossils, all samples are considered to be younger than 0.25Ma.

The foraminifer fossils suggest sedimentation environment of these sediments to be tropical to sub tropical geographic province, at the latitude not so much different from present day. Since benthic foraminifer fossils scarcely occur, nutrient saline flux from sea surface to deeper depths is assumed to be poor.

Sample no. 03SE01MC04 FS01-FS03

The results of foraminifer fossils analysis suggest that two of the samples of lower location, FS02 and FS03, are older than 0.22 Ma and the FS01 sample is considered to be younger than 0.22Ma. By the same reason as the case of 03SE01MC02 FS01-FS04 samples, the geologic age of this sample is thought to be younger than 0.16 Ma (Late Pleistocene).

From the inspection of foraminifer fossils, all samples are considered to be younger than 0.25Ma.

The foraminifer fossils suggest sedimentation environment of these sediments to be tropical to sub tropical geographic province, at the latitude not so much different from present day. Since benthic foraminifer fossils scarcely occur, nutrient saline flux from sea surface to deeper depths is assumed to be poor.

The results of fossil analysis of all the MC samples of the area suggest that the geologic age of the sedimentation of unconsolidated sediments is younger than 0.25 Ma and that depositional environment is tropical to sub tropical geographic province, similar environment to that of present day.

3-4 Occurrence of Cobalt Crust

(1) Results of Sampling

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 photographs of all of the collected samples by AD (AD09 to AD16) conducted this year and photographs of samples at 03SE01AD09 are shown in Fig.3-3-5 and Fig.3-4-1, respectively.

(2) Description of Cobalt Crust

The cobalt crusts collected at 03SE01AD09 are crust and boulder type crust.

The average thickness of crust collected at 03SE01AD09 is 35mm (ranging from 35 to 45mm). The surface shows botryoidal appearance, and it is black and hard, having two layers texture and weakly mottled. It, also, shows, in part, a growth texture enclosing manganese nodule (nucleus is discoidal tuff). The substrate of the crust is phosphorite and partly phosphatized limestone.

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. Clay fillings are not observed in black and hard manganese oxides. 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.

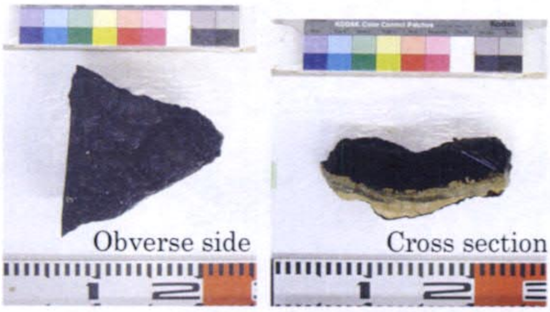
The collected samples at other seven sampling points were mainly limestone (partly phosphatized) and pumice fragments. These are soft rocks and only thin-coated manganese oxides are observed, and not encrusted by thick manganese oxides.

(3) Chemical Composition of Cobalt Crust

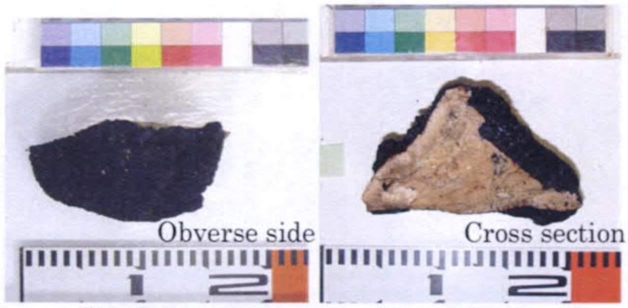
The chemical analyses of two crust samples (one crust, one boulder type crust) collected by AD at 03SE01AD09 were conducted.

AD with samples

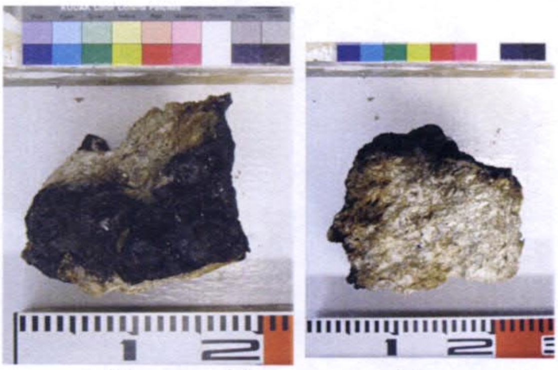
Dreded samples(03SE01AD09)



Crust 35mm Thickness



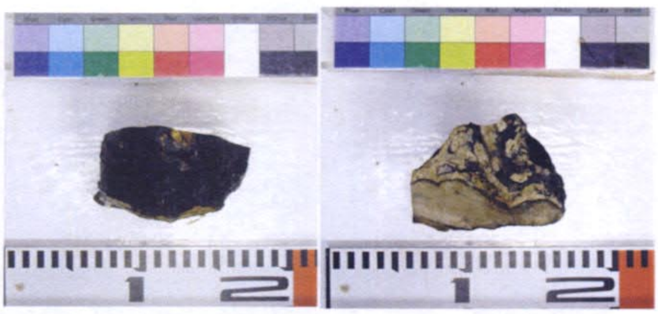
Conglomerate 20mm Thickness



Obverse side Cross section

Limestone with Manganese Oxide Coating

Phosphation Limestone with Manganese Oxide Coating



Obverse side Cross section

Fig. 3-4-1 Photograph of samples (AD09)

Analyzed elements are in total of 36, including major metal elements of Co, Ni, Cu, Mn, Fe, minor elements and rare earth elements (Co, Ni, Cu, Mn, Fe, Pb, Zn, Ti, Mo, V, Si, Al, Ca, Na, K, P, Ba, Sr, Pt, LOI, H_2O^+, H_2O^-, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu).

The results of analysis are given in Table 3-4-1, and other information such as analytical method and detection limits are given in Appendix documents 3.

In Table 3-4-2, an average composition of two samples collected at 03SE01AD09 were shown together with results of other seamount in the Gilbert Islands (SE02 to SE05 Seamounts) and that of cobalt crust in the Marshall Islands area. The previous survey in SE01 Seamount carried out in 1991 resulted in collecting no cobalt crust samples and the analytical results of two samples are the only the results of chemical analyses for SE01 Seamount. Comparing the chemical compositions of the two samples of SE01 Seamount with those of other seamounts of the Gilbert Islands area and cobalt crust of the Marshall Islands area, the Co content of two samples are 0.97% and 1.52% with an average of 1.24%, higher than other two areas. Ni is 0.56% and 0.82%, slightly higher than other two areas, but Cu is low , 0.02% and 0.04%. Mn is considerably high, around 30% (29.39% and 32.70%), and Fe shows a little low content (15.72% and 13.02%), consequently, ratio of Mn/Fe is higher than other two areas, showing 1.87 and 2.50. The analytical results of two samples of SE01 Seamount are shown on Fe-(Cu+Ni)-Mn triangle diagram (Fig. 3-4-2). Both samples are plotted in the field of hydrogenous manganese oxides with poor Cu+Ni.

Therefore, the cobalt crust of the SE01 Seamount has chemical composition similar to manganese oxides of hydrogenous origin, and Co, Mn, Mn/Fe are higher than those of other seamounts of Gilbert Islands and Marshall Islands area

Metal elements, other than major metal elements, such as Pb, Zn, Ti, Mo, V, do not show significantly high concentrations and Pt is 0.2ppm and 0.3ppm, and lower than that of average cobalt crust from seamounts in the Pacific Ocean, 0.77ppm (Usui and Someya, 1997).

The analytical results of rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) were normalized to the values of chondrite and the North American Shale and normalized patterns are shown in Fig. 3-4-3. The total values of rare earth elements (Σ REE) are 1,770 and 1,481ppm, but these values are controlled by concentration of Ce, 1,102.0ppm and 990.5ppm, respectively.

Table 3-4-1 Results of Chemical Analysis

No.	Sample No.		Depth (m)	Lithology	Remarks	Co (%)	Ni (%)	Cu (%)	Mn (%)	Fe (%)	Mn/Fe	Pb (%)	Zn (%)	Ti (%)	Mo (%)	V (ppm)	Si (%)	Al (%)	Ca (%)	Na (%)	K (%)	P (%)	Ba (ppm)	Sr (ppm)	Pt (ppm)	LOI (%)	H_2O^+ (%)	H_2O^- (%)
1	03SE01AD09	CM01	1,766	Crust	thickness35mm	0.97	0.56	0.02	29.39	15.72	1.87	0.18	0.07	0.96	0.08	819	1.88	0.20	0.30	0.15	0.44	0.50	210	1726	0.2	19.34	10.39	4.98
2		CM02	1,766	Cobble-type crust	thickness 20mm	1.51	0.82	0.04	32.70	13.05	2.50	0.20	0.08	0.99	0.08	670	1.53	0.22	2.96	2.13	0.51	0.40	1690	1444	0.3	18.39	9.73	5.04

No.	Sample No.		Depth (m)	Lithology	Remarks	La (ppm)	Ce (ppm)	Pr (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Gd (ppm)	Tb (ppm)	Dy (ppm)	Ho (ppm)	Er (ppm)	Tm (ppm)	Yb (ppm)	Lu (ppm)	Σ REE (ppm)
1	03SE01AD09	CM01	1,766	Crust	thickness 35mm	243.0	1102.0	41.3	177.5	34.7	8.8	44.3	6.5	41.7	8.9	27.8	3.6	25.8	4.1	1770
2		CM02	1,766	Cobble-type crust	thickness 20mm	176.5	990.5	29.0	126.0	25.1	6.4	32.4	4.8	31.9	7.2	23.1	2.9	22.2	3.6	1481

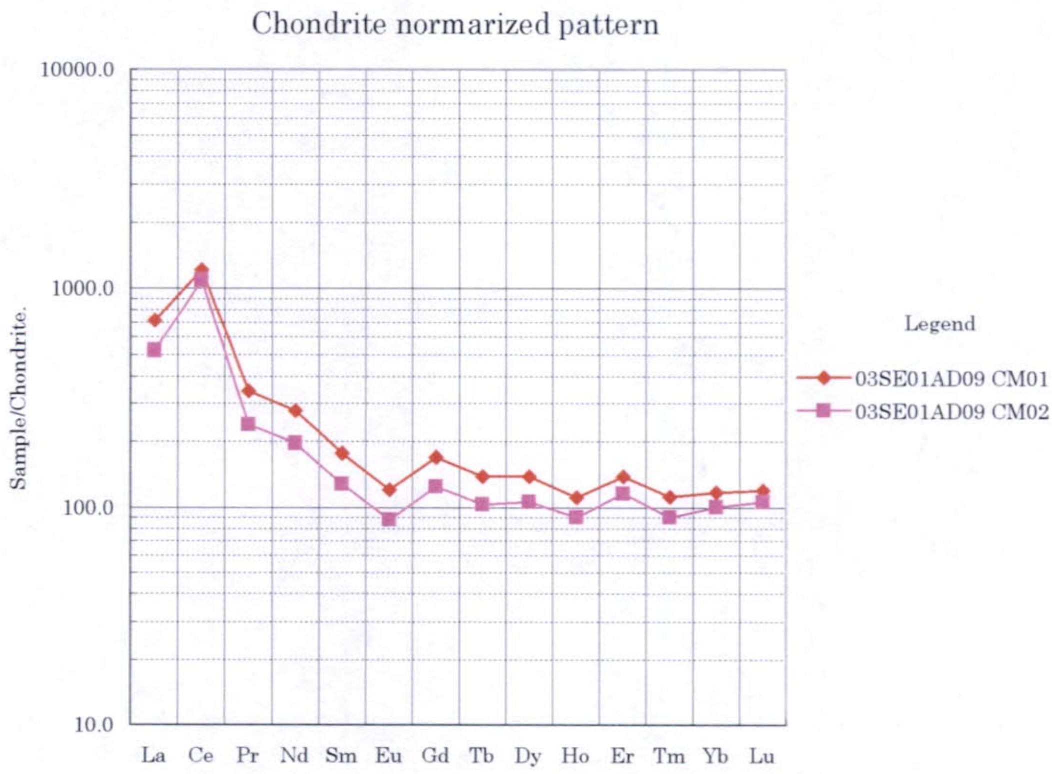
Table 3-4-2 Average Chemical Composition of Cobalt Crust

	This survey		Gilbert Islands in Kiribati EEZ (Survey of 1991)[1]								Marshall Islands Area[2]	
	SE01 Smt.	n	SE02 Smt.	n	SE03 Smt.	n	SE04 Smt.	n	SE05 Smt.	n		n
Average thicness(mm	35	—	15.6	—	11.2	—	9.7	—	12.9	—	—	—
Co %	1.24	2	0.77	3	0.85	7	0.51	10	0.62	10	0.85	13
Ni %	0.69	2	0.70	3	0.64	7	0.45	10	0.53	10	0.39	13
Cu %	0.03	2	0.09	3	0.09	7	0.08	10	0.13	10	0.04	13
Mn %	31.04	2	26.75	3	24.32	7	20.09	10	20.33	10	20.30	13
Fe %	14.39	2	16.86	3	16.88	7	18.99	10	19.06	10	12.50	13
Mn/Fe	2.19	2	1.57	3	1.44	7	1.06	10	1.07	10	0.62	13
Co+Ni+Cu%	1.96	2	1.56	3	1.58	7	1.04	10	1.28	10	1.28	13
Pb %	0.19	2	0.12	3	0.10	5	0.12	3	0.10	3	0.14	13
Ti %	0.97	2	0.82	3	0.88	5	0.77	3	0.96	3	0.83	13
Si %	1.70	2	1.80	3	2.00	5	1.83	3	3.16	3	2.51	13
P %	0.45	2	0.67	3	0.63	5	0.48	3	0.54	3	0.43	13
Pt ppm	0.28	2	0.12	3	0.53	5	<1	3	<1	3	0.32	8

[1] : after JICA/MMAJ. (1991)

[2] : after Hein et al. (1992)

* : SE01:averege value of AD09 site,other seamountain:averege value of seamountain.



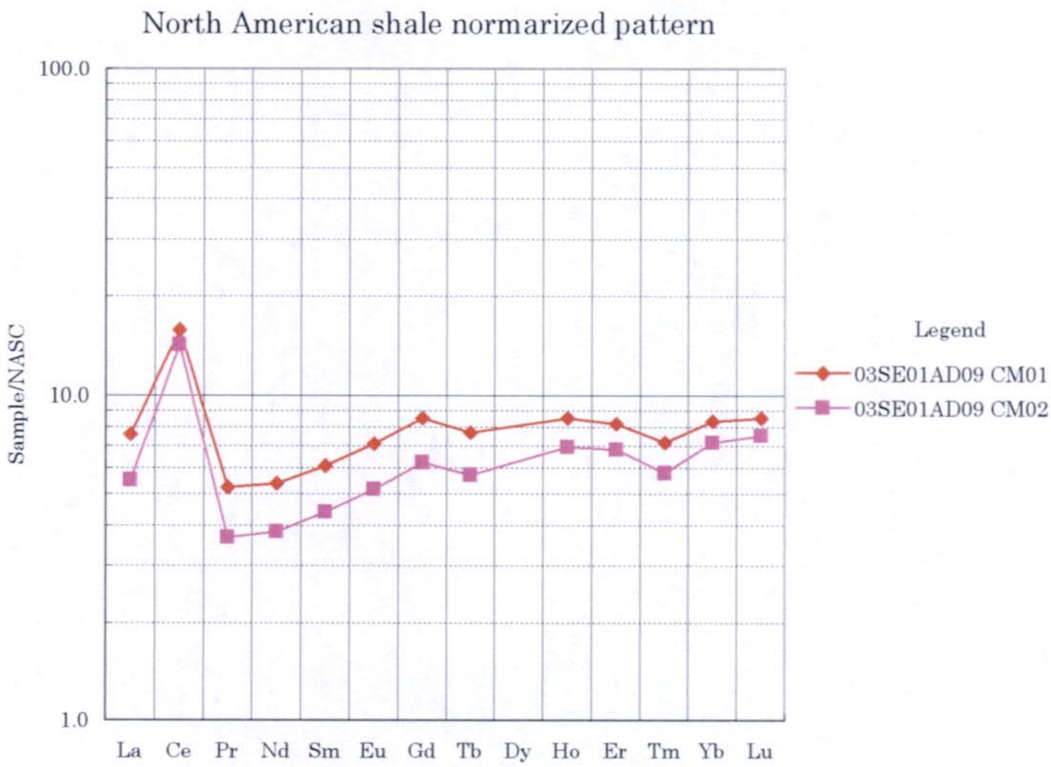
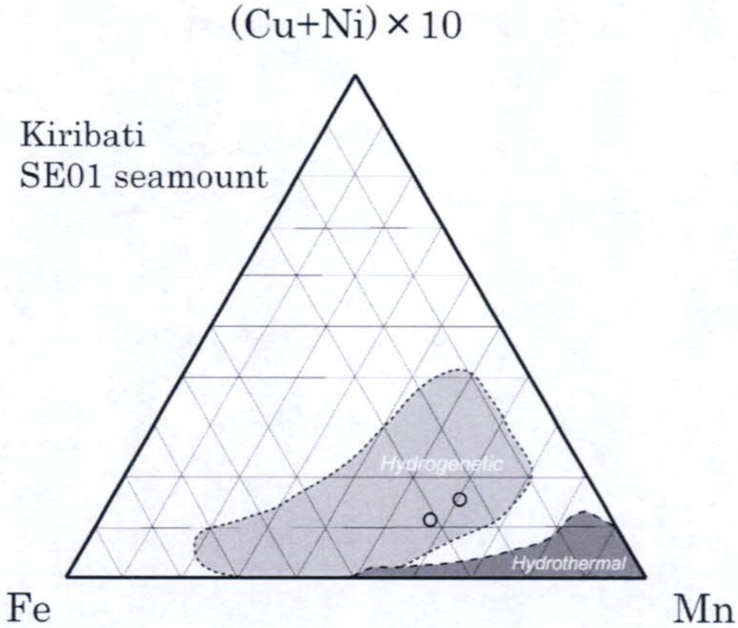


Fig. 3-4-3 REE Normarized Pattern



Fields for '*Hydrogenetic*' Fe-Mn deposits and
'*Hydrothermal*' Mn deposits are after Usui and Someya (1997)

Fig. 3-4-2 Fe-(Cu+Ni)-Mn Triangular Diagram

In the figure of of chondrite normalized patterns, two sample show similar pattern declining to the right, with light rare earth elements of 500 to 700 times higher than chondrite and heavy rare earth elements of 100 times higher than chondrite, and clear positive anomaly of Ce is observed.

The concentration of rare earth elements of manganese nodules and crust is known to show large difference between those of hydrogenous origin and hydrothermal origin. The former has significantly high concentration of total REE and Ce often shows positive anomaly (Usui and Someya, 1997). The chondrite normalized patterns of rare earth elements of two samples show similar pattern to those of hydrogenous manganese oxides. The concentration of Ce is known to be largely affected by the oxidation-reduction condition during the formation of manganese oxides (De Carlo and McMurty, 1992). Since the concentration of Ce in the survey area is high (average 1,046ppm), the cobalt crust in the area is assumed to have grown under oxidation environment of deepwater.

3・5 Environmental Survey

(1) Survey Area

The surveys were conducted at four stations located in SE01 Seamount in the EEZ of the Republic of Kiribati. Station 03SE01MC01 is located at the western foot of SE01 Seamount at water depth of ca. 4,400m. Stations 03SE01MC02 and 03SE01MC04 are on the top of two different seamounts of Northwest and Center Seamounts, respectively and the water depth at these stations is about 1,200 m. Station 03SE01MC03 is located on the col between these seamounts, and the water depth at this station is ca. 2,200m, (Fig. 3-3-1).

By the sampling using Multiple Corer (MC), equipped with eight acrylic tube samplers, sediments are successfully collected for seven tubes at Station 03SE01MC01and for eight tubes at Stations 03SE01MC02 to MC04. The photographs of collected samples and photographs of seafloor are shown in Appendix Fig.3.

(2) Sediment Properties

1) Water Content

The vertical profiles of water content of each station are shown in Fig. 3-5-1 and Appendix Table 2. Investigation of the vertical distribution of water content at station MC01 showed the highest value of about 60.5 % on average in the 0-1 cm layer. Water content tended to decrease with depth from the surface to the 4-5 cm layer and was 47to 48 % on average in layers deeper than 10 cm. Lower values of 52.0 to 55.8% on average were found in the 0-1 cm layer at stations MC02 and MC04 on summit of seamount and station MC03 on the col. Water content was 48.3 to 52.3% on average below the 1-2 cm layer and only a little vertical variation was observed.

2) Specific Sediment Gravity

The vertical distributions of specific sediment gravity at each station are shown in Fig. 3-5-2 and Appendix Table 1. The average values of specific sediment gravity of all layers for each station were 2.75, 2.75, 2.75 and 2.76, respectively, for stations MC01, MC02, MC03 and MC04. There was only little variation between these stations.

3) Total Organic Carbon

The vertical distributions of total organic carbon concentrations of each station are shown in Fig. 3-5-3 and Appendix Table 1.

The highest concentration of more than 2.10 mg/g(D) on average was found in the 0-1 cm layer at stations MC01 and MC02, followed by a concentration of 1.5 mg/g(D) on

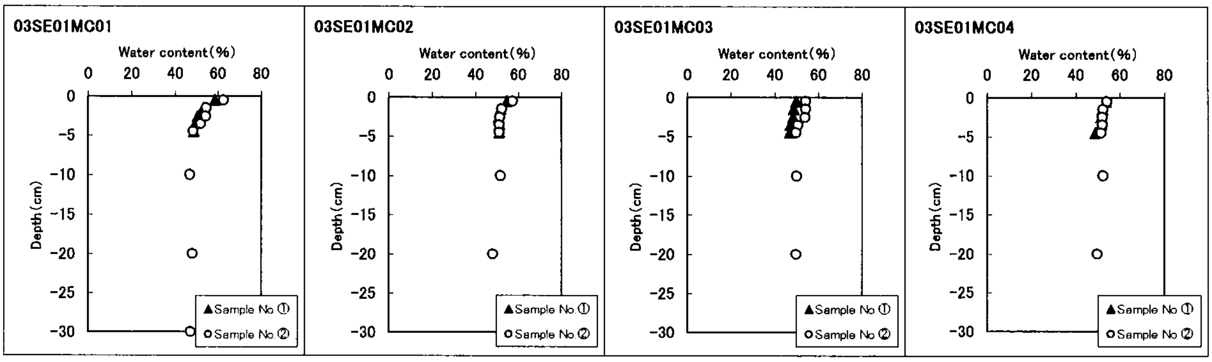


Fig. 3-5-1 Vertical Profiles of Water Content at Each Station.

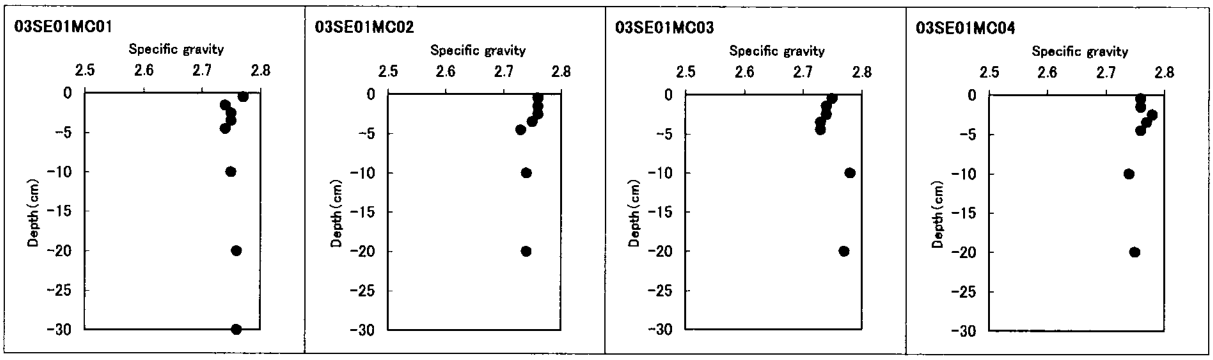


Fig. 3-5-2 Vertical Profiles of Specific Sediment Gravity at Each Station.

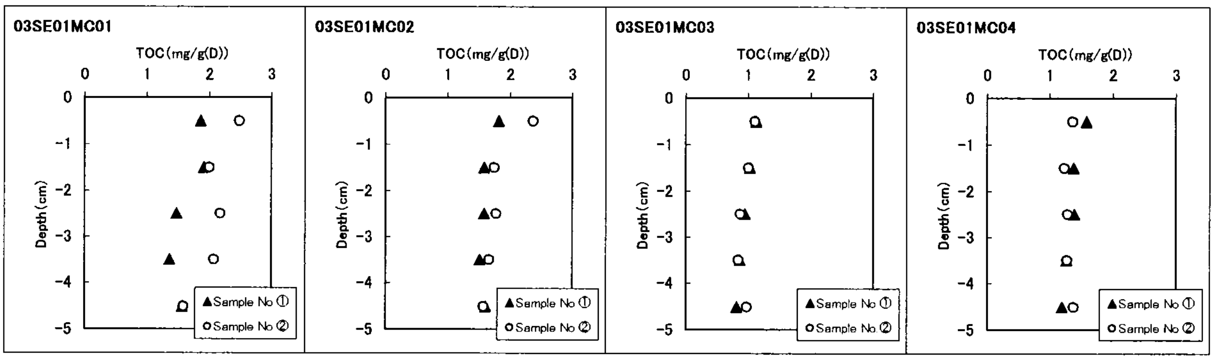


Fig. 3-5-3 Vertical Profiles of Total Organic Carbon at Each Station.

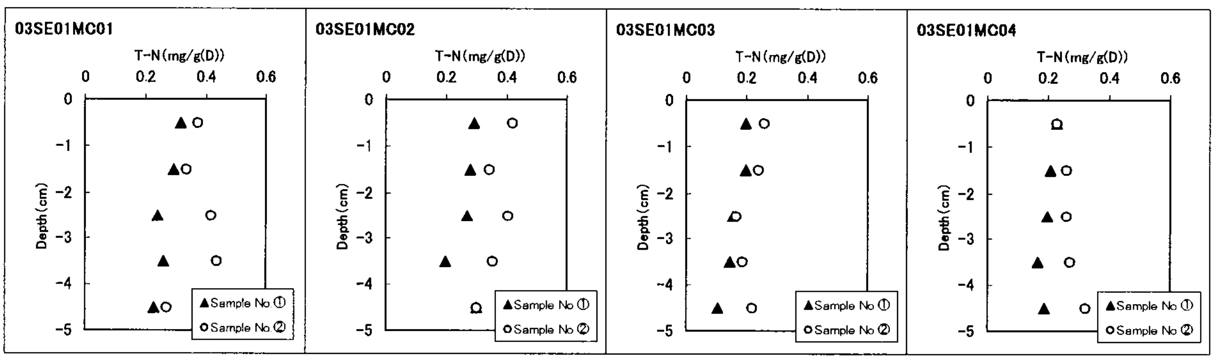


Fig. 3-5-4 Vertical Profiles of Total Nitrogen at Each Station.

average at station MC04, while the lowest concentration of 1.1 mg/g(D) on average was found at station MC03. The total organic carbon concentrations showed the tendency to decrease from the surface to deeper layers at station MC01, whereas only little vertical variation was observed at the other stations.

4) Total Nitrogen

The vertical distributions of total nitrogen concentrations at each station are shown in Fig. 3-5-4 and Appendix Table1. A concentration of over 0.34 mg/g(D) on average was found in the 0-1 cm layer at stations MC01 and MC02, a higher value than the 0.23 mg/g(D) on average was found at stations MC03 and MC04. At all stations, concentrations did not change with increasing sediment depth.

5) Sediment Particle Size Distribution

The sediment particle size distribution of each layer of each station is shown in Fig. 3-5-5 and Appendix Table 2.

In all layers of station MC01 particles with a diameter of 3.3μm showed the highest frequency. Additionally, in the 0-1 cm, 2-3 cm, 20 cm and 30 cm layers a second peak frequency of 40 to 80μm diameter particles was found. All other stations showed a frequency peak resembling to a normal distribution with a peak at particle diameter of 48~68μm.

(3) Benthic Organisms

1) Meiobenthos

Abundance and vertical distribution of metazoan meiobenthos at each station are shown in Table 3-5-1.

i. Fauna

Eighteen taxa were identified in the meiobenthos samples, including the major phyla Arthropoda (six taxa), Annelida (four taxa), Nematoda (two taxa). Cnidaria, Gastrotricha, Kinorhyncha, Loricifera, Tardigrada and Sipuncula also appeared. Arthropoda, Annelida and Nematoda were found at all stations. From the eighteen taxa observed, ten to thirteen were found simultaneously at each station. Although Protozoa (Foraminifera) were observed at all stations, this phylum was excluded from the table.

ii. Abundance

The total metazoan meiobenthos abundance was more than 300 inds./10cm^2 on average at MC02 and MC04 on the summit of the seamounts, and ca. 240 inds./10cm^2

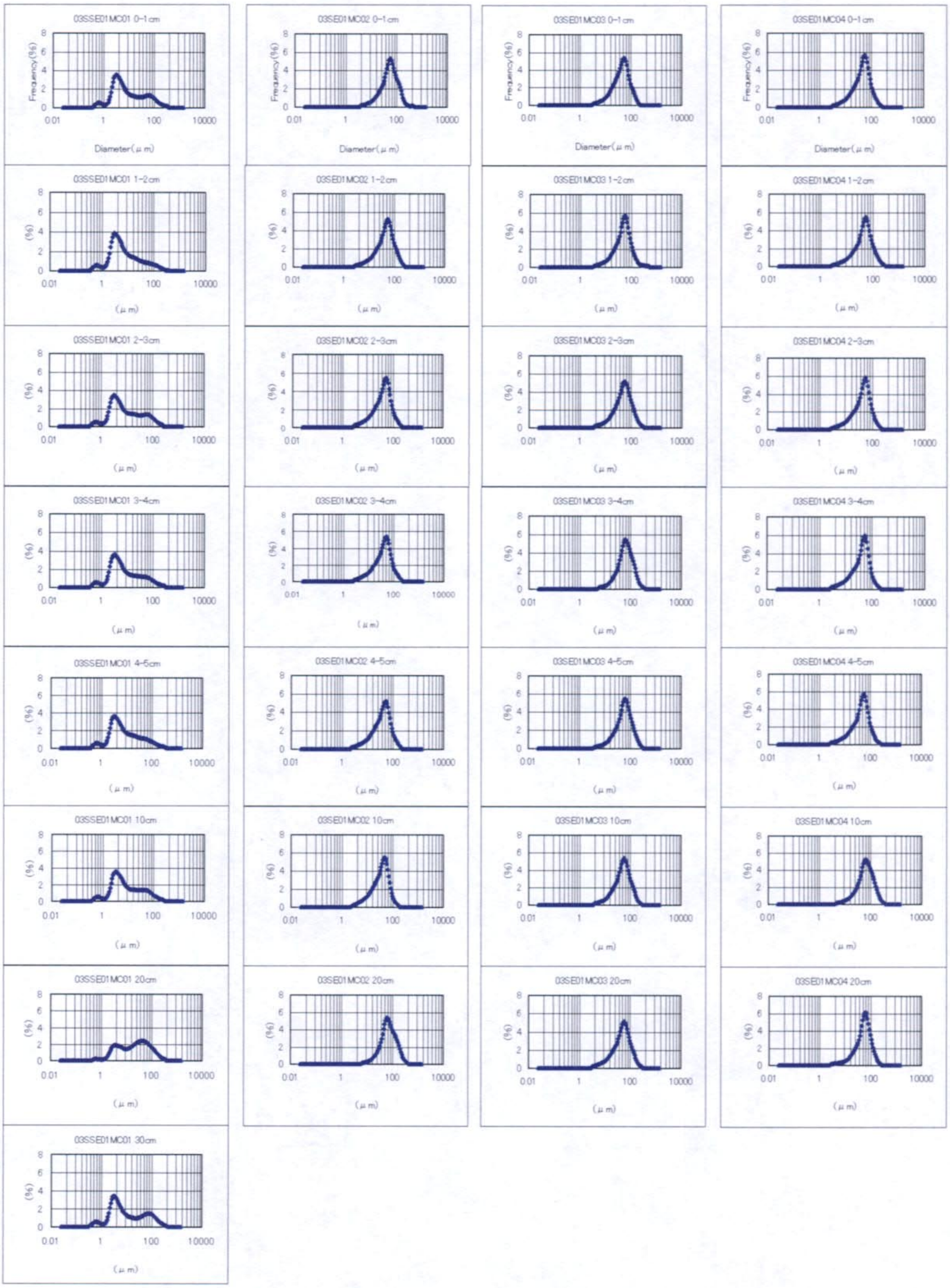


Fig. 3-5-5 Sediment Particle Size Distribution at Each Station.

Table 3-5-1 Abundance and Vertical Distribution of Metazoan Meiobenthos at Each Station

inds./10cm²

No.	Phylum	Class	Taxa	03SE01MC01-1					03SE01MC01-2					03SE01MC01 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA																
2	GASTROTRICHA		GASTROTRICHA						1.1	2.3				0.6	1.2				1.8
3	NEMATODA	ADENOPHOREA	Desmoscolecidae	13.5					5.6	2.3				9.6	1.2				10.8
4			NEMATODA	163.7	29.3	4.5	2.3	2.3	105.0	65.5	22.6	13.5	13.5	134.4	47.4	13.6	7.9	7.9	211.2
5	KINORHYNCHA		KINORHYNCHA	1.1										0.6					0.6
6	LORICIFERA		LORICIFERA																
7	TARDIGRADA		TARDIGRADA																
8	SIPUNCULA		SIPUNCULA																
9	ANNELIDA	POLYCHAETA	Spionidae	1.1										0.6					0.6
10			Sabellidae	1.1										0.6					0.6
11			POLYCHAETA																
12		OLIGOCHAETA	OLIGOCHAETA																
13	ARTHROPODA	ARACHNOIDEA	Acarina																
14		CRUSTACEA	Ostracoda						1.1					0.6					0.6
15			Harpacticoida	4.5					5.6					5.1					5.1
16			nauplius larvae	4.5					5.6					5.1					5.1
17			Copepoda						1.1					0.6					0.6
18			TANTULOCALIDA																
			total	189.5	29.3	4.5	2.3	2.3	125.1	70.1	22.6	13.5	13.5	157.8	49.8	13.6	7.9	7.9	237.0

No.	Phylum	Class	Taxa	03SE01MC02-1					03SE01MC02-2					03SE01MC02 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA	1.1										0.6					0.6
2	GASTROTRICHA		GASTROTRICHA	3.4					3.4					3.4					3.4
3	NEMATODA	ADENOPHOREA	Desmoscolecidae	1.1	2.3				2.3					1.7	1.2				2.9
4			NEMATODA	124.1	70.0	38.4	18.1	6.8	190.7	36.1	27.1	15.8	11.3	157.4	53.1	32.8	17.0	9.1	269.4
5	KINORHYNCHA		KINORHYNCHA																
6	LORICIFERA		LORICIFERA																
7	TARDIGRADA		TARDIGRADA																
8	SIPUNCULA		SIPUNCULA																
9	ANNELIDA	POLYCHAETA	Spionidae																
10			Sabellidae						5.6					2.8					2.8
11			POLYCHAETA						4.5					2.3					2.3
12		OLIGOCHAETA	OLIGOCHAETA	1.1					2.3					1.7					1.7
13	ARTHROPODA	ARACHNOIDEA	Acarina																
14		CRUSTACEA	Ostracoda						4.5					2.3					2.3
15			Harpacticoida	7.9	2.3		2.3		15.8					11.9	1.2		1.2		14.3
16			nauplius larvae	10.2					13.5	4.5				11.9	2.3				14.2
17			Copepoda	1.1					3.4					2.3					2.3
18			TANTULOCALIDA																
			total	150.0	74.6	38.4	20.4	6.8	246.0	40.6	27.1	15.8	11.3	198.3	57.8	32.8	18.2	9.1	316.2

No.	Phylum	Class	Taxa	03SE01MC03-1					03SE01MC03-2					03SE01MC03 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA																
2	GASTROTRICHA		GASTROTRICHA	1.7										0.9					0.9
3	NEMATODA	ADENOPHOREA	Desmoscolecidae	1.1		1.1			4.0	2.3				2.6	1.2	0.6			4.4
4			NEMATODA	14.7	10.2	4.5		3.4	23.1	4.5	7.9		2.3	18.9	7.4	6.2		2.9	35.4
5	KINORHYNCHA		KINORHYNCHA						0.6					0.3					0.3
6	LORICIFERA		LORICIFERA						1.7	7.9				0.9	4.0				4.9
7	TARDIGRADA		TARDIGRADA	1.7					1.1					1.4					1.4
8	SIPUNCULA		SIPUNCULA																
9	ANNELIDA	POLYCHAETA	Spionidae																
10			Sabellidae																
11			POLYCHAETA						1.7		1.1			0.9		0.6			1.5
12		OLIGOCHAETA	OLIGOCHAETA																
13	ARTHROPODA	ARACHNOIDEA	Acarina																
14		CRUSTACEA	Ostracoda	2.3		2.3			0.6		1.1			1.5		1.7			3.2
15			Harpacticoida	6.2	2.3	2.3	1.1		9.0	6.8	1.1	3.4	1.1	7.6	4.6	1.7	2.3	0.6	16.8
16			nauplius larvae	4.5	2.3	4.5			10.7	3.4	2.3	1.1		7.6	2.9	3.4	0.6		14.5
17			Copepoda	0.6	2.3				1.7		1.1			1.2	1.2	0.6			3.0
18			TANTULOCALIDA																
			total	32.8	17.1	14.7	1.1	3.4	54.2	24.9	14.6	4.5	3.4	43.8	21.3	14.8	2.9	3.5	86.3

No.	Phylum	Class	Taxa	03SE01MC04-1					03SE01MC04-2					03SE01MC04 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA																
2	GASTROTRICHA		GASTROTRICHA	2.3					5.6	4.5				4.0	2.3				6.3
3	NEMATODA	ADENOPHOREA	Desmoscolecidae	4.5				4.5	3.4	4.5	2.3			4.0	2.3	1.2		2.3	9.8
4			NEMATODA	158.0	49.7	11.3	13.5	4.5	125.3	29.3	18.1	24.8	9.0	141.7	39.5	14.7	19.2	6.8	221.9
5	KINORHYNCHA		KINORHYNCHA						1.1					0.6					0.6
6	LORICIFERA		LORICIFERA																
7	TARDIGRADA		TARDIGRADA	1.1					5.6	2.3				3.4	1.2				4.6
8	SIPUNCULA		SIPUNCULA	1.1										0.6					0.6
9	ANNELIDA	POLYCHAETA	Spionidae																
10			Sabellidae	1.1					2.3					1.7					1.7
11			POLYCHAETA	2.3					7.9			2.3		5.1			1.2		6.3
12		OLIGOCHAETA	OLIGOCHAETA																
13	ARTHROPODA	ARACHNOIDEA	Acarina						1.1					0.6					0.6
14		CRUSTACEA	Ostracoda	4.5				2.3	2.3					3.4				1.2	4.6
15			Harpacticoida	29.3	2.3				10.2					19.8	1.2				21.0
16			nauplius larvae	16.9					13.5	2.3				15.2	1.2				16.4
17			Copepoda																
18			TANTULOCALIDA	6.8	11.3									3.4	5.7				9.1
			total	227.9	63.3	11.3	13.5	11.3	178.3	42.9	20.4	27.1	9.0	203.5	53.4	15.9	20.4	10.3	303.5

on average at MC01. At MC03, the abundance was only about 30% of the abundance at MC02 and MC04.

The most dominant organisms were nematodes, which accounted for more than 46% of the abundance at MC02 and for more than 76% at the other stations. Nematode numbers were always similar in duplicate cores.

iii. Vertical Distribution

At all stations, over 50% of the meiobenthic organisms were found in the 0-1 cm layers. The densities of all taxa tended to decrease with depth from the surface to deeper layers, and at station MC01 only nematodes were observed below 2 cm sediment depth.

2) Macrobenthos

Abundance and vertical distribution of metazoan macrobenthos at each station are shown in Table 3-5-2.

i. Fauna

24 taxa were identified in the macrobenthos samples, including the major phyla Annelida (eleven taxa) and Arthropoda (five taxa), Cnidaria, Nemertea, Nematoda, Mollusca, Sipuncula, Ectoprocta, Echinodermata and Chordata also appeared. Arthropoda, Annelida and Nematoda were found at all stations. From six to eighteen of the observed taxa were found at each station, with the highest diversity at stations MC02 and MC04 on summit of the seamounts. Although Protozoa (Foraminifera) were observed at all stations, this phylum was excluded from the table.

ii. Abundance

The total metazoan macrobenthos abundance was more than 2800 inds./m^2 on average at summit stations of MC02 and MC04, and about 1500 inds./m^2 on average at MC01. The lowest density was found at MC03 with about 30% of the abundance observed at MC02 and MC04.

Annelids were the most dominant organisms accounting for 43% of the abundance at stations MC03 and MC04 and more than 31% of the abundance at station MC02. At station MC01, however, arthropods, followed by nematodes, had the highest densities. Comparing the duplicate samples at each station, no differences in abundance were observed.

iii. Vertical Distribution

Over 63% of the total metazoan macrobenthos abundance was observed in the

Table 3-5-2 Abundance and Vertical Distribution of Metazoan Macrobenthos at Each Station

inds.／m^2

No.	Phylum	Class	Taxa	03SE01MC01-1					03SE01MC01-2					03SE01MC01 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA																
2	NEMERTEA		NEMERTEA																
3	NEMATODA		NEMATODA	141		141			423	141				282	71	71			423
4	MOLLUSCA	BIVALVIA	BIVALVIA						282		141			141		71			212
5	SIPUNCULA		SIPUNCULA																
6	ANNELIDA	POLYCHAETA	Phyllodocidae																
7			Dorvilleidae																
8			Orbiniidae																
9			Paraonidae																
10			Spionidae																
11			Cirratulidae																
12			Maldanidae																
13			Ampharetidae																
14			Sabellidae																
15			POLYCHAETA	423					141					282					282
16		OLIGOCHAETA	OLIGOCHAETA																
17	ARTHROPODA	CRUSTACEA	Cypridinidae																
18			Ostracoda																
19			Harpacticoida	423		141			141	141				282	71	71			423
20			Tanaidacea						141					71					71
21			Isopoda	141										71					71
22	ECTOPROCTA	BRYOZOA	BRYOZOA																
23	ECHINODERMATA	OPHIUROIDEA	OPHIUROIDEA																
24	CHORDATA	UROCHORDATA	UROCHORDATA																
			total	1128	0	282	0	0	1128	282	141	0	0	1128	141	212	0	0	1481

No.	Phylum	Class	Taxa	03SE01MC02-1					03SE01MC02-2					03SE01MC02 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA	141					141					141					141
2	NEMERTEA		NEMERTEA																
3	NEMATODA		NEMATODA	423					705	141				564	71				635
4	MOLLUSCA	BIVALVIA	BIVALVIA						282					141					141
5	SIPUNCULA		SIPUNCULA																
6	ANNELIDA	POLYCHAETA	Phyllodocidae																
7			Dorvilleidae																
8			Orbiniidae	141										71					71
9			Paraonidae							141					71				71
10			Spionidae						141	141				71	71				141
11			Cirratulidae	282										141					141
12			Maldanidae						141	141				71	71				141
13			Ampharetidae																
14			Sabellidae	141										71					71
15			POLYCHAETA	141		141			141					141		71			212
16		OLIGOCHAETA	OLIGOCHAETA	141					141	141				141	71				212
17	ARTHROPODA	CRUSTACEA	Cypridinidae							141					71				71
18			Ostracoda						282			141		141			71		212
19			Harpacticoida	423					141	141				282	71				353
20			Tanaidacea						282					141					141
21			Isopoda	423					282					353					353
22	ECTOPROCTA	BRYOZOA	BRYOZOA	141					282					212					212
23	ECHINODERMATA	OPHIUROIDEA	OPHIUROIDEA																
24	CHORDATA	UROCHORDATA	UROCHORDATA						141					71					71
			total	2397	0	141	0	0	3102	987	0	141	0	2750	494	71	71	0	3384

No.	Phylum	Class	Taxa	03SE01MC03-1					03SE01MC03-2					03SE01MC03 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA																
2	NEMERTEA		NEMERTEA																
3	NEMATODA		NEMATODA	141			141		141				141	141			71	71	282
4	MOLLUSCA	BIVALVIA	BIVALVIA																
5	SIPUNCULA		SIPUNCULA																
6	ANNELIDA	POLYCHAETA	Phyllodocidae																
7			Dorvilleidae							141					71				71
8			Orbiniidae																
9			Paraonidae																
10			Spionidae																
11			Cirratulidae						141					71					71
12			Maldanidae																
13			Ampharetidae																
14			Sabellidae																
15			POLYCHAETA	141					141					141					141
16		OLIGOCHAETA	OLIGOCHAETA		141				141					71	71				141
17	ARTHROPODA	CRUSTACEA	Cypridinidae																
18			Ostracoda						282					141					141
19			Harpacticoida	141										71					71
20			Tanaidacea						141					71					71
21			Isopoda																
22	ECTOPROCTA	BRYOZOA	BRYOZOA																
23	ECHINODERMATA	OPHIUROIDEA	OPHIUROIDEA																
24	CHORDATA	UROCHORDATA	UROCHORDATA																
			total	423	141	0	141	0	987	141	0	0	141	705	141	0	71	71	987

No.	Phylum	Class	Taxa	03SE01MC04-1					03SE01MC04-2					03SE01MC04 average					
				0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	total
1	CNIDARIA		CNIDARIA																
2	NEMERTEA		NEMERTEA		141										71				71
3	NEMATODA		NEMATODA	564					423				141	494				71	564
4	MOLLUSCA	BIVALVIA	BIVALVIA																
5	SIPUNCULA		SIPUNCULA	141					282					212					212
6	ANNELIDA	POLYCHAETA	Phyllodocidae	141										71					71
7			Dorvilleidae																
8			Orbiniidae																
9			Paraonidae	141										71					71
10			Spionidae						141	141				71	71				141
11			Cirratulidae	141	141									71	71				141
12			Maldanidae																
13			Ampharetidae				141										71		71
14			Sabellidae							141					71				71
15			POLYCHAETA	282					141	141	141			212	71	71			353
16		OLIGOCHAETA	OLIGOCHAETA	282					141	141				212	71				282
17	ARTHROPODA	CRUSTACEA	Cypridinidae																
18			Ostracoda	141		141				282		141		71	141	71	71		353
19			Harpacticoida																
20			Tanaidacea		141										71				71
21			Isopoda	141					141					141					141
22	ECTOPROCTA	BRYOZOA	BRYOZOA	141					141					141					141
23	ECHINODERMATA	OPHIUROIDEA	OPHIUROIDEA									141					71		71
24	CHORDATA	UROCHORDATA	UROCHORDATA																
			total	2115	423	141	141	0	1410	846	141	282	141	1763	635	141	212	71	2820

uppermost layer at every station. The density of all taxa showed the tendency to decrease with increasing sediment depth. Although maximum numbers of taxa were found at stations MC02 and MC04, only Nematoda, Ampharetidae, Polychaeta, Ostracoda and Ophiuroidea were found below the 2-3 cm layer at these stations.