Only two samples; 95SLC20R and 95SCB08R, are shown in Fig. 5-5-5, and the rest of samples are plotted in the same range as these two.

• Group B: Patterns show the gentle slope between La and Sm, and descend to the left (depleted in light-REE)

5 samples: 95SFPG02R, 95SFPG03R, 95SCB03R1, R2, 95SCB06R

Three samples (95SFPG03R, 95SCB03R2 and 95SCB06R) are plotted in Fig. 5-5-5. All five samples show a similar pattern but they have the different concentration of each element. The samples of this group have no common geological features and the reason for this variation of the concentration is unknown. 95SFPG03R, which occupies the lowest side of the Fig 5-5-5, was collected on the knoll closest to the island arc (the Tonga islands).

• Group C: Pattern shows the gentle slope between La and Sm and almost flat line 1 sample: 95SEPG01R

This sample was collected on the knoll west of the spreading center and has the different geological environment from those of other samples.

Except for one sample of Group C, the variations of chondrite normalized pattern are not related to the geological and petrological features. The glass part of the child margin (R2 and CN at the end of sample number) and the inner part of the same body (R1 and R at the end of the sample number) shows no differences in chondrite normalized pattern.

As mentioned above, the chemical composition suggests that the basalt produced by the volcanic activities of the spreading center in the Lau basin belong to tholeiitic series and they have chemical characters both of the island arc tholeiite and mid-oceanic ridge basalt.

5-6 Chemical Analysis of Sea Floor Sediments

The chemical analyses of seventeen elements, relating to the hydrothermal activities and mineralization, were conducted for the muddy sediments collected by LC, FPG and CB. A total of 141 samples, consisting of 130 samples collected by LC at 19 sites, 2 samples collected by FPG at 2 sites and 9 samples collected by CB at nine sites, were chosen for the chemical analyses. The results are shown in Table 5-6-1 (1)-(4).

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Table 5-6-1(1)

Results of chemical analysis of sea floor sediments.

Ÿ $\forall \forall \nabla \nabla$ $\overrightarrow{\mathbf{v}}$ \forall ∇ $\nabla | \nabla$ \forall $\triangleleft \triangleleft$ $\forall \forall$ 4 4 $\overline{\Delta}$ $\forall \forall$ $\forall \forall \forall \forall$ $\Delta | \Delta$ \forall Ϋ́Ι 4 ភ្នេដ្ឋ ŝ -2 5 \$ 0 0 90 3 C1 50 32 0 90 $\overline{2}$ ŝ 30 5 90 20 <u>e</u>j ġ 28 3 33 11 ñ 0 5 20 ģ 3 Edd 5 4 S 7 ŝ 8 3 <u>_</u>1 4 3 0 3 17 õ 2 4 4 сл 24 23 25 o 10 4 N 62 6 ŝ 28 udd Ź 18 16 44 4 3 53 хî 24 15 33 4 26 23 6 53 23 17 ដ 9 24 õ 53 5 25 4 7 5 5 S bpm 8 62110 64978 71972 58403 77568 66936 71902 74140 75119 68685 71063 75399 75609 74000 69174 74910 77498 68964 54626 75819 72182 69384 54976 70014 71203 69454 71412 75189 74980 56375 56025 60082 73091 69384 31754 60573 undd Fc 4610 3340 2260. 138 260 1640 10001 3250 4070 4280 1580 3910 4030 4140 4350 270 4 6140 2810 3320 1780 10061 394 203 4190 967 102 530 2350 4830 550 563 4010 2650 107 1400 397 -MM HIdd 33 34 19 ŝ 59 28 29 40 3 5 26 30 38 8 44 8 0 4 ŝ ģ 4 ŝ 5 2 99 14 33 e B 6 42 101 26 22 Zn udd 5 4 থ ŝ Q Ś Ś 'n $\overline{\nabla}$ ò Ś 0 ц 4 ŝ m ∇ 20 â š 16 5 шdd à 88 88 51 58 58 61 61 60 54 66. 312 001 03 53 20 09 16 133 14 38 30 25 98 E 32 128 86 34 66 42 3 87 47 5 3 g 086 750 900 S40 860 850 810 850 860 | 950 | 1140 800 1060 940 680 720 980 0101 \$80 930 780 860 066 500 140 870 950 540 **S**80 1000 800 1160 870 710 s IIIdd 238 265 242 268 239 633 314 58 213 170 156 259 263 306 272 195 213163 131 281 267 261 201 161 227 181 an Ed 0.6 33870 0.3 58638 0.3 60402 54193 55604 64072 63648 68588 69858 63930 63013 55039 57439 39022 42903 67247 44384 77620 74162 54545 64001 62025 69011 62307 65977 66118 62237 66188 59767 61743 42409 88557 83759 57933 90815 52005 ឡផ្ត 4 0.4 0.4 0.3 0.3 0.4 4 4.0 40 0.3 0.4 0.3 0.3 0.4 4.0 0.4 4.0 0.4 0.6 0.4 4.0 4.0 б. О 0.3 0.6 0.7 0.4 0.3 <u>6</u> 0.3 ័រផ្ត 0.2 0.2 <u>c</u>: 0 0.2 000 3 0.2 0 0 6.5 Ç.1 3 50 0.4 0.2 0.2 0.1 3 0.2 50 0.2 0.3 S 0.3 4.0 ε Ο 0.3 0.1 5 5 10 0.1 20 0 5 0.1 ds mq ¢ ? <u>s o</u> 2.8 S. 0 7.41 6.6 7.6 8.1 6.4 0.3 10.01 16.8 6.8 8.2 3.6 ŝ 1.0 6.7 0 9.3 7.3 4 6.5 5.0 6.3 ñ 5.7 16.5 5 ŝ udd A: 15.90 19.40 16.60 12.80 12.30 15.50 21:30 2 18.90 19.70 20.20 16.80 19.80 16.30 21.30 24.80 19.00 16.60 12.50 19.80 16.90 18.40 16.60 12.80 16.20 8.83 12.60 12.50 17.90 14.30 9.75 13.00 15.80 38.50 10.70 21.00 Noda Add ত 3 4 30 04 25 Е Q Ø 60 0 999 9 Q va õõ 1 2 and Dpb Sampling depth 5 011-20 100-105 35-40 25-30 65-70 <u>80-85</u> 5-40 5-60 80-85 50-25 15-20 55-60 65-70 50-55 25-30 5-30 45-50 85-90 35-40 10-75 65-70 70-75 35-40 20-25 35-40 90-95 5-10 55-60 90-95 S-10 5-10 5-10 S-10 61-5-10 50 0-0 95SLC07 M1 95SLC07 M2 95SLC07 M3 95SLC07 M4 958LC10 M1 958LC10 M2 958LC10 M3 958LC10 M3 95SLC03 M4 95SLC04 M1 95SLC05 M1 95SLC05 M2 95SLC08 M1 95SLC08 M2 95SLC08 M3 95SLC08 M4 95SLC08 M5 95SLC09 M1 95SLC14-M3 **SSLC13 M2** 95SLC13 M3 **JSSLC13 M5 95SLC14 M2 95SLC05 M3** SSLCOS MS 95SLC09 M2 **PSSLC13 M1 5SLC13 M4 JSSLC14 MI JSSLC14 M4 5SLC04 M2 95SLC04 M3** SSLC04 M4 95SLC05 M4 95SLC03 M1 95SLC03 M2 **35SLC03 M3** Sample No.

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Sample No.	Sampling depth	ΡŪ	- V 8	÷	20	3	3	5 Ta	~	3	2 2	4	цМ	Ş	3	Ż	5	3
	5	οdd	add	шdd	- mdd -	ELC	udd	udd	udd	udd	uidd	udd	urdd	Hdd	mdd	HIdd	mdd	undd
95SLC14 MS	80-85	2	14.30	3.4	1.0	0.3	41562	202	680	191	1	13	765	52807	12	12	¢	A
95SLC15 M1	5-10.		23.50	9.9	0.2	9.0	68305	246	IIIO	107	9	54)	4350	74000	26	15	20	4
95SLC15 M2	15-20	11	36.30	4.3	1.0	0.4	63013	175	1330	72	10	27	734	74140	24	9	23	4
95SLC17 M1	5-10	11	25.50	11.7	0.2	0.6	79525	254	1160	161	2	38	4050	69594	22	15	18	4
95SLC17 M2	30-35	8		7:5	0.2	0.3	71057	228	1020	56	4	26	3070	72532	2.5	12	1.2	4
95SLC17 M3	50-55	8		5.5	1.0	0.4	70140	201	820	45	ŝ	21	2060	76518	26	6	13	4
95SLC17.M4	80-85	2		5.9	0.2	C.3	70493	205	006	54	m	22	1840	30044	26	7	12	4
95SLC19 M1	S-10	V	13.30	6.0	0.2	0.5	54828	200	940	102	£	47	29.50	77847	28	6	23	4
95SLC19 M2	30-35			5.6	0.1	0.3	56662	186	1760	- 93	3	41	1020	76378	25	7	19	A
95SLC19 M3	45-50	8		4.5	0.1	0.3	56804	178	1630	80	5	33	996	13281	26	-	20	A
95SLC19 M4	65-70	6	27.00	2.9	0.1	0.4	60685	675	1630	59		21	605	74140	25	4	20	4
95SLC21 M1	5-10	Q	13.00	3.8	0.2	0.4	59203	168	720	62		27	1590	73301	25	6	25	4
95SLC21 M2	25-30	4		4.1	0.1	0.4	61037	193	890	36	6	151	902	73161	25	5	101	4
95SLC21 M3	45-50	4	16.10	7.4	0.2	7. 0	69434	213	880	-92	5	30	2890	73860	25	13	24	4
95SLC21 M4	70-75	4	17.40	1.8	0.1	0.4	63013	168	710	20	٦	1.0	313	77707	26	3	13	4
95SLC21 MS	90-95	-	14.70	4.0	0.1	0.3	61955	188	830	46	6	17	1460	77637	28	9	ΓI	₹
95SLC26 M1	5-10	8	18.50	13.0	0.2	0.4	86158	-306	11/20	84	20	43	5590	72112	26	19	41	⊽
95SLC26 M2	30-35	30	16.00	5.6	0.2	0.3	65906	206	760	56	m	23	2270	27008	27	4	- 13	∀
95SLC26 M3	45-50	0		3.0	0.2	0.3	60685	177	720	. 35		14	1770	76588	25	5	11	4
95SLC26 M4	65-70	8	ι.	2.7	0.1	0.3	66471	222	800	69	4	25	1590	73721	24	9	13	4
95SLC26 M5	90-95	8	11.10	5.1	1.0	0.4	59626	208	0.16	54	2	20	666	72252	23	4	14	4
95SLC26 M6	110-115	6	14.00	11.4	0.2	0.5	73950	241	930	101	8	58	4030	73231	24	16I	16	4
95SLC26 M7		4	18.20	18.3	0.3	0.3	92367	306	0601	128	12	11	8810	66866	23	27	20	-
95SLC26 M8		10	13.70	3.2	0.2	0.4	44455	237	890	32	1	14	2730	47212	14	8	12	4
95SLC26 M9		4	13.80	3.0	1.0	0.5	39727	272	860	23	1	14	613	41337	6	4	6	⊽
95SLC26 M10		8	1.1	13.6	0.2	0.5	85170	373	870	70	8	35	4900	50499	18	15	24	4
95SLC27 M1		10	15.70	5.7	0.1	0.5	65130	192	920	16	3	38	1640	724.62		6	19	V
95SLC27 M2	20-25	11 -	15.00	4.9	0.1	0.4	69787	210	860	63.	2	22	1290	73021	25	6	19	4
95SLC27 M3	35-40	8	13.20	4.9	1.0	4.0	59767	201	1280	48	2	21	671	72182		5	13	∀
95SLC27 M4	70-75	8		4.7	0.2	0.4	67529	195	850	54	2	24	1220	69524		9	14	₽
95SLC27 MS	001-56	8		2.7	1.0	0.4	55039	190	760	52	2	23	512	65747	23	S	21	A
95SLC27 M6	125-130	\$	80.70	1.2	0.1	0.3	63084	121	890	102	4	. 13{	200	78617	32	4	35	4
95SLC27 M7	155-160	\$	17.00	3.8	0.2	0.3	176691	127	940	34	2	18	1170	34132	11	4	19	₫
95SLC27 M8		2		3.5	0.2	0.3	141903	149	1080	24	2	17	774	42945		5	20	1
95SLC27 M9	185-190	8	14.40	5.1	0.2	0.5	67811	185	830	51	2	23	608	72042	26	9	24	₹
95SLC27 M10		₹	28.20	4.9	0.1	0.4	71269	223	170	64	с	23	539	60361	22	8	55	4

Table 5-6-1 (2) Results of chemical analysis of sea floor sediments

Table 5-6-1 (3) Results of chemical analysis of sea floor sediments

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Valiple No.	Sampling depth	Au	88	\$¥	8	ŗ	3	3	~	3	<u>e</u>	5	E.	2	3	Z	5	3
	ų	٥dd	odd	– wdd	Wdd	udd	wdd	шdd	Hidd	ndd	- urdd	шdd	bru	шdd	шdd	undd	bpm	nudd
95SLC28 M1	5-10	0	15.80	6.1	0.2	0.6	60614	200	950	84	3	36	2130	75889	27	11	21	Ą
95SLC28 M2	15-20	\$	21.10	15.0	0.3	0.3	887.69	309	1230	87	8	43	6410	70713	27	21	19	4
95SLC28 M3	45-50	4	12.50	5.4	0.2	0.3	63860	203	960	56	3	23	3000	77078	27	6	15	4
95SLC28 M4	70-75	8	29.60	3.4	0.1	0.3	61108	173	1210	38	2	16	730	75050	25	S	12	4
95SLC28 M5	85-90	17	24.60	2.3	0.1	0.3	61390	166	950	28		11	669	75609	29	4	15	4
95SLC28 M6	105-110	18	17.30	6.5	0.2	0.3	66188	224	006	11.	6	23	2240	75119	26	10	16	Ą
95SLC28 M7	135-140	4	25.50	2.8	0.1	0.4	59273	176	1170	1.5		12	200	75119	26	4	13	4
95SLC28 M8	160-165	4	19.60	1.6	0.1	0.3	59697	175	880	25	1	8	563	76099	26	4	17	4
95SLC28-M9	180-185	12	10.80	5.8	0.1	0.3	58991	- 220 -	10201	57	67	20	1450	72741	25	7	16	∀
95SLC28 M10	205-210	Q	17.20	9.8	0.2	0.3	67600	245	10101	69	6	361	2610	67286	24	12	20	4
95SLC28 M11	1230-235	Q	18.60	13.0	0.3	0.4	S2489	- 264	1040	108	20	50	5370	72602	25	21	18	4
95SLC28 M12	250-255	3		6.6	0.2	0.4	49183	254	1060	4	ŝ	23	3190	47282	14	10	15	4
95SLC29 MI	0-5	<u>छ</u>	Ł	8.1	0.2	0.7	70563	244	1150	82	4	43	3410	71902	27	15	25	4
95SLC29 M2	5-15	9	21.80	16.5	0.3	0.3	97871	328	1260	96	6	47	7160	68405	26	25	17	4
95SLC29 M3	15-25	Ø	ł.	9.2	0.2	- 0.3	79102	256	1070	68)	S	32	4290	73581	27	16	14	4
95SLC29 M4	25-35	18	15.70	. 9.3	0.2	0.3	78678	252	950	71	6	32	3930	73161	26	15	17	4
95SLC29 MS	35-45	17	16.00	13.9	- 0.3	0.3	83194	278	1110	93	6	46	5650	69034	24	20	19	Ŷ
95SLC29 M6	45-55	20	13.20	6.6	0.2	0.4	72116	221	980	83	9	45	3930	74280	27	14	21 [-	7
95SLC29 M7	55-65	12	13.20	22.1	0.3	0.3	111278	336	1180	130	14	75	11200	62320	. 23	37	22	1
95SLC29 M8	65-75	Q	16.10	10.4	0.2	0.4	68094	300	066	64	12	36	5670	52248	17	18	16	∀
95SLC29 M9	75-85	Ŷ	13.90	9.4	0.2	0.3	83053	270	1020	. 61 .	6	33	5400	58753	- 21	17	21	7
95SLC29 M10	85-95	Ŷ	15.60	10.4	0.2	0.4	70916	340	1010	58	7	29	5320	42736	15	16	18	Ą
95SLC29 M11	95-1.05	2	12.20	1.3	1.0	0.5	34717	289	750	16	r-i	- 7	548	34272	6	5	11	V
95SLC29 M12	105-115	17	16.20	12.6	0.3	0.5	95896	335	1140	76.	S	38	5350	69034	28	16	21	A
95SLC29 M13	115-125	₹	9.45	5.0	0.1	0.6	20069	223	190	55	3	25	2150	72811	28	8	26	4
95SLC29 M14		0	11.60	5.9	0.2	0.4	63578	212	990	53	3	28	2660	69594	24	10	20	4
95SLC29 M15	135-145	0	14.10	6.5	0.2	0.5	66400	273	1030	45	4	27	2490	61061	20	10	19	4
958LC29 M16	145-155	7	13.30	5.7	0.1	0.4	69152	249.	840	49	ũ	23	2020	63719	23	S	26	4
95SEC29 M17	155-165	Q	16.90	3.4	0.1	0.4	68023	176	650	52	2	23	1180	71762	30	6	35]	V
95SLC29 M18	165-175	13	16.50	1 1	0.2	0.4	80372	243	880	62	4	27	3260	67845	24	12	21	₽
95SLC29 M19	175-185	Ø	12.70	15.4	0.3	0.3	107.680	343	1020	85	10.1	- 41	6340	64138	26	17	34	₽
95SLC29 M20	185-195	V	15.80	6.5	- 0-2	0.7	69787	219	870	74	4	31	3030	71273	27	12	22	₽
95SLC29 M21	195-205	0	15.40	17.4	0.3	0.4	112619	343	1250	100	13	51	7760	60851	23	23	24	Ą
95SLC29 M22	205-215	6	12.60	10.7	0.2	0.5	92650	269	066	77	٤ .	37	5610	65887	25	18	26	4
95SLC29 M23	215-225	13	12.00	11.4	0.2	0.4	84535	315	1040	63	8	37	5930	57074	18	17	.15	V
95SLC29 M24	225-235	2		2.3	0. 1 .	0.5	46078	215	760	24	1	15	705	53996	13	S	6	4
95SLC29 M25	235-245	V	11.20	5.8	0.1	0.4	76702	246	870	ŝč	4	25	2100	62600	23	6	2.8	7

3	mdd	₽	Ą	Ą	∀	Ą	Ą	Ą	Å	7	7	Ą		Ā	4	7	A	4	₫	₫	-4	н	4	Ą	4	4	V	4	Ą	A	4	V
კ კ	ppm f	31	21	6	6	15	11.	14	14	18	20	12	22	18	13	15	18	24	151	7	24	80	8	18	13	19	51	45	61	. 18	19	22
ī		18	18	8	2	10	14	6	8	10	19	3	13	12[15	8	11	25	11	4	13	21	9	27	24	191	17	20	27	17	16	14
8	ppm	26	24	17	16	20	27	25	24	27	_ 24		. 23	27	26	24	- 25	25	16	6	24	19	13	22	21	23	26	32	28	19	51	25
Fc	mdd	63789	63089	58193	58403	63229	73791	74070	70993	74840	66237	41127	60431	74420	74420	74910	73161	653.27	52947	41267	62530	40218	49100	63928	\$7704	66586	74070	76728	20993	59032	64488	67006
чW	undd .	5610	5980	1730	374	1870	3970	2520	2280	2530	5010	380	3870	2540	3840	2080	2530	\$220	2520	645	3920	3180	1270	8000	6820	5540	2900	2610	5570	4460	4410	3110
Zn	undd	37	37	22	17	35	30	20	18	36	50	11	33	40	28	12	34	54	22	13	33	33	22	50	51	- 86	51	34	74	51	49	36
Qa	- Wdd	6	6	Э	2	4	S.	3	C 1	4	6	1	7	4	ŝ	, LU	4	11	3	1	2	8 .	5	14	13	16	2	10	11	1	9	Š
ð	undd	76	72	36	29	62	99	15	50		66	17	89	83	5.9	52		100	46.	. 20	69	46	35	16	06	- 109	64	52	108	93		73
	undd	1_	950	780	860	970	1090	850	066	830	1060	910	960	1000	1020	940	850	1160	970	770		1100	650	1340	1350	1290	1	800	13.80	1340		1270
	Шdd	282	Ŀ	249		181		200	196		265	259	310	227	244	210		294		<u> </u>				329	279	315	193	156	1 254	249		1 260
3	mdd	102176	88063	50029	49465	55604		61390	56521		.	39092	92015	64142	75362	64424	<u> </u>	98506	54475	39374	99353		48406	91732	<u> </u>	810.07	68729	75432	84747	69293		88204
ඊ	Hidd		1 19.4	8.0	L	0.3	0.4	4.0.4	0.3	0.4	0.4	0.5	0.4	0.5	4.0		L_	3 0.3	2 0.4	1 0.5	2.0.4	2.0.2	2 0.3	t 0.4	0.4	21-0.7	2 0.4	2 0.3	3 0 4	2.0.4	2 0.5	2 0.4
q:	Erde				7 0.1				1 0.2		:	5 0.1				0							3 0.2	6 0.4			3 0.2	L	0 0.3			6 0.2
V	Had Had	_	0 11.0	0 4.0	0 2.7		0 8.8	0.2 5.0	0 5.1		0 14.3	0 1.6	0 12.4	0 7.6					0 6.0	0 2.8	1.11 0	0 8.9	0 5.3	0 14.6	0 13.6	0 10.7	0 6.3	0 5.9	0 13.0	0 12.1	0 11.3	
1 Ag		5	Q 10.40	6 11.30	21 12.20	2 19.00	15 15.20	14 14 10	2 19.00	10 19.10	16 26.80	<2 18.90	<2 20.00	9 17.60	7 17.10	2 11.80		1	2 15.70	2 18.40	10 27.90	9 14.90	2 17.90	4 36.20	20.40	14 25.30	I	11 21.40	18 37.20	24.50	8 24.70	
th i Au	. _											-				:			-			-	-									
Sampling depth	C. C	245-255	255-265	265-275	275-285	5-10	25-30	50-55	65-70	80-85	105-110	145-150	155-160	S-10	25-30	45-50	70-75	95-100	115-120	135-140	145-150											
Nample No.		95SLC29 M26	M27				95SLC30 M2		١.	1	Ì-		I.	95SLC31 MI		Ľ			Γ	Γ	95SLC31 M8	95SFPG01	95SFPG02	95SCB01	95SCB02	95SCB03	95SCB05	95SCB06	95SCB07	95SCB09	95SCB10	95SCB11

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Table 5-6-1(4) Results of chemical analysis of sea floor sediments

(1) Analytical Method

The analytical methods, together with analyzed elements, are shown below. The numbers in the parenthesis following the each element denote the detection limit. After drying until reaching to the constant weight, sample preparation was conducted.

• ICP: Au(2ppb), Au(0.02ppm), As(0.2ppm), Sb(0.2ppm), Cs(0.1ppm), Ca, Ba, Cu, Pb, Zn, Mn, Fe, Co, Ni, Cr, Cd (from Ca to Cd: 0.1ppm)

• XRF: S(50ppm)

(2) Statistical Analysis

The statistical analysis of the analytical results consists of the calculation of basic statistics and the multivariate analysis. The values less than detection limit are replaced with the half value of the detection limit. Cd is excluded for this analysis, since almost samples show the value below than the detection limit. Because geochemical data generally shows a normal distribution in logarithm, the analytical values are converted to logarithm for the following analysis.

1) Basic Statistics

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The basic statistics are given in Table 5-6-2. The reason for high Ca is that the sea floor sediments include calcium carbonate of organic origin such as microfossils. Similarly, the sea floor sediments are rich in Mn and Fe because they include considerable amount of Mn-Fe oxides.

The average values of the basalt (Table 5-5-3) are also given in Table 5-6-2. A comparison of these average values shows that eight elements of Au, Ag, As, Sb, Cs, Ba, Pb and Mn are higher in the sea floor sediments than in the basalt. Among these, As and Ba show large differences. While, S and Cr are less in the sea floor sediments than in basalt. The averages of the base metal elements (such as Cu, Pb, Zn and Fe), which are related to the minerals occurring in the submarine hydrothermal deposits, are not clearly high to indicate the hydrothermal activities.

2) Multivariate Analysis.

The factor analysis, one of the multivariate analysis, was conducted for 16 elements (Cd is excluded.) of 141 samples. The communality is estimated from the multiple correlation coefficients. After the varimax rotation, factor loadings and factor scores are calculated. The correlation coefficients and factor loadings are, respectively, shown in Tables 5-6-3 and 5-6-4.

As given in Table 5-6-4, following elements of two groups show mutually high positive correlation coefficients in each group.

Basic statistics Table 5-6-2

1366 6454 86 287 15.74 rock samples 14.0 0.1 7903L 77651 0.1 Mcan of 32.323 38.6 39.9 26.7 26.96 0.37 0.89 380.4 1416.7 19.43 90.7 115255 163.1 17067.9 94320.3 9 M+2×SD 8.3 23.368 12.6 297.1 1163.9 94.8 49:5 5987.3 29.3 25.5 0.25 0.59 8.44 88221.4 78705.9 8 M+SD 0.8 12.214 181.2 785.5 14.7 736.8 16.8 10.4 2:75 0.26 1.59 0.11 51689.7 61 62 54803.9 ŝ QS-W 0.2 0.18 141.5 645.3 258.5 6.7 8.83 1.29 0.08 18.6 0.69 ò, 12.7 2.5 39565.6 45731.3 M-2×SD 0.362 0.263 0.12 0.51 0.33 0.176 0.116 0.107 0.085 0.236 0.455 0:079 0.302 0.194 0.141 0.171 Std. dev. (s_0) 2.6 3.67 2100.3 22.2 5.89 0.17 232 956.2 53 16.3 **10** 67528.8 55.1 65676.3 10 16.894 Mcan $\left(\frac{1}{2} \right)$ 8.83 0.5 0.5 6 Γ... 0.1 0.1 33870500 80 w. 31754 9 17 121 44 Minimum 19.4 675 6 00611 80 80.7 0.4 1760 133 101 78617 S3 5 22.1 3 190803 Maximum ÷ 141 1+1 141 141 141 111 H 141 141 141 171 141 141 111 Number of sample Unit mdd mqq mqq mdd ppm mqq mqq mqq bpm mdd mqq undd mqq ppb. bpb udd Component name Аu As As ŝ ð Ű Ba õ 2 5 Ž ц 8 5 Ŵ Z

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Standard deviation (std. dev.) is shown in logarithmic scale.

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Table 5-6-3 Correlation coefficient

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N.	141	141	141	141	141	141	1+1	171	1+1	141	141	141	141	1+1	1	.336	
8	141	141	141	141	1+1	141	1+1	1+1	141	141	1+1	1+1	1+1		.335	123 r.	
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Mn	141	141	171	141	141	141	141	1+1	1+1	141	141		.029	.238	-216	.196	
Zn	141	141	141	141	141	141	141	141	1+1	141	<u>-</u> 	.856	133	.306	.859	340	
Pb	141	141	ItI	141	141	141	1+1	1+1	141		.895	.896	.043	.257	-916	.260	
ö	141	141	141.	141	141	141	141	1+1		162.	.931	.796	.329	.486	.800	414	
S	141	141	141	141	141	141	141	 	.492	.338	420	331	.166	.254	.395	.322	
Ba	141	141	Ttl	141	141	1+1		.265	.399	.578	+8+		2.45	138	.529	++0	
ซื	141	141	141	141	1+1	 	.209	413	.500	.593	.489		094	L0t.	.573	.557	
Cs	141	141	141	141	1	2+0 -	.166	036	.133	.1+2	170	.166	- 063	0+0 -	6+1.	058	
Sb	141	141			.029	.554	.435	.263	.586	.752	.663	.786	.002	.200	.792	661.	
As	141	141		.714	133	.512	.577	001	.842	.880	.889	.911	.030	-214	148.	.239	
Ag	141	•	660	.042	- 177	126	- 022	.477	.293	.080	174	100	.232	- 219	820.	.246	
Au -	 	.149	.162	.067	032	.120	601.	.192	. 199	.183	197	.152	.100	- 127 -	.145	.120	
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Note : Correlation coefficients are written in left-bottom side. Numbers of data are written in left-bottom side.

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Communalitie		anderskale zuwanische under dassen ofer bekennt C	actor loading	T.	an ann a' an ann an	Component
	Fifth factor	Fourth factor		Second factor	First factor	name
0.07	-0.016	-0.040	0.222	0.064	0.122	Au
0.56	0.160	-0.071	0.723	0.108	-0.036	Ag
0.88	-0.167	-0.092	0.222	0.030	0.893	As
0.71	0.159	-0.171	0.006	0.030	0.812	Sb
0.17	•0.378	-0.014	-0.121	-0.041	0.131	Cs
0.74	0.249	0.629	0.120	0.110	0.511	Ca
0.47	-0.104	0.112	0.110	-0.254	0.614	Ba
0.51	0.097	-0.193	0.619	0.054	0.290	S
0.93	-0.307	-0.187	0.436	0.309	0.724	Cu
0.90	-0.098	-0.162	0.131	0.058	0.923	Pb
0.92	-0.320	-0.155	0.313	0.131	0.828	Zn
0.94	-0.116	-0.080	0.067	0.063	0.958	Мл
0.95	0.029	0.036	0.182	0.958	-0.035	Fe
0.91	0.049	-0.312	0.143	0.879	0.155	Co
0.90	-0.086	-0.219	0.132	0.117	0.902	Ni
0.76	-0.152	-0.803	0.256	0.147	0.088	Cr

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Table 5-6-4 Results of factor analysis

· As, Sb, Cu, Pb, Zo, Ma, Ni

• Fe, Co

Except for these relations, neither positive nor negative high correlation coefficients exist. The results of factor analysis, also, show the large contribution of these two groups of elements.

In the factor analysis, the number of factors is decided as 5 from the eigenvalue and cumulative contribution. The results of the factor analysis is given below on each factor.

① Factor 1 (FI)

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The factor loading of the each element suggests that As, Sb, Ba, Cu, Pb, Zn, Mn and Ni contribute to F1. This factor seems to be related to hydrothermal activities, but hydrothermal activities are not observed in this survey. Since manganese oxides are attached on the surface of older rock, F1 can be related to the precipitation of manganese on the sea floor. The elements given above are enriched together with manganese oxides in the sea floor sediments.

The samples with high F1 factor score have higher concentration of the above elements.

⁽²⁾ Factor 2 (F2)

Fe and Co are related to F2. This factor is related to the enrichment of Fe and Co, but the cause of this enrichment is unknown. The form of Fe and Co in the sea water (for example, a complex ion is formed or not, the kind of complex ion) and the precipitating way of these (direct precipitation from the sea water, or precipitation from the pore water in the sediments) is different from that of other elements, so that Fe and Co seperately contribute to F2.

The samples with high F2 factor score correspond to the samples of high Fe.

③ Factor 3 (F3)

Ag and S are related to F3. This seems to be related to hydrothermal activities, but no clear evidence is found. The samples with high F3 factor score correspond to the samples of high Ag and S.

④ Factor 4 (F4)

Ca and Cr are related to F4. Calcareous microfossils and the concentration of mafic minerals of volcanic rocks are considered to be the factors controlling F4. The samples with high F4 factor score correspond to the samples with high Ca and Cr.

(5) Factor 5 (F5)

Cs, Cu and Pb show a slightly higher factor loading, but since there are no elements clearly showing high factor loadings of F5, the interpretation of F5 is difficult.

(3) Consideration of the Analytical Results

From the consideration of the relations among characters of muddy sediments, sampling depth and analytical results, the following characteristic tendencies are obtained. In order to study the change of analytical value against the sampling depth in each LC, bar graphs of analytical value for Mn, Cu and Ag, which represent each factor (F1 to F3), are made (Fig. 5-6-1 (1) to (3)). In this figure, the letters after the LC No. (M1 to M29) mean the difference of sampling depth. The actual sampling depths are shown in APPENDIX Table 4 (1) - (3).

1) Relation between the nature and the analytical value of LC samples.

- The black to dark gray volcanic ash and volcanic sand have clearly lower Mn and slightly lower Cu,
- Pb and Zn compared with the normal muddy sediments.
- · Olive mud is lower in Mn compared with brown mud.

2) Relation between the sampling depth and the analytical value of LC samples (See Fig. 5-6-1)

- · There is no clear relation between the sampling depth and the analytical value.
- Depending on the LC site, some elements decrease the values as the sampling depth increases. The example is Mn of 95SLC17, samples of which are brown mud.

3) Relation between the location and the analytical value of LC samples

• There is no clear relation between the location of LC (relative location on south-north direction, distance from the spreading center and topography) and the analytical values.

4) Conclusions

- The analytical values of As, Sb, Ba, Cu, Pb, Zn, Mn and Ni (contributing to F1 in factor analysis) are low in the volcanic sediments (volcanic ash and sand), and high in the ordinary sea floor sediments (muddy sediments).
 - The vertical variations of chemical composition seem to be controlled by the environments of sedimentation rather than by the depth of sediments.

On the basis of the vertical variations of chemical composition, there is no evidence of intensive regional hydrothermal activities at the certain time, because the geochemical anomalies occur very locally.

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Fig. 5-6-1 (1) Bar graphs of chemical analysis data of sea floor sediments (Mn)

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Fig. 5-6-1 (2) Bar graphs of chemical analysis data of sea floor sediments (Cu)

Table 4 (1)-(3).

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95SLC19 M1 95SLC19 M2 95SLC19 M3 95SLC19 M3 95SLC19 M4 95SLC21 M1 95SLC21 M2						C30 MS			· · · · ·		
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95SLC19 M3 _ 6888 95SLC19 M4 _ 6988 95SLC21 M1 _ 6888 95SLC21 M2 _ 6888		_	ļ			C30 M4					
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	Mal	··				.C30 M8 .C31 M1		· · · · · ·			
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95SLC21 M3 275			<u> ····</u>			.C31 M2 .C31 M3					+
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95SLC26 M2			<u> </u>			C31 M6			1		
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95SLC26 M5 6			:	t		SFPG01		1	1	İ	1
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95SLC27 M8					Į				Ag (ppt) }	
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5SLC27 M10 2000			Ļ	ļ	1	Note: T	he lett	ers aft	er the	LC No.	(M1-M2
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Fig. 5-6-1 (3) Bar graphs of chemical analysis data of sea floor sediments (Ag)

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5-7 Microfossil in the Sea Floor Sediments

Among the sea floor sediments collected by LC and FPG, four samples were selected for the identification of foraminifera and radiolaria. The results are given in Table 5-7-1. The photographs of representative microfossils are shown in Fig. 5-7-1 (1), (2).

(1) Foraminifera

Abundant pieces of foraminifera are found in each of the four samples. The foraminiferas found in the four samples are predominantly planktonic foraminifera and benthonic foraminiferas are rarely found. The fossil zone is based on the classification of Blow (1969) and the geological period is based on Berggren et al. (1985) which is applicable for the lower latitude zone. The results are given below.

T

1) 95SLC15 (Depth: 10 to 15cm) (See Fig. 4-1-2 (2))

The planktonic foraminiferas are preserved well. The occurrence of *Globigerinella calida* suggests that the sample is classified to N23 zone (0 to 0.3 Ma). Because the sample contains abundant *Globigerinoides sacculifer*, it belongs to tropical or subtropical area.

2) 95SLC17 (Depth: 40 to 50 cm) (See Fig. 4-1-2 (2))

The planktonic foraminiferas are preserved well. The occurrence of *Globorotalia truncatulinoides* and the absence of *Globigerinella calida* suggest that the sample belongs to early to middle Pleistocene. Because the sample contains abundant *Globigerinoides sacculifer*, it belongs to tropical or subtropical area.

3) 95SFPG01 (See Fig. 4-1-2 (4))

The planktonic foraminiferas are preserved well. The occurrences of *Globorotalia truncatulinoides*, Globigerinella calida and dextral Pulleniatina (genus) suggest that the sample is classified to N23 zone (0 to 0.3 Ma). Because *Globigerrinoides ruber* is more abundant than *Globigerinoides sacculifer*, and *Globorotalia inflata*, which is common in the middle latitude area, occurs, the sample belongs to subtropical area.

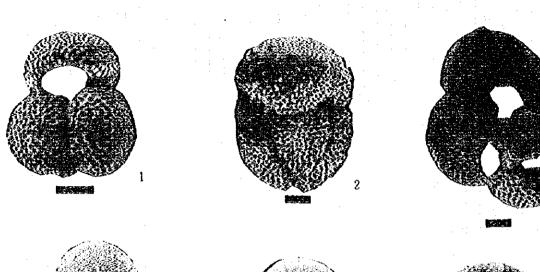
4) 95SFPG02 (See Fig. 4-1-2 (4))

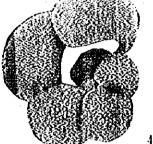
The planktonic foraminiferas are preserved very well. The occurrence of *Globigerinella calida* suggests that the sample is classified to N23 zone (0 to 0.3 Ma). Because the sample contains abundant

Foraminifera			ic number of fo	
Species name	95SLC15 F	95SLC17F	958FPG01F	95SFPG02
Candeina nitida		:		2
Globigerinella acquilateralis	7	11	5	8
G. cəlidə	1		2	3
Globigerinita glutinata	4			6
Globigerinoides conglobalus	10	13	15	13
G. ruber	26	29	40	24
G. saccolifer	27	39	27	51
Globorotalia cressaformis	4	5	7	12
G. inflata	1		10	····
G. menardii			1	1
G. truncatulinoides		3	3	
G. tumida		· · · · · · · · · · · · · · · · · · ·	1	1
Globorotaloides héxagonus	·		1	·
Neogloboquadrina dutertrei	<i></i>		1	1
Orbulina universa	<u>1</u>	11	4	6
			2	1
Pulleniatina obliquiloculata	A state of the second secon		Contractor of the second se	
Radiolaria				he occurrence
Species name	958LC15 F	95SLC17F	95SFPG01F	958FPG02
Acrosphaera lappacea (Haeckel)	+			
Acrosphaeta spinosa (Haeckel)	+	-1-	-+	
Siphonosphacra sp.	4	+	+	
Axoprunum stauraxonium Hacckel	-4-	+	-+-	+
Cenosphaera spp.	···	+	} : •⊧ }	+
Ellipsoxiphus atractus Hacckel	•+	+	+	-+-
Heliosphaera inermis Haeckel		+		
Hexacontium anaximandri (Haeckel)		+,		
Actinommidae genn. et spp. indet.	+			
Didymocyrtis tetrathalamus (Hacekel)		+		
Stylochlamydium asteriscus Hacokel	-+			
Stylodictya multispina Hacekei	· · · · · · · · · · · · · · · · · · ·	-+	+	· · · · ·
Stylodictya camerina Campbell and Clark	· · · · · · · · · · · · · · · · · · ·			· · · · · · · · · · · · · · · · · · ·
Dictyocoryne spp.				
Euchitonia furcata Ehrenberg	+	· †		
Spongaster tetras tetras Ehrenberg	+	.		
other spongodiscids	·f·	-+-		، با با ما معام می
· · · · · · · · · · · · · · · · · · ·	····	+		· · · · · · · · · · · · · · · · · · ·
Hexapyle sp.		-+	·····	
Hexapyle sp. Tetrapyle octacantha Muller	· · ·	1 1		•
Tetrapyle octacantha Muller	-4-			
Tetrapyle octacantha Muller Lithelius minor Jorgensen	-4	+	·····	
Tetrapyle octacantha Muller Lithelius minor Jorgensen Spongurus ef. elliptica (Ehrenberg)	4			· · · · · · · · · · · · · · · · · · ·
Tetrapyle octacantha Muller Lithelius minor Jorgensen Spongurus ef. elliptica (Ehrenberg) Liriospyris costata (Haeckel) juvenile	+	+		
Tetrapyle octacantha Muller Lithelius minor Jorgensen Spongurus ef. elliptica (Ehrenberg)	+	+	- 4 -+ -+	

Table 5-7-1 Results of microscopic observation of microfossils

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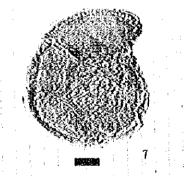








Î



(Foraminifera)

- 1. Globigerinoides ruber (d'Orbigny)
- 2. Globigerinoides conglobalus (Brady)
- 3. Globigerinoides sacculiler (Brady)
- 4. Globigerinella aequilateralis (Brady)
- 5. Candeina nitida d'Orbigny
- 6. Globorotalia inflata (d'Orbigny)
- 7. Globorotalia truncatulinoides (d'Orbigny)
- 8. Globorotalia truncatulinoides (d'Orbigny)

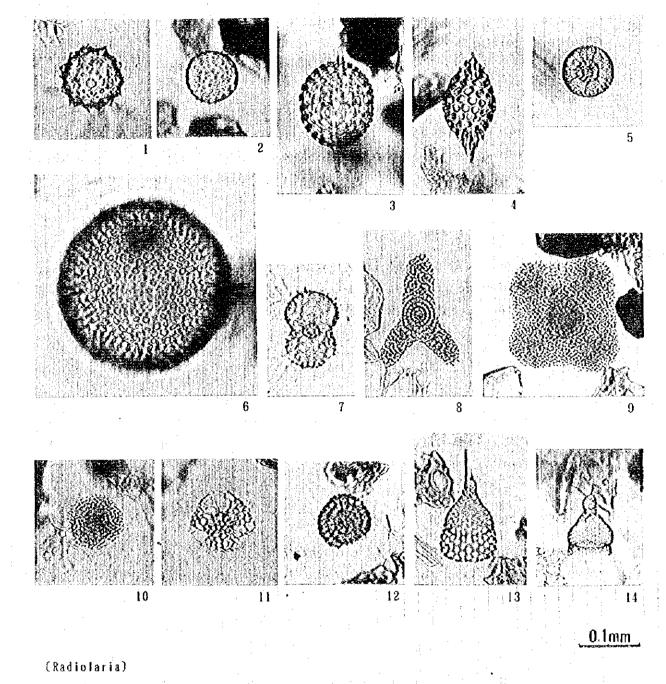


Scale Bars: $100 \,\mu$ m

95SFPGO1, umbilical view 95SLC17 40-50cm, side view 95SLC15. umbilical view 95SLC15. umbilical view 95SFPGO2. spiral view 95SLC15. spiral view 95SLC17 40-50cm, spiral view 95SLC15. umbilical view

Fig. 5-7-1 (1) Photographs of microscopic observation of microfossils

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1. Acrosphaera spinosa (95SFPG02)

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X

- 2. Siphonosphaera sp. (95SFPG01)
- 3. Axoprunum stauraxonium (95SFPG02)
- 4. Ellipsoxiphus atractus (95SLC17)
- 5. Heliosphaera inermis (95SFPG02)
- 6. Cenosphaera sp. (95SLC15F)
- 7. Didymocyrtis tetrathalamus (95SFPG02)

- 8. Buchitonia furcata (95SFPG02)
- 9. Spongaster tetras letras (95SFPG01)
- 10. Spongodiscidae gen.et sp.indet. (958FPG02)
- 11. Hexapyle sp. (95SFPG02)
 - 12. Lithelius minor (95SFPG02)
 - 13. Lamprocyclas maritalis (95SLC15F)
 - 14. Theocorythium trachelium (95SFPG02)

Fig. 5-7-1 (2) Photographs of microscopic observation of microfossils

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Globigerinoides sacculifer, it belongs to tropical or subtropical area.

(2) Radiolaria

In all four samples, radiolarians are very rare and poor in species number. No diagnostic radiolarians provide precise information on the geological age. Rare occurrence of radiolarians suggests that organic particles such as radiolarians were diluted by a very high sedimentation rate.

P

1) 95SFPG01F (See Fig. 4-1-2 (4))

Radiolarians are moderately preserved. Little corrosion of the surface of shells is observed. The species of radiolarians are mainly Acrosphaera spinosa (Haeckel), Axoprumon stauraxonium Haeckel and Spongaster tetras tetras Ehrenberg, which live in today's tropical and subtropical regions.

2) 95SFPG02F (See Fig. 4-1-2 (4))

Radiolarians are moderately preserved. Little corrosion of the surface of shells is observed. The species of radiolarians are mainly Acrosphaera spinosa, Axoprunum stauraxonium, Didymocyrtis tetrathalamus (Haeckel) and Theocorythium trachelium (Ehrenberg), which live in today's tropical and subtropical regions.

3) 95SLC15F (See Fig. 4-1-2 (2))

Radiolarians are moderately preserved. Little corrosion of the surface of shells is observed. The species of radiolarians are mainly *Acrosphaera spinosa*, *Axoprunum stauraxonium* and *Theocorythium* trachelium, which live in today's tropical and subtropical regions.

4) 95SLC17F (See Fig. 4-1-2 (2))

Radiolarians are moderately preserved. Little corrosion of the surface of shells is observed. The species of radiolarians are mainly *Axoprunum stauraxonium* and *Ellipsoxiphus atractus* Haeckel, which live in today's tropical and subtropical regions. These possess stout spherical or ellipsoidal shells. Other species having relatively fragile shells such as *Acrosphaera spinosa*, which is dominant in other samples, are not observed. This fact suggests the sorting by a bottom current or the destruction of shells by the friction with volcanic ash particles.

(3) Conclusions

In all four samples, foraminiferas and radiolarians are composed of the species occurring in the tropical

to subtropical regions. The sample of 95SFPG01, which locates in the southmost survey area, namely in higher latitude area, actually includes the foraminifera which is common in the middle latitude area.

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CHAPTER 6 DISCUSSION

In Lau Basin which is the current spreading back-arc basin, Mariana Trough, North Fiji Basin, Okinawa Trough and so on, active hydrothermal activities or hydrothermal deposits are discovered. All these hydrothermal activities occur in the spreading center of the basin.

In the Lau back-arc basin, high temperature active chimneys and sulfide ore deposits are confirmed on the southernmost part of the Valu Fa Ridge which is an active spreading center. The survey area includes a part of this hydrothermal activity area in the southern part of the area, and almost part of the Valu Fa Ridge with the northern extension of the ridge as its center.

Thus, the survey area is expected to have an enough potential for hydrothermal activity. As a result of survey, however, neither hydrothermal activity, hydrothermal ore deposits nor their indications are found. Although several precipitations of manganese oxides and iron oxides are confirmed, these precipitations are not the evidence suggesting the typical hydrothermal activities. It is the known ore deposits district that shows the most sites of the ore indications.

Judging from the geological structure of the spreading center, the survey area is roughly divided into two areas in north and south. In the south the spreading center generally forms ridges, while grabens in the north.

In the ridges of the southern part of the area, brecciated lava, as lava and pillow breccia of basalt are predominant so that much sea water penetrates into gaps (between pebbles) of lava. Under such circumstances, the hydrothermal fluids coming up from the underground mix with cold sea water and cool down, which makes hydrothermal activity hard to come up to the sea floor. From the topographic factor, in steep ridges sea water easily penetrates into the deeper part from the surface.

In the grabens of the northern part of the area, open cracks formed by tension stress field due to the spreading are very abundant. It is conceivable that much sea water seeps into the basement rock through these cracks.

In the survey area, therefore, the shallow parts of outcropping basement rocks form generally a discharged zone. The condition that hydrothermal deposits occur in such circumstances is the existence of strong hydrothermal activity as well as a cap rock sealing it in any forms. In the case of the known ore deposits in the southern end of the Valu Fa Ridge, iron-manganese crusts formed by the hydrothermal activity play a roll of cap rock, and chimneys and ore deposits occur along the normal fault made by a tectonic movement.

In this survey, we investigated first around this known hydrothermal ore deposits, and then, considering these results and existing data such as literature, we carried out the survey preferentially in the places which have characteristics of geographical and geological stuctures and which are expected to have a high potential of ore deposits. Bacause the sea floor sediments in the northern spreading center of the survey area are more thickly deposited than those in the southern spreading center, and so on, the volcanic activity of the northern area is judged to be old and inactive. In the southmost part of the Valu Fa Ridge (outside the survey area) where the spreading center is propagating towards south, the volcanic activity is continuously occurring. From these facts, it is concluded that the potential of ore deposits is low in the northern part of the survey area and high in the spreading ridge of the southern part.

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CHAPTER 7 CONCLUSION

The survey has been undertaken for five year period starting from fiscal 1995. The survey of the first year, consisting of bathymetric survey and exploration of submarine hydrothermal ore deposit, was carried out within the exclusive economic zone of the Kingdom of Tonga. The actual survey period is 69 days.

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The survey area locates in the middle to eastern part of the Lau Basin in the west of Tonga Islands. In the Lau Basin, there are two spreading centers running NNE-SSW direction in the central part of the northern area and the eastern part of the southern area. The southern spreading center (Valu Fa Ridge) runs through in the center of the survey area.

The survey consists of bathymetric survey by MBES to make a bathymetric map, SSS survey, sea floor observation by FDC, and sampling by LC, FPG and CB for ore deposits survey. Moreover, as a supplementary survey for geological survey, magnetic survey was carried out simultaneously with the bathymetric survey. Water temperature measurements using CTD mounted on FDC were also made.

(Bathymetric Survey)

The basic track line interval of bathymetric survey is 2 nautical miles with a supplementary line interval of 1 nautical mile in a shallow area. A total line length is 6,060.6 nautical miles.

According to the bathymetric map, detail topography of the whole survey area and the spreading center running NNE-SSW direction in the middle of the survey area are clarified, confirming some characteristic topography which suggests the tectonic movement. The spreading center running through the area consists of several grabens and ridges, and the overlapping spreading center was detected in the center of the area.

(MBES Acoustic Reflection Image)

The acoustic reflection image was made in receiving sound echo from each beam by MBES. This image is useful to clarify the status of sediments to some extent by the strength of acoustic reflection such as high sound echo from the outcrops and low sound echo from thick sediments. Thus, acoustic reflection image is used for distribution of sediments, and is effective data for selecting FDC observation sites and sampling points.

In the survey area, high sonic pressure zone which corresponds to NNE-SSW trending spreading center was clearly detected by MBES acoustic reflection image.

(SSS Survey)

The object of the SSS survey is to study precise topography and distribution of sediments, and to select the site for sea floor observation of FDC. Three survey lines were established around the spreading center in the central part of the area. Total line length is 49.7 nautical nules. The SSS records show linear structures which suggest cracks of rocks, topographic high in the form of a mound, and images which suggest widely distributed outcrops. Furthermore, the detailed distributions of sea floor sediments were clarified, which provide the important information for selecting sea floor observation sites. The records, which might be a plume and a direct sign of hydrothermal activity, were shown in several places.

(nSBP Survey)

The objects of nSBP survey are to know the distribution of sea floor sediments and under-sea floor structure. As a result of the survey, submarine structures such as distributions of sediments, etc. were considerably clarified, corresponding well with sounding image map. An application limit, however, is found in the area of steep slope, so that this method could be applied as a supplementary tool for hydrothermal exploration.

(Magnetic Survey)

As shown in the total magnetic force map, the total magnetic intensity in the survey area is within the range of 42,300 - 44,800 nT, gradually increasing towards the south as a general tendency. This local gradient is concordant with the theoretical global magnetic field.

As seen in the IGRF residual magnetic anomaly map, amplitude of anomaly is rather small within the range of -300 - +300 nT, and the NNE-SSW trending magnetic anomalous belt is predominant in all over the area, which correspond well with topographic trend of the survey area.

As the results of magnetic analysis, several high magnetization belts are detected in "the positive magnetization dominant area". Most of these belts correspond to the ridges. Especially, high magnetization zone in the central part of "the positive magnetization dominant area" is continuous corresponding to the ridges, which are considered to be the spreading center. Furthermore, judging from the characteristics of distribution of positive magnetization dominant area in the northern and southern parts, it is estimated that spreading rate increases towards the north or beginning age of spreading may be earlier in the northern part than that in the southern part.

(Geological Structure)

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The most important and predominant geological structure is the spreading center of the Lau Basin, which runs NNE-SSW direction in the survey area. This spreading center consists of several ridges and

grabens in echelon array, and in the center of the area overlapping spreading centers are observed at two places. The spreading center in the northern half of the area is formed mainly by grabens, while the southern spreading center by ridges.

The NNE-SSW trending lineaments in parallel with the spreading center is predominant, and near the overlapping spreading center or the bended zone, the parallel lineaments with these spreading center are observed. Most of the lineaments mean the cliff of normal fault formed by the spreading movement.

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(Ore Deposits Investigation)

As a part of ore deposits investigation, FDC survey, SSS survey, and sampling by LC, FPG and CB were conducted. The surveys were mostly focused to the spreading center where the latest volcanic rocks existed.

Firstly, the sea floor observation was made by FDC survey to study the characteristics of volcanic products, muddy sediments and geological structures and to find out ore deposits. The SSS survey was made in a restricted area as a supplement. Then, samplings were carried out based on these survey results.

(FDC Survey)

In the middle to southern part of the area, 10 track lines were set to run along or across the spreading center, and in the southern part of the area, two track lines were set over the knolls in the east of the spreading center and one on the seamount in the west of it, with 13 track lines in total.

As a result, only local precipitations of manganese oxides and iron oxides are confirmed as weak ore indications in several places. No hydrothermal ore deposits, hydrothermal activity, even nor their significant signs were found out.

(Temperature Anomaly)

On-line temperature measurements were carried out by CTD which is mounted on FDC over all the FDC survey lines.

Several temperature anomalies were detected on 6 track lines. Some of them show the values which could suggest the sign of hydrothermal activity, on the contrary, no eminent anomaly is detected in the FDC observations.

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(Sampling)

In the northern part of the survey area, LC sampling was made at 17 stations in the graben of the spreading center and its eastern side. In the central southern part of the area, LC sampling was also made at 14 stations along the baseline crossing the spreading ridge. Collection rate of sediments was very poor on the spreading center because of no sediments or thin sediments, but much better in other area. No ore indication such as argillization is observed in the sediments, but a few pyrites were confirmed in basalt fragments which were collected in two places.

FPG samplings were made at three places; the spreading center, the seamount and knoll chain in the southernmost part of the area. At each site, basalt consisting mainly of pillow lava were collected.

CB samplings were conducted at 11 places around the spreading center in the central to northern part of the area. The target of sampling was set to the fault cliffs corresponding to the boundary between grabens and horsts. As a result, basalt consisting mainly of pillow lava were collected at 8 stations.

Many basalt lava were collected by FPG and CB, but no ore indications such as mineralization and alteration were observed.

(Discussions)

As procedure of the actual survey, we firstly made a bathymetric map simultaneously with magnetic map, and on the basis of these and the potential place of known ore deposit, promising areas were selected. After this, the sea floor observation by FDC and the investigation of precise topography and sea floor situation by SSS in some area were made, and the sampling locations were determined. The results of the MBES acoustic reflection image can be used for the estimation how sediments cover the sea floor, so these are useful in selecting outcropped zone.

The survey area includes almost all the Valu Fa Ridge except for its southmost part, which is a current spreading center. The existence of active hydrothermal activities and ore deposits in the southmost part of Valu Fa Ridge was reported. The survey area includes the north end of these ore deposits and corresponds to the northern extension area of the deposits, so that we expected ore deposits to exist in the survey area. In this survey, however, hydrothermal activity, hydrothermal ore deposits and their significant indications were not observed at all.

The biggest reason no hydrothermal ore deposits were observed is presumed that the cap rock sealing the hydrothermal activity has not been formed because the hydrothermal activity has been weak and not been continuous. This presumption is based on the fact that we could find out no hydrothermal activities and hydrothermal ore deposits by the sea floor observations and samplings although young volcanic activities exist, and that the ore indications such as temperature anomalies are local and very weak.

Considering the occurrence condition of the known ore deposits, in this survey we carried out the investigation preferentially in the places which have characteristics of geographical and geological structures. Judging from the results of this investigation and the past investigations around this survey area, we concluded that the potential of ore deposits is low in the northern part of the survey area and high in the spreading ridge of the southern part.

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	[APPENDIX]
Table 1	Results of FDC survey
Table 2(1),(2)	Results of sampling survey
Table 3	Ore indications
Table 4(1)-(4)	Sample list of analysis and observation
Table 5	Sea-water sound velocity for MBES
Table 6	Weather and sea-state data

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rack line No.	Item	Obse	rvation	Lo	ation	Depth -	Obs. time	Obs. length	Number of
	,	Date	Time	Latitude (S)	Longitude (W)	(m)	(SO to EO)	(nm)	photograph
	TS	8/8	19:05				· · · · · · · · · · · · · · · · · · ·		
95SFDC01	SO		19:44	21 * 50, 60 *	176 ° 29. 77 '	1, 986			
	EO	8/9	01:35	21 ° 56. 30 °	176 ° 32. 29 '	1,829	5h 51m	6.2	300
	TD		02:16						
	TS	8/12	18:56						
95SFDC02	SO		19:54	20 * 20. 22 *	176 * 07. 71	2, 771			
	EO		22:47	20 * 22. 31 *	176 ° 08. 93 '	2, 651	2h 53m	2.4	126
	TD		23:37				[
	TS	8/13	00:03						
95SF0C03	SO		00:55	20 ° 25 32 '	176 ° 10, 99 '	2,602			
	E0		03:47	20 ° 26.49 '	176 ° 08.82 '	2, 585	2h 52m	2.4	124
	TD		01:36						
	TS	8/13	19:02						
95SFDC04	S0		19:58	20 * 31. 01	176 • 11. 29	2, 676			
	E0		21:35	20 ° 29 64	176 ° 10. 91 ′	2, 732	1h 37m	1.4	62
	TD		22:30	~ 		·		· · · · · · · · · · · · · · · · · · ·	
	TS	8/13	23:00						
95SFDC05	S0		23:56	20 ° 30. 76 ′	176 ° 11. 53 '	2,744			
	EO	8/14	01:28	20 ° 29.41 '	176 ° 10.98 '	2, 742	1h 32m	1.4	94
·	TD		02:23					÷	·
	TS	8/14	18:58						
955FDC06	SO		19:50	20 * 27.03	176 ° 10.03 '	2,610			
. 1	EO		20:50	20 ° 27.11	176 ° 09.29	2, 578	1h 00m	0. 7	36
<u> </u>	TD TS	8/14	21:40 22:28		···			<u>_</u>	
95SFDC07	50	87 <u>1</u> 4	22:28	20 * 32, 39 *	176 * 12. 97 *	9.000			
99210001	E0	8/15	01:06	20 32.39	176 ° 08. 07 '	2,555 2,331	4h 47m	4.7	213
	TD	0/13	04:54	20 33.11	110 40.41	2, 001	410 410	4. I 🔡	613
	TS	8/15	19:06		· · · · · · · · · · · · · · · · · · ·		·		
95SFDC08	SO	0/10	19:48	21 * 24, 75 *	176 * 24. 66	1, 986		•	
30510603	ĔÕ		23:28	21 24.77	176 21.05	2, 213	3h 40m	3.4	148
1 - A	TD	8/16	00:15	61 64.14	110 21.05	2, 610	OH HVIR	0.4	110
	TS	8/17	09:03						
95SFDC09	so		19:54	21 * 50, 91	176 ° 46.63	2, 267			
	EO	8/18	01:54	21 * 56.41	176 * 43. 41	1, 527	6h 00m	6.3 ·	307
	10		02:30			.,			
	TS	8/18	19:03		· · · · · · · · · · · · · · · · · · ·				
95SFDC10	SÓ		19:48	21 ° 23. 15 '	176 ° 16. 14 '	2, 146	• • •		
	EO		23:12	21 26 48	176 ° 16, 39	2, 424	3h 24m	3. 3	135
	TD	8/19	00:00				2 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -		
	1S	8/19	01:02					· · · ·	
95SFDC11	S0		02:33	21 ° 34 12 '	176 19.83	2, 477			
	E0		03:47	21 * 34.79	176 ° 18.65 °	2, 266	1h 14m	1.3	53
	TD		01:34		1				<u> </u>
	TS	8/19	18:30						-
955FDC12	SO		19:15	21 17.69	176 21.63	2, 122			
	EO		20:52	21 ° 16.47 ′	176 * 20. 17	2, 087	ih 37m	1.8	77
	TD	0 /00	21:35				<u>+</u>	1	
00000040	TS	8/20	23:57		100 0 10 10 1	0 000		1997 - 19	н
95SFDC13	SO		00:43	20 53.21	176 14.17	2,239	01 10		100
	EO		02:56	20 ° 52.70 °	176 * 12, 02 *	2, 166	2h 13m	: 2. l	155
	TD		03:40	L	i				

APPENDIX Table 1 Results of FDC survey

Legend of Item : TS : FDC on the sea surface SO : start of the observation EO : end of the observation TD : FDC on the der Note : Date and Time show UTC.

Depth is calculated by CTD data, and Location by wire length and Depth.

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APPENDIX Table 2 (1) Results of sampling survey

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Sample No.	Date	Time	Longitude	Latitude	Depth	Core Length	Remarks
95SLC01	7/27	19:52:25	21° 04. 901'S	176° 16. 849'¥	2,296m	Ocm	*1,*2
95SI.C02	7/27	21:54:55	21° 03. 732'S	176° 16. 212'W	2,436m	Ocm	*1,*2
95SLC03	7/27	23:49:20	21° 03. 701 S	176° 15. 333'¥	2,126m	110cm	
95SLC01	7/28	01:50:30	21* 05. 298*S	176° 15. 977'W	2,128m	95cm	*1
95SLC05	7/28	21:12:50	21° 06. 022'S	176° 12.050'W	2,447m	90cm	· · ·
95SLC06	7/28	23:12:25	21° 05. 689'S	176° 13.778'¥	2,330m	Ocm	*1
95SLC07	7/29	01:08:10	21° 05. 325°S	176° 14. 258'¥	2,401m	100cm	
95SLC08	7/29	03:05:50	21° 04. 600'S	176° 13.985'W	2,309m	85cm	
95SLC09	7/28	19:10:35	21° 04. 845°S	176° 15. 080'¥	2,211m	55cm	
95SLC10	7/29	19:16:25	21° 03. 954'S	176° 17. 194'¥	2,152m	60cm	· · · · · · · · · · · · · · · · · · ·
95SLC11	7/29	21:14:10	21° 03. 266°S	176° 17. 650'W	2,342m	Ocm	*1,*2
95SLC12	7/29	23:10:20	21° 02. 870'S	176° 18. 120'W	2,211m	0cm	*1,*3
95SLC13	7/30	01:12:45	21° 02. 506'S	176° 19. 533'W	2,456m	110cm	
95SLC14	7/30	04:04:50	21° 01. 121'S	176° 20.074°¥	2,259m	90cm	
95SLC15	8/22	20:13:45	20° 20. 836*S	176° 08.063'¥	2,809m	20em	+1
95SLC16	8/22	22:40.05	20° 21. 973*S	176° 08. 593'¥	2,792m	0em	+1,+2
95SLC17	8/23	01.03.00	20° 23. 495'S	176° 08. 266' W	2,515m	93cm	*1
95SLC18	8/23	03:39.55	20° 26. 071'S	176° 09.966'W	2,737m	0em	*1,*2
95SLC19	8/23	19:34:25	20° 13. 192'S	176° 05. 298'¥	2,796m	70cm	
95SLC20	8/23	22:20:25	20° 15. 892'S	176°06.835'¥	2,275m	Ocm	*1,*3
95SLC21	8/24	00:55.00	20° 18.011'S	176° 06.936'W	2,845m	105cm	*1
95SI.C22	8/24	03:29.05	20° 19. 973'S	176° 07. 731'¥	2,788m	0em	*1,*2
95SLC23	8/24	19:31:10	19° 52. 131 'S	176° 03.383'W	2,626m	Ocm	*1,*2
95SLC24	8/24	22:00:20	19° 53. 907'S	176° 04. 104'¥	2,638m	0cm	*1,*2
95SLC25	8/25	00:33:35	19° 55. 920'S	176° 04.761'W	2,719m	Ocm	*1,*2
95SLC26	8/25	19:29:10	19° 46. 543'S	175° 57, 446'W	2,615m	200cm	
95SLC27	8/26	01:23:35	19° 36. 004'S	175° 42. 942'¥	2,368m	215cm	
95SLC28	8/26	19:31:45	19° 49. 326'S	175° 58.453'¥	2,653m	255cm	
95SLC29	8/26	22.07:40	19° 49. 006'S	175° 56.116'¥	2,450m	285cm	
95SLC30	8/27	00:35:25	19° 49. 011'S	175° 53. 485'¥	2,603m	165cm	
95SLC31	8/27	02:59:45	19° 46. 669'S	175° 53.071'₩	2,605m	155cm	

*1 : Bit was deformed

*2 : No sample was collected

*3 : Rock fragments were collected

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APPENDIX Tab

Table 2 (2)Results of sampling survey

Sample No. Item	1						
	Date	Time	Longitude	Latitude	Depth	Sample wt.	Remark
95SFPG01 LF	8/20	20:33:05	21° 56. 324'S	176° 43 781'¥	1,657m	480kg	
95SFPG02 LF	8/21	00:11:30	21° 50. 077'S	176° 29 184'W	1,910m	380kg	
95SFPG03 LF	8/21	03:37:50	21° 57. 079'S	176° 22. 118'W	2,061m	60kg	
95SCB01 SD	8/21	21:34:10	21° 02. 562'S	176° 18. 488'W	2,306m	3.9kg	
ED		22:09:55	21° 02. 956°S	176° 18. 395'W	2,320m		
95SCB02 SD	8/22	00:37:30	21° 02. 828'S	176° 18.202'W	2,276m	1.38kg	
ED		01:18:50	21° 02. 970'S	176° 17.871'W	2,306m		:
95SCB03 SD	8/22	03:52:30	21° 08. 924'S	176° 18.711'W	2,195m	65kg	
ED	· ·	04:24:25	21° 09. 219'S	176° 18.296'W	2,255m		
95SCB04 SD	8/27	19:26:50	20° 15. 701'S	176° 06. 990'W	2,743m	146kg	
ED		20.01:25	20° 16. 125'S	176° 06. 570'W	2,755m		
95SCB05 SD	8/27	22:48:20	20°21. 178'S	176°09.292'W	2,737m	210.92kg	
ED		23:47:10	20°21. 970'S	176° 08. 726' W	2,798m		
95SCB06 SD	8/28	02:18:40	20°21.325'S	176° 07. 907'¥	2,717m	137.56kg	
ED		02:58:05	20° 21. 444'S	176° 07. 663' W	2,540m		
95SCB07 SD	8/28	19:23:05	19° 55, 015'S	176° 04.019'W	2,647m	410.05kg	. :
ED		20:14:20	19° 55. 426'S	176° 03. 832'W	2,540m		
95SCB08 SD	8/28	23:02:30	19°51.512'S	176°02.904'₩	2,566m	34.1kg	
ED		23:36:50	19° 51. 693'S	176° 02. 340'W	2,556m		
95SCB09 SD	8/29	01:58:30	19° 51. 892'S	175° 59.097'W	2,531m	12.2kg	
ED	1 () 1 ()	02:41:40	19° 52. 151'S	175° 58, 792'W	2,394m		
95SCB10 SD	8/29	19:23:45	19° 49. 958'S	175° 54.953°W	2,563m	4.14kg	
ED	ł	20:25:55	19° 49. 914'S	175° 54. 008'¥	2,520m		
95SCB11 SD	8/29	23:38:10	19° 50. 531'S	175°41.664'W	2,023m	1.3kg	
ED	8/30	00:22:25	19° 50. 822'S	175° 41. 369'W	1,915m		

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Legend of Item : LF : leave the sea floor SD : start of dredge ED : end of dredge

Note : Date and Time show UTC. Longitude and Latitude are the GPS position of R/V. Depth data of LC (except for LC24,LC26-30) and CB08-11 are calculated by CTD data. The other Depth data are NBS data.

Sample wt. means the total weight of rocks and sediments.

APPENDIX Table 3 Ore indications

ſ	Sampling No.		Location	Depth	Time	Range	Contents	Photo No.
l	Track line No.	:	Latitude / Longitude	(m)	(UTC)			
ł	95SLC12		21° 02. 87′ S	2,211		unknown	Very weak dissemination	
			176° 18. 12′ W	-			of sulfides in basalt	
ł	95SLC20		20° 15. 89′ S	1,412		unknown	Weak dissemination	
l			176° 05.83' W				of sulfides in basalt	
	95SFDC01		21° 52. 99′ S	1,773	22:21:55	partly	White materials in sediments	133
I			176° 30. 84′ ¥					
I		from	21° 53. 64′ S	1,795	23:00:25	a few 10m	Effusive holes and deposits	164-169
I			176° 31. 16' W				of black Mn-oxides	4.
		to	21° 53. 65′ S	1,786	23:01:15		Deposits of yellow to	
			176° 31.16′ W				yellowish brown oxides	
		from	21° 53. 87′ S	1,846	23:14:40	a few 10m	Deposits of black Mn-oxides	176-178
		Î	176° 31. 33′ W				on the rock surface	·
		to	21° 53. 89′ S	1,845	23:15:30			
	:		176° 31. 33′ W			E		
			21° 54.99′ S	1,895	00:20:00	partly	Deposits of brown oxides	227
1			176° 31.75′ W			:	in the inside wall of pit	
		from	21° 56. 09′ S	1,829	01:23:20	140m	Effusive holes and deposits	283-292
			176° 32. 20′ W		1	i.	of black Mn-oxides	
		to	21° 56. 17′ S	1,835	01:28:05		Deposits of yellow to	÷
			176° 32. 24′ ¥		·		yellowish brown oxides	
	95SFDC02	from	: 20° 20. 85′ S	2,791	20:49:45	spotty	Effusive holes and deposits	26-31
			176° 08. 05′ ¥		i	within 100m	of black Mn-oxides	
		to	20°20.91′S	2,797	20:52:45		Deposits of yellowish brown	
		<u></u>	176° 08. 07′ ¥				oxides	
	95SFDC09		21° 55. 92′ S	1,591	01:24:45	partly	Deposits of black Mn-oxides	290
			176° 43. 66′ ¥	1 700	001055	(widely?)		16.10
	95SFDC10	from	21° 23. 68′ S	1,780	20,17:55	a few 10m	Deposits of yellowish brown	16-18
			176° 16.07′ ¥	1 703	20:18:55		oxides	
		to	21° 23. 69 S	1,783	20:18:55			
	060EDG10	<u> </u>	176° 16.08' ¥	2 002	10.47.05	about 10m	With the moderning of a horizon	27.00
	95SFDC12	from	21° 17.40′ S 176° 21.17′ W	2,093	19:47:25		White materials and brown oxides on the rock surface	27,28
				2,097	19:47:40		OVIDES OF THE LOCK STHREE	
		to	21° 17.40′ S 176° 21.17′ W	2,091	12.4739U			
		from		2,074	19:52:15	50m	White materials on the	32-34
			176° 21. 10′ W	2,014	12.36.13	Join	rock surface	52-34
		to	21° 17. 29′ S	2,058	19:54:20		Deposits of brown materials	
			176° 21. 08' W	ocu, 2	1 17.34.2V 		industrie of prown materials.	
	95SFDC13		20° 53. 19' S	2,203	00:52:20	partly	White materials on the	6
	75017015		176° 14.06' W	2,205	00.32.20	P.u. 17	rock surface	
		L	LIN LUND	L	L	L		

APPENDIX	Ť
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NDIX Table 4 (1) Sample list of analysis and observation (sediments)

Sample No.	Latitude (S)		Longitude (W)		Depth	Sampling depth		Sediments		Analysis		
	(deg.) (min.)		(deg.) (min.)		(m)	(cm) top bottom		Munsell No. & Color	Size	MC		F
35SLC03-M1	21	03.701	176	15.333	2,126	5	10	10YR4/2 dark grayish brown	silt	Ō		
-M2	1					45		5Y4/4 olive	sit	0		
-M3		· · ·				70	75	10YR 5/2 gravish brown	silt	0		
-M4					· · · · ·	100	105	2.5Y3/2 very dark grayish brown	süt	O		
SSLC04-MI	21	05.298	176	15.997	2,128	5	10	10YR3/2 very dark grayish brown	silt	0	:	
-M2					:	35	40	10YR2/2 very dark brown	silt	0		
-M3						55	60	5Y5/3 olive	silt	0		-
-M1						80	85	10YR3/2 very dark grayish brown	silt	$\overline{\mathbf{O}}$		
5SLC05-MI	21	06.022	176	12.050	2,447	5		10YR3/2 very dark grayish brown	silt	$\overline{\mathbf{O}}$		
-M2						20		2.5Y4/0 dark gray	silt	0	÷	
-M2 -M3						35		10YR3/2 very dark grayish brown	sit	Õ		
		· · · ·	· · · ·	· · · · · · · · · · · · · · · · · · ·		65		5Y2.5/1 black	silt	õ		-
-M5						80		SY3/2 dark olive gray	silt	ŏ		
5SLC07-M1	21	05.325	176	14.258	2,401	0		10YR3/3 dark brown	silt	õ		
-M2			- 110	17.2.30	101,42	35		5Y4/3 olive	silt	õ		\vdash
-M2 -M3		<u> </u>		·	 	70		2 5Y3/2 very dark grayish brown	silt	ŏ		
-M3 -M4						- 70		5Y2.5/1 black	silt	$\overline{0}$		-
		01.000	176	13.985	9.200	- 0		10YR3/2 very dark grayish brown	silt	õ		-
5SLC08-MI	21	04,600	110	13,983	2,309	15		10 YR3/1 very dark gray	silt	ŏ		-
-M2		[ļ		· · · · · · · · ·	55		5Y2 5/1 black	silt	0		_
- <u>M3</u>			<u> </u>	· · · · ·	· · · · · · · · · · · · · · · · · · ·	60		10YR2/1 black	sand	<u> </u>	0	
-C1		ļ				1		5YR2.5/2 dark reddish brown	silt	0		-
-M4			·			65			silt	· · · - ·		-
-M5		01010	176			80		10YR4/2 dark grayish brown 2.5Y3/2 very dark grayish brown	silt	0		-
SSL009-MI	21	01.845	1/0	15.080	2,211	5			sut	ō		
-M2				-		50		5Y3/2 dark olive gray	· · ·			
5SLC10-MI	21	03.954	176	17.191	2,152	5		10YR3/2 very dark grayish brown	; silt	0	-	
-CI		· · · ·			<u> </u>	15		10YR2/1 black	sand		0	-
-M2	· · · ·				<u> </u>	25		10YR3/2 very dark grayish brown	silt	0		-
-M3					1 at	35		10YR2/2 very dark brown	silt	0		
-C2	,	·			· · · ·	40		10YR2/1 black	sand		0	
-M4		<u>.</u>				55	1 .	SYR3/1 very dark gray	silt	0	· ·	
SSLCI3-MI	21	02.506	176	19.533	2,456	5		SYR3/1 very dark gray	silt	0		
-M2	:		<u></u>			25		2.5Y3/2 very dark grayish brown	silt	0		_
-C1	· · · ·	· .				60		SY2.5/1 black	sand		0	
-M3			<u> </u>			65		5Y2.5/1 black	sanu	0		
-M4						80		10YR2/2 very dark brown	silt	0	-	
-C2		[<u> </u>		:	100		SY2.5/1 black	sand	: 	0	
-M\$		· 1				105		SYR3/1 very dark gray	sit	0		
05SLC14-M1	21	01.121	176	20.074	2,259	-5		10YR3/2 very dark grayish brown	silt	0		_
-CI						15		10YR2/1 black	sand	: 	0	 _
-M2						25		10YR3/2 very dark grayish brown	silt	0	1	
-M3						35		10YR3/2 very dark grayish brown	silt	0	. 1	
-M4						50		10YR3/2 very dark grayish brown	silt	0	!	
-M5	1					80		2.5Y4/2 dark grayish brown	silt	0		Ľ
SSLC15-MI	20	20.836	176	08.063	2,799	5		10YR3/3 dark brown	silt	0		L
•F		:				10	15	10YR3/3 dark brown	silt			
-M2	1			 		15	20	7.5YR4 0 dark gray	silt	0		[
DSSLC17-MI	20	23.495	176	08 266	2,515	5	10	10YR3/3 dark brown	silt	0		
-M2	1	1			4	30	35	10YR3/3 dark brown	silt	0		ľ
-F		<u> </u>	1			40	50	10YR2/1 black	sand			Ē
-M3		1	1		1	50		10YR3/3 dark brown	silt	0	·	[-
-M4		1	1	1	·	- 80		10YR3/2 very dark grayish brown	silt	ō		t

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APPENDIX Table 4 (2) Sample list of analysis and observation (sediments)

Sample No.		પ્રેલ (S)	Longia		Depth	Samplin		Sediments			Inalys	
		(min.)	(deg.)	(min.)	(m)	(cm) top		Munsell No. & Color	Size	М	С	F
95SLC19-M1	20	13.192	176	05.298	2,796	10		10YR3/3 dark brown	silt	0		
-M2						30		5Y4/1 dark gray	silt	0		
-M3						45		SY4/1 dark gray	silt	0		
-M4						65	70	5Y4/1 dark gray	silt	0		
95SLC21-MI	20	18.011	176	06.936	2,845	5	10	10YR3/3 dark brown	sit	0		•
-M2			:			25	30	10YR3/2 very dark grayish brown	silt	0		
-M3	:		· · ·			45		10YR3/2 very dark grayish brown	silt	0	†	
-M4				·		70		2 SY3/2 very dark grayish brown	silt	0		
-M5				· · · · ·		- 90		SY4/2 olive gray	silt	0		· · · ·
95SLC26-M1	19	46.543	175	57.466	2,615	10		10YR3/2 very dark grayish brown	silt	Õ		
-M2						30		10YR3/2 very dark grayish brown	silt	õ		
-M3			<u> </u>			45		10YR3/1 very dark gray	silt	ŏ		
-M4		· · ·				65		10YRV2 very dark grayish brown	silt	ŏ		
-M9 -M5	·. · ·	· · · · · · ·			· · ·	90		2.5Y4/2 dark grayish brown	silt	ŏ	·	- 12
	<u>}</u>					110		10YR3/2 very dark grayish brown	sat sat	$\frac{0}{0}$		
-M6			 		· · · ·	i			sut silt	$\frac{0}{0}$	<u></u>	
-M7	 					125		10YR3/1 very dark gray				
-M8	1					155		5Y5/2 olive gray	silt	0		<u> </u>
-M9					1 · · .	170		SYS/3 olive	silt	0	2	
-MI0	ļ			1.1.1		190		10YR3/2 very dark grayish brown	silt	0		
95SLC27-MI	19	36.004	175	42.942	2,368	5		10YR3/3 dark brown	silt	0		
-M2		· .				20		10YR3/2 very dark grayish brown	silt	0		· · · · ·
-M3				:	:	35		10YR3/3 dark brown	silt	0		
-M4				;		70	-	10YR3/2 very dark grayish brown	silt	0		:
-M5			· ·			95		10YR3/2 way dark grayish brown	silt	0		1
-M6						125		5Y3/2 dark olive gray	silt	0	· .	
-M7						155	160	2.5Y6/2 light brownish gray	sit	0	·	-
-M8		1				170	175	2.5Y5/2 grayish brown	silt	0		
-M9	1 1					185	190	5Y3/2 dark olive gray	sit	0		
-M10						205	210	SY2.5/1 black	stit	0		
95SLC28-M1	19	49.326	175	58.453	2,653	5	10	10YR3/3 dark brown	silt	0		
-M2						15	: 20	10YR3/2 very dark grayish brown	silt	0		:
-M3						45		2.5Y3/2 very dark grayish brown	silt	0	: • <u>-</u>	<u> </u>
-M1				· · · · · · · · ·		70		5Y3/2 dark olive gray	silt	0		
-M5					<u>.</u>	85		5Y2.5/2 black	silt	Ō		
-M6			<u> </u>		<u> </u>	105		2.5Y3/2 very dark grayish brown	silt	ō		
M7		· · ·				135		5Y3/2 dark olive gray	silt	ō		
-M8	·					160		5Y2 5/2 black	silt	ŏ		
-M9			1	3		180		2.5Y3/2 very dark grayish brown	silt	ŏ		-
MIO		· · ·				205		10YR3/2 very dark grayish brown	silt	ŏ		÷
-Mil						200		10YR3/2 very dark grayish brown	silt	0		·
the state of the second se				<u> </u>		1			silt	0	- <u></u>	
-M12	10	40.025	1 175	56.116	2.460	250		2.5Y4/2 dark grayish brown 10YR3/3 dark brown				<u> </u>
95SLC29-MI	1 19	49.006	1/3	011.0	2,450				silt	0		ļ
-M2	<u> </u>	· · · · ·	<u> :</u>	 		5		10YR3/2 very dark grayish brown	silt	0	<u> </u>	<u> </u>
-M3	- 	 `	·	 	·	15		10YR3/2 very dark grayish brown	sit	0		
-M4	· 	·	· · · · ·	 	· · ·	25		10YR3/2 very dark grayish brown	sit	0		
-M5		1	<u> </u>			35		10YR3/2 very dark grayish brown	silt	0	<u> </u>	<u> </u>
-M6	· · · · ·				· · · ·	45		10YR3/3 dark brown	silt	0		
-M7	<u> </u>	1		. :_	L	55		10YR2/2 very dark brown	silt	0		
-M8	1.0					65		10YR4/2 dark grayish brown	silt	0		
-M9				<u> </u>		75		10YR4/2 dark grayish brown	silt	0		
-MI0				1		85	95	10YR3/2 very dark grayish brown	sand	0	1	

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APPENDIX Table 4 (3) Sample list of analysis and observation (sediments)

Sample No.	Latin	ode (S)	Longitu	ide(W)	Depth		ng depth	Sediments			Inalys	
1	(dcg.)	(min)	(dcg.)	(min.)	(m)	(cm) top			Size	Μ	С	l
058LC29-M11	19	49.006	175	56.116	2,450	95		5Y6/2 light olive gray	silt	0		
-M12						105	115	10YR3/2 very dark grayish brown	silt	0		
-M13		· · ·				115	125	5Y4/2 olive gray	silt	0		
-M14					· · ·	125	135	5Y4/2 olive gray	silt	0	1	
-M15	· · · ·		-			135	145	5Y4/2 olive gray	silt	0		–
-M16	· · · · · ·					145	155	10YR3/2 very dark grayish brown	silt	0	[]	
-M17						155		5Y2 5/2 black	silt	0		
-MI8						165		10YR3/2 very dark grayish brown	silt	0	· ·	
-M19						175		10YR3/2 very dark grayish brown	silt	0		
-M20					·	185		2 5Y3/2 very dark grayish brown	silt	0		
-M20 -M21		·····			··	195		10YR3/2 very dark grayish brown	silt	Ō		
-M21 -M22		··/	· ·		· · · ·	205		10YR3/2 very dark grayish brown	silt	ō	<u>├</u> ──	-
			<u> </u>			215		2.5Y3/2 very dark grayish brown	silt	ŏ		-
-M23	···					225		2.5Y3/2 very dark grayish brown	silt	ŏ	<u> </u>	-
-M24		·	 			225		10YR3/2 very dark grayish brown	silt	0		-
-M25								10YR3/2 very dark grayish brown	silt	0		-
-M26	·					245		10YR3/2 very dark grayish brown	silt	ŏ	<u></u>	
-M27						255			silt	0		╞
-M28			ļ			265		2.5Y3/2 very dark grayish brown	L	F		-
-M29			· · · · ·	·		275		2.5Y4/2 dark grayish brown	silt	0		-
05SLC30-M1	19	49.011	175	53,485	2,603	5		2.5Y3/2 very dark grayish brown	silt	0	 	ļ_
-M2						25		10YR3/2 very dark grayish brown	silt	0	<u> </u>	_
-M3					· · ·	50		10YR3/2 very dark grayish brown	silt	0	ļ	_
-M4					·	65		10YR3/2 very dark grayish brown	silt	0		
-M5	i			· · ·	;	80		5Y3/2 dark olive gray	કહેા	0		Į.,
-M6						105		10YR3/2 very dark gravish brown	silt	0		
-M7		[· · ·			145	r	2.5Y4/2 dark grayish brown	silt	0		
-M8	1					155	1 2 1 2 4	10YR3/2 very dark grayish brown	silt	0		
95SLC31-M1	19	46.669	175	53.071	2,605	. 5		2.5Y3/2 very dark grayish brown	silt	0		
-M2			:			25	30	10YR3/2 very dark grayish brown	silt	0		Ŀ
-M3	+			8 8 A		.45	50	10YR3/2 very dark grayish brown	silt	0		
-M4						70	75	10YR3/2 very dark grayish brown	silt	0		
-M5						95	100	10YR3/2 very dark grayish brown	silt	0		1
-M6	· · ·			· <u> </u>	1	115	120	2.5Y3/2 very dark grayish brown	silt	0		F
-M7	· · ·		· · · · ·	· · · · · · · - ·		135	140	5Y4/2 black	silt	0		T
-M8		1				145		10YR3/2 very dark grayish brown	silt	0		Ē
95SFTG01-M	21	56.324	176	43.781	1,657			very dark grayish brown	silt	Ō	1	Ť
-F			1			<u>+</u>		very dark grayish brown	silt			
95SFPG02-M	21	50.077	176	29.220	1,910			very dark grayish brown	şilt	0		
-F								very dark grayish brown	silt	<u> </u>		1
95SCB01-M			*					very dark grayish brown	silt	<u></u>		
95SCB01-M 95SCB02-M								very dark grayish brown	silt	ŏ	<u>;</u>	1
	*		* *		 		;	very dark grayish brown	silt	ŏ		┢
95SCB03-M	- *							very dark grayish brown	silt	ŏ		ŀ
95SCB05-M	*		*	ļ			· · · ·		silt	0	<u> </u>	-
95SCB06-M	*		*		┨;	· [very dark grayish brown	sit	0		╀
95SCB07-M	*	· · ·	+	ļ	1	<u> </u>		very dark grayish brown				ł-
95SCB09-M	*		*	 	.	. 	 	very dark grayish brown	silt	0		+
95SCB10-M	*		*				<u> </u>	very dark grayish brown	silt	0	_	
95SCB11-M	1 +	1	1 * .		1	1	1 .	very dark grayish brown	sit	0	1	1

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APPENDIX Table 4 (4)	Sample	list of analysis	and	observation	(rocks)

Sample No.	Latit	ude (S)	Longit	ude (W)	Depth	Rock facies				nalys	sis		
			(deg.)	(min.)	(m)		C	M	N	Ť	P	X	K
95SLC12-M	21	02.870	176	18.120	2,211	basalt lava		0	. :				
·T						basalt lava		-		Ô			
-P			 			basalt lava	1		- 14 - 14		0		t
X						básált lava		·				TO	1
958LC20-R	20	15.892	176	06.835	3,275		0	0	Ō				
-T						basalt lava		-		Ō			
-P			· · · ·		<u>`</u>	basalt lava				<u> </u>	Ō	╏───└─	<u> </u>
X	·		<u> </u>	· · · ·		basalt lava	<u> </u>				l —	0	ł
-C+N			·	· · · ·	_	basalt lava (glass)	Ō		$\overline{\mathbf{O}}$				
95SFPG01-R	21	56.324	176	43.781	1,657		ŏ	0	ŏ				f
-T	- 21	50.524	1/0	43.701	1,001	basalt lava				0		·	
	- <u>-</u>					basalt lava	···-	<u> </u>		<u> </u>	· · ·		0
95SFPG02-R		50.077	176	29.184	1,910		0	0	Ō	·		}	ĻΥ
•T		50.017		27,104	1,710	basalt lava		$\vdash \stackrel{\smile}{\rightarrow}$		0		···-	
					· · · · ·	basalt lava	·	· · ·	· .	19	· · ·	0	ł
-X -K	<u> </u>		 	ļ		basalt lava	 		i		·	0	
			 				l ÷			÷	· · · · ·		0
-M+N		(7.070	1.77	0.0.1.0	0.064	basalt lava (oxidized)		0	0	·	·	<u> </u>	
95SFPG03-R	21	57.079	176	22.118	2,061		0	0	0				<u> </u>
-Tl	·				· · · ·	basalt lava	 	<u> </u>		0			
-T2		· · · · · · · · · · · · · · · · · · ·		i		basalt lava	<u> </u>		Į	0		ļ	
K	ļ					basalt lava						12	0
95SCB03-R1	*		*		. <u>.</u>	basalt lava	0	0	0		<u> </u>	<u> </u>	
-R2						basəlt lava (glass)	0	0	0	·			
-T			1			basalt lava	<u> </u>			0			
-К						basalt lava							0
95SCB04-R1	*		*			basalt lava	0	0	O				
-R2				-		basalt lava (glass)	O	0	0	,		1	
- T -						basalt lava		[Ō			
-K		;				basalt lava						1	0
95SCB05-R1		· ·	*			basalt lava	0	0	0		,	1	
-R2		· · · · ·				basalt lava (glass)	Ō	Ō	0				
-T1				· · · ·		basalt lava	<u>†-₹</u>			0		1 	
•T2						basalt lava				Ť			
ĸ		· · · ·				basalt lava	· ·			- <u> </u>		· · ·	$\overline{0}$
95SCB06-R			1			basalt lava	O	0	Ō				<u> </u>
-T						basalt lava	┟┷╴	<u>├──</u>	Ť	0			ł – – –
				<u> </u> ;		basalt lava	<u> </u>			Ť			fo
95SCB07-RI		t	*			basalt lava	0	0	ō				۲×
-R2				 · - · · · · · ·		basalt lava (glass)	ŏ	ŏ	ŏ				
		 		 		basalt lava (glass)	⊢∽	⊦ ∽	\vdash	Ö	· · ·	<u> </u>	<u> </u>
	<u> </u>		<u>├</u>			basalt lava				ŏ	}		<u> </u>
					····	basalt lava							lo
95SCB08-R		i		 	1 - 1	basalt lava	0	0	0	· ·			⊢⊣
-C+N	<u> </u>	· · · · · · · · · · · · · · · · · · ·		↓	·	basalt lava (glass)	B	19	6			<u>.</u>	<u> </u>
-C+N	·			······	·	basalt lava (glass)	는		\vdash	0	· · ·		↓
-1 -K	 			 		basalt lava		-÷		4		1 1	1
95SCI309-R													0
	 					basalt lava	0	0	0		ļ	i	
-T			÷-	·····` - · ·		basalt lava	ļ	!	 	0		 	╞╤
-K	<u>-</u>			ļ		basalt lava	1	 					0
95SCB10-T	*:	 			· · · ·	basalt lava	l			0	 		<u> </u>
95SCB11-T	•	I	! *	<u> </u>		basalt lava	L		L	0			1

*: Locations of CB dredge sampling are shown in Appendix Table 2.

Legend of Analysis

C : Chemical analysis (major components)

M : Chemical analysis (base metal elements)

N : Chemical analysis (rare earth elements)

T : Thin section observation

P : Polish observation

X : X-ray diffraction analysis

- K : Age determination (K-Ar method)
- F: Micro fossil observation

Appendix Table 5	· .	Sea-water	sound	velocity	for	MBES
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9°16.5′S. 176°	09.1'W (CTD01)	21°04.9′S, 176°	17.0'W (LCO1)
Water depth (m)	Sound velocity (m/soc)	Water depth (m)	Sound velocity (m/sec)
10.0	1, 535. 9	10.0	1, 532. 6
20.0	1, 536. 4	20.0	1, 532, 5
40.0	1, 536. 8	40.0	1, 533. 1
60.0	1.536.2	60.0	1, 533, 3
80. 0	1, 535. 0	80.0	1, 533. 6
100. 0	1. 532. 1	100. 0	1, 533. 6
150. 0	1. 528. 3	150.0	1, 529, 1
200. 0	1, 525, 5	200. 0	1, 526, 7
300. 0	1, 516. 5	300.0	1, 519. 6
400.0	1, 503. 5	400.0	1, 510. 2
500.0	1, 492. 6	500.0	1, 198. 2
600. 0	1, 488, 5	600.0	1, 489. 2
700. 0	1, 486, 3	700. 0	1, 485, 8
800.0	1, 485, 4	800.0	1, 483. 9
1,000.0	1, 484. 5	1,000.0	1, 482. 8
1, 500. 0	1, 485. 6	1,501.0	1, 485, 2
2,001.0	1, 492. 4	2.000.0	1, 192. 3
2.500.0	1, 500. 5	2, 500. 0	1.500.5
3,000.0	1, 509. 3	3, 000. 0	1, 509. 3
3, 011, 0	1, 509. 5	3, 011, 0	1, 509. 5

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Appendix Table 6

Weather and sea-state data

E S E W S W E N E S S E S S W Ŵ N W N N W C A N N E Not Ś N N E Е S E S W w Tot i 1 N W Clear і м kon th 12 2.51 44 8.17 39 8. 13 60 12,50 48 9. 59 78 15. 83 71 14.79 34 7.08 21 4. 37 12 2.51 11 2.29 10 2.08 2 0. 42 33 6.87 450 100 July 9 1.88 Ж 37 5. 22 233 32.86 90 12.70 20 2.82 709 100 167 96 13, 54 August K 1 3 62 8.75 0.14 0.42 23.55

Monthly frequency distribution of wind direction in 1995

Monthly frequency distribution of wind velocity in 1995

																			(N. Y	: a/sec/
R. Y Nonth	C A L M	1	2	3		5	6	7	8	9	10	11	12	13	14	15	16	17	Not Clear	lota)
July X	:		10 2.08	34 7.08	45 9.38	75 15.62	71 14, 79	87 18.12	62 12.93	50 10. 42	13 2.70	11 2 29	17 3, 54	3 0.63	1 0.21	 0.21				430 100
August 36		1 0. 14	3 0. 42	7 0. 99	22 3. 10	30 4 23	43 6. 77	72 10. 16	83 11. 71	109 15. 37	10) 14, 24	68 9.59	27 3. 81	16 2.26	11 1.55	8 1, 13	5 0.71	2 0.28	96 13.54	709 100

Monthly frequency distribution of weather in 1995

Reater Month	Fice	Cloudy	Raia	Not clear	Total	Light raia
Joly	14	5	1	:	20	4
%	70.00	25.00	5.00		100	20.00
August	17	7		5	29	4
95	58.62	24.14		17.24	100	13.79

Monthly frequency distribution of atomospheric pressure (daily average) in 1995 (AP : hPa)

	5	5	5	5	5	5	1012.0	5	5	S .	5	5	S	5	\$.5	5
July K	4 0.83	10 2.68	15 3, 13	19 3.96	29 6.04	36 7.29	30 6.25	. 31 7.71	46 9. 59	71 14. 79	87 18. 13	77 18.04	16 3.33	4 0.83			
August %							8 1.13	38 5.08	78 10.72	125 17.64	115 16.22	75 10.58	54 7.62	34 4 80	28 3.94	24 3.38	23 3.24

A.P. Month	3 5 3	1024. 0 1 1024. 9		Total
July 36			:	480 100
August X	14 1.97	2 0. 28	95 13.40	709 100

S.D. Roath	N	ม ม ย	N E	E N E	Ē	មេខ	S E	S S E	S	S S ¥	S ₩	¥ S ¥	w	Ŵ Ň W	.× ¥	N N W	Kol : Clear	Total
July N	3 0. 63		45 8.54	21 4. 38	13 2.70	8 1.67	3 0.63	5 1.04	12 2.50	21 4. 37	84 17. 5	5 1.04		1 0. 21	3 0. 63		260 54.16	480 100
Acevist 96				2 9.28	11 ៤.55	46 8. 49	122 17. 21	49 8.91	47 8.63	1 0.11	4 0.58						427 60. 23	703 100

Monthly frequency distribution of swell height in 1995

Monthly frequency distribution of swell direction in 1995

(\$.C:sec) Not S. C Total Clear Month Julý 96 10.00 4. 37 100 8. 75 5. 22 0. 21 0.42 1.88 14.79 0.21 54.16 0.28 2. 26 4.83 3. 94 11.85 12 98 1.83 1. 41 August % 0.42 63.23

Monthly frequency distribution of swell cycle in 1995

S.H.	1	2	3	4	5	8	No1 Clear	S.H : B) Total
July N	117 24.38	71 14 79	25 5.21	7 1.45			260 54.16	480 100
August %	37 5.22	126 11.77	82 11.57	22 3. 10	1 1.55	4 0.56	427 60, 23	709 109

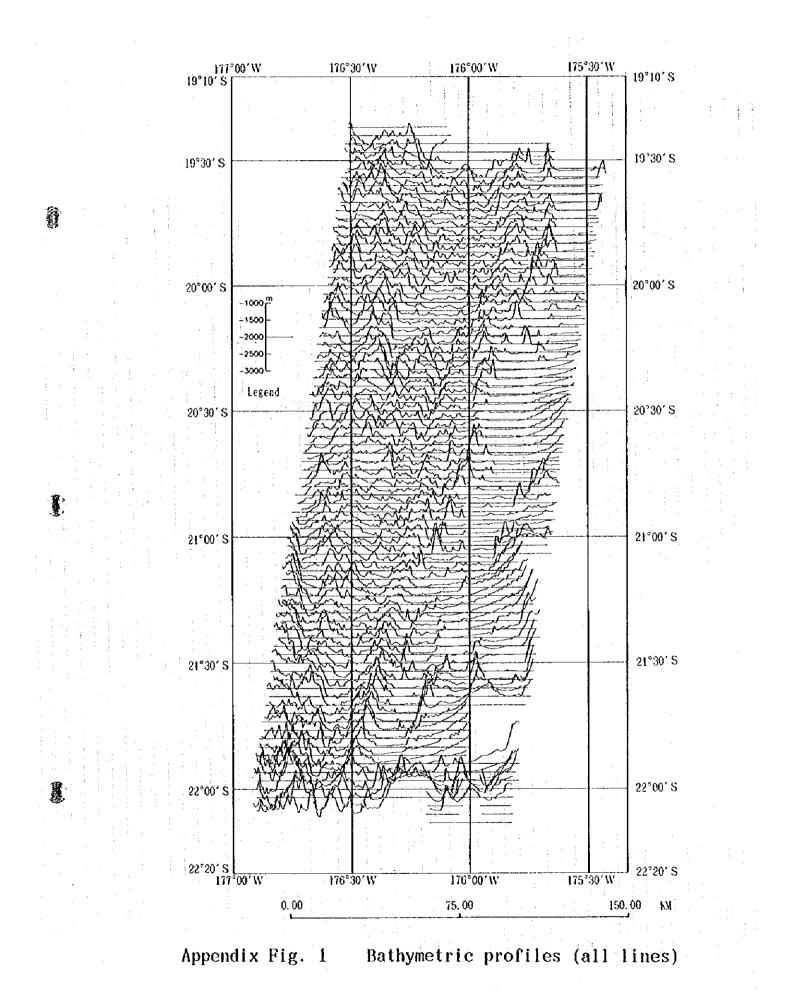
Monthly frequency distribution of degree of cloudiness in 1995

D.C Nunth		2	3	4	5	6	3	8	9	Not Clear	Total
Jely K	5 1.01	20 4 17	99 20.62	89 18.54	74 15.42	52 10.83	62 12.92	79 16.46			480 100
August %		10 1.41	115 16. 22	140 19.75	191 18.48	8) 11. 42	37 5.22	100 14, 10		95 13.40	709 100

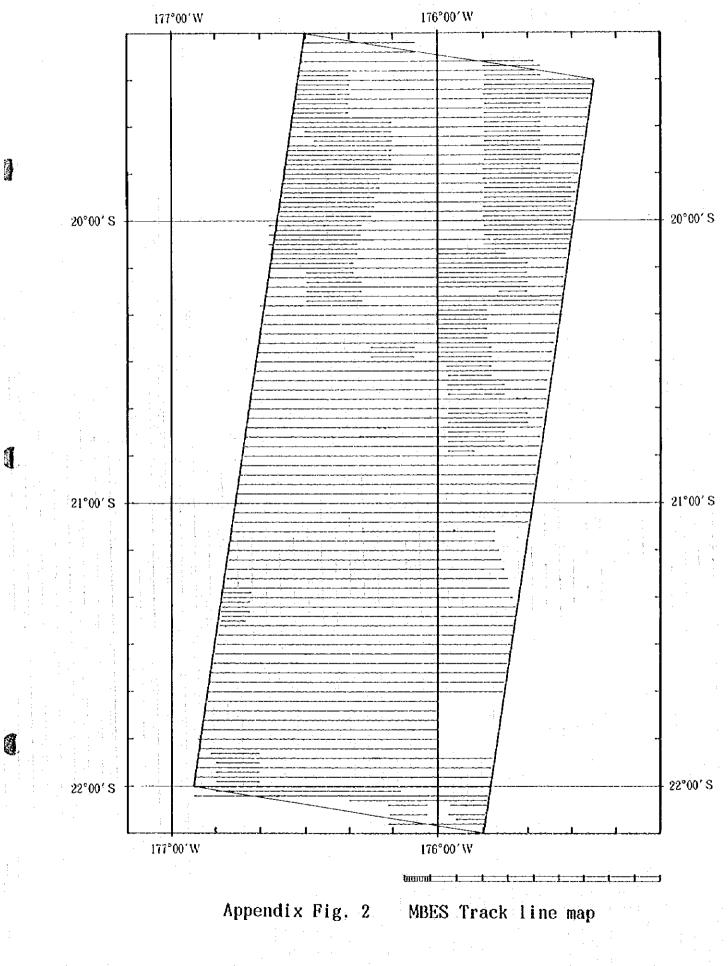
[APPENDIX]

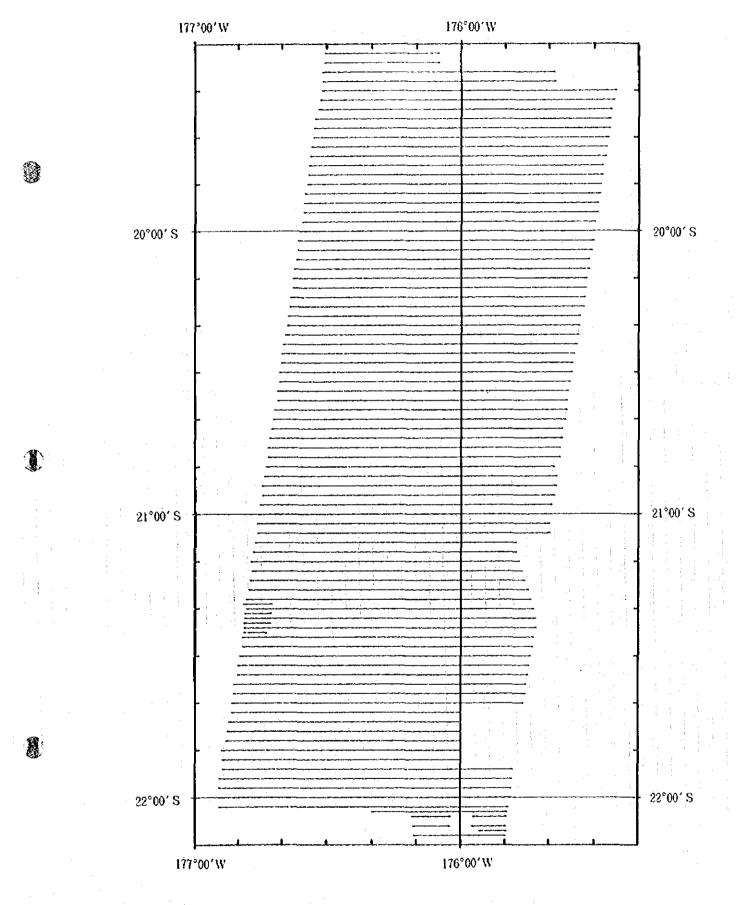
Fig. 1	Bathymetric profiles (all lines)
Fig. 2	MBES Track line map
Fig. 3	PGM Track line map
Fig. 4	SSS Vehicle position map
Fig. 5(1)-(13)	Route-maps of FDC observation
Fig. 6(1)-(3)	Columnar chart of LC core
Fig. 7	3-D bathymetric map based on MBES

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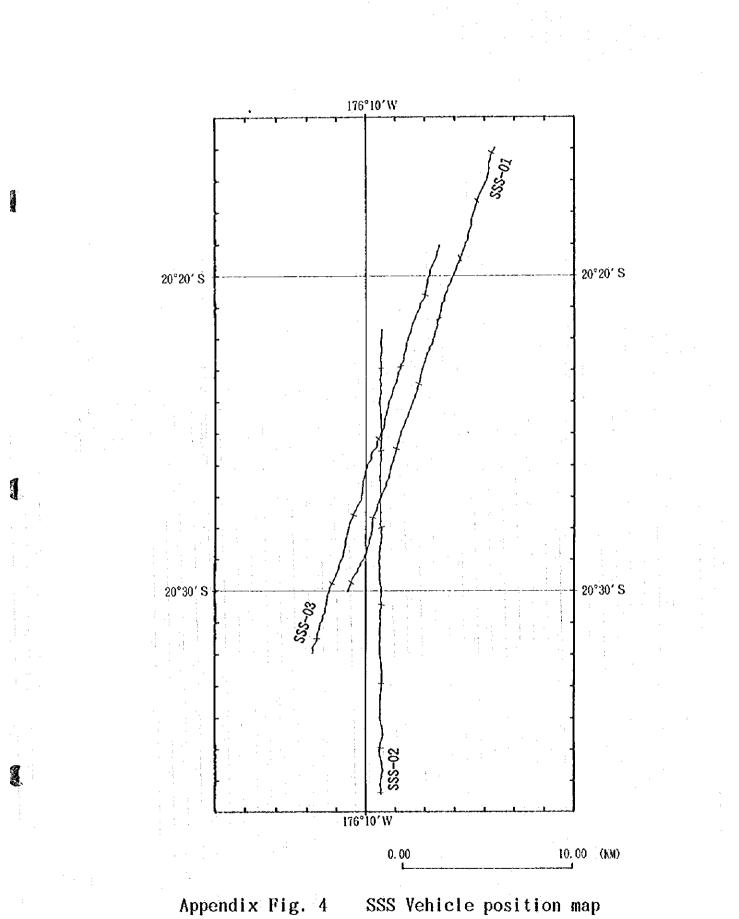
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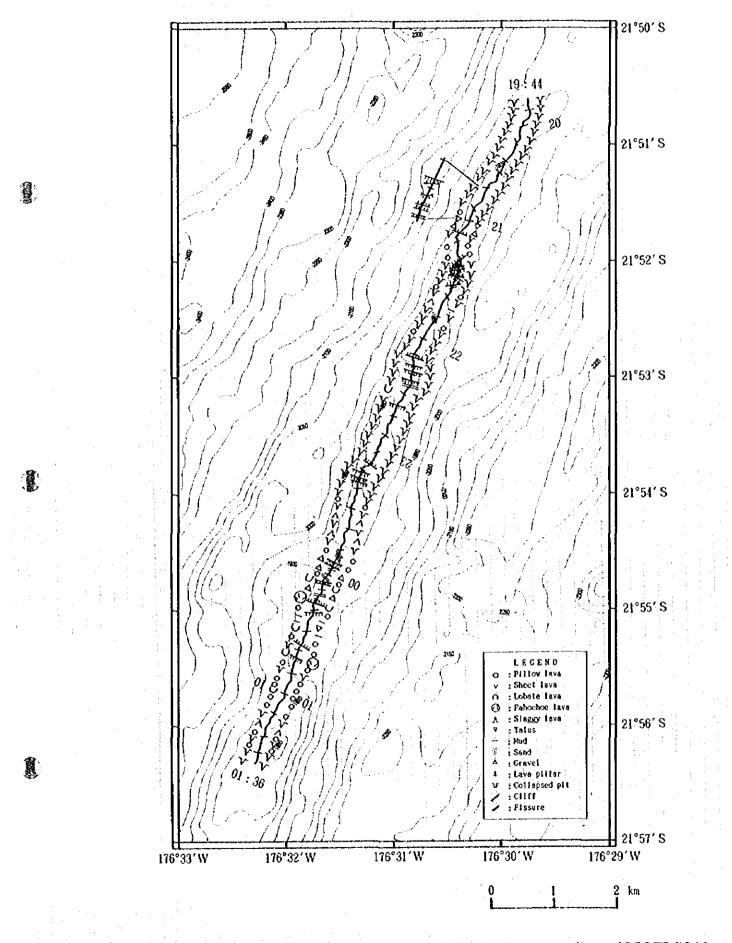




Appendix Fig. 3 PGM Track line map

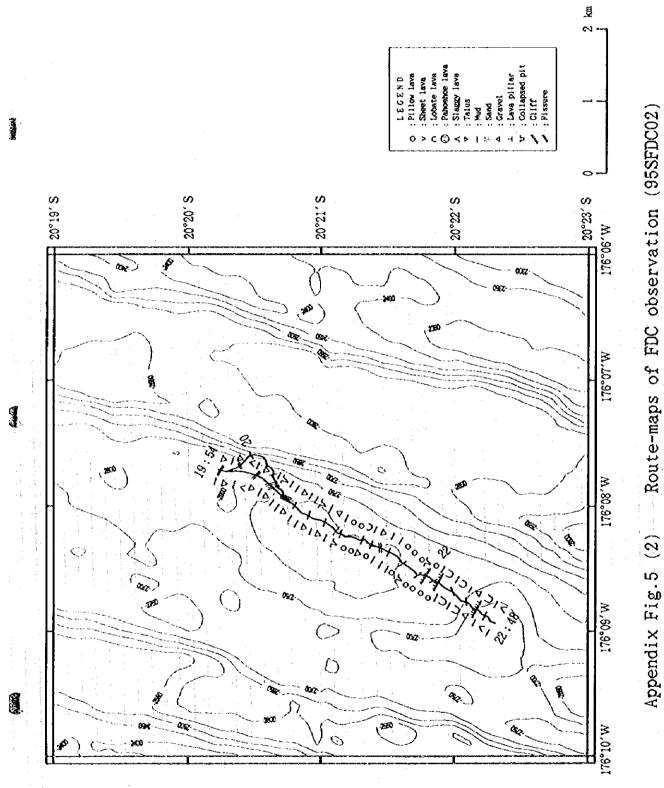
. .

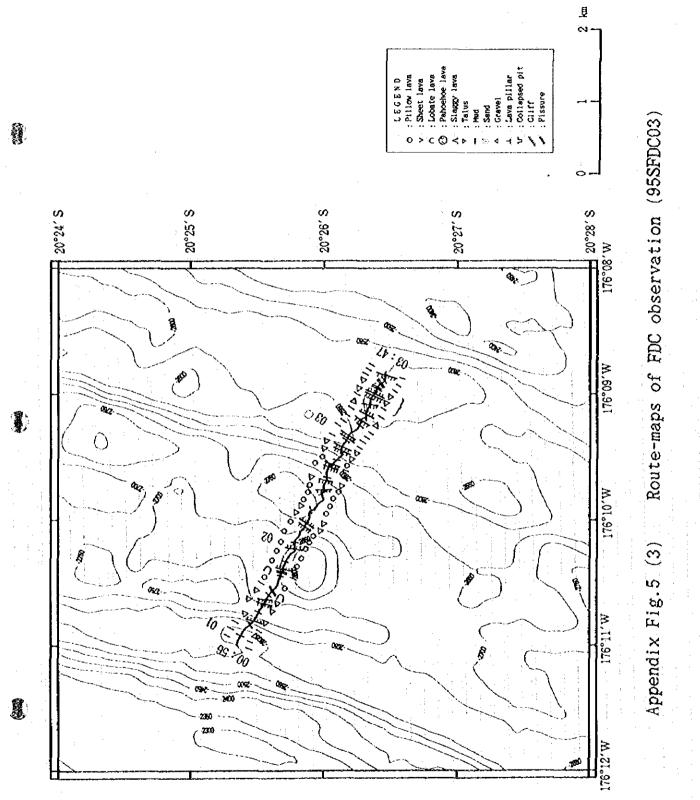


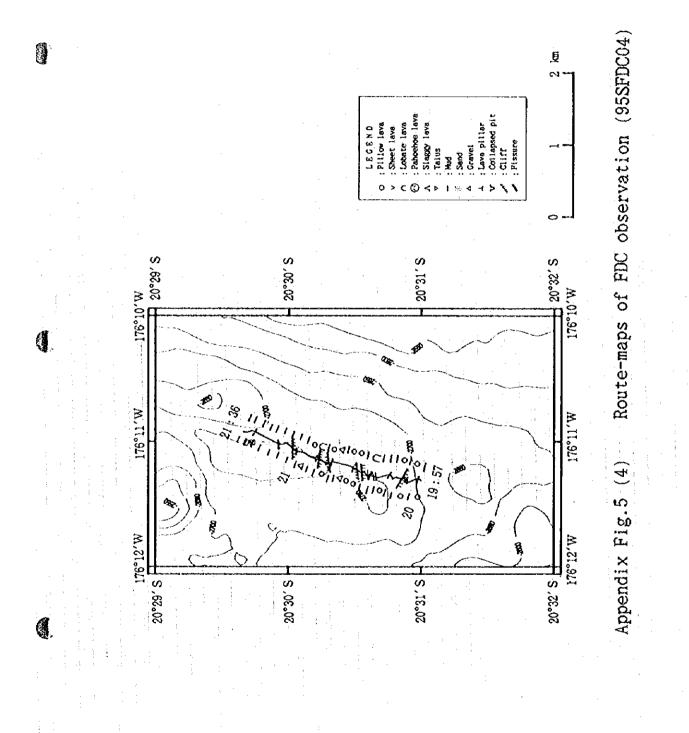


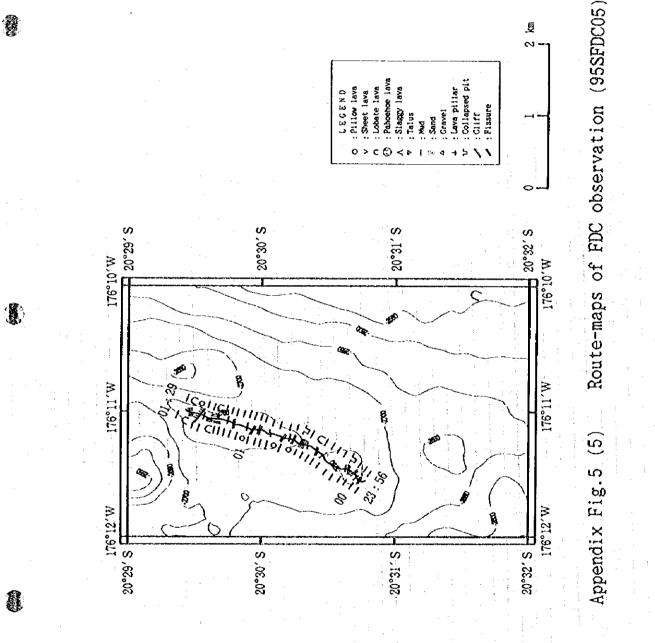
10 (17

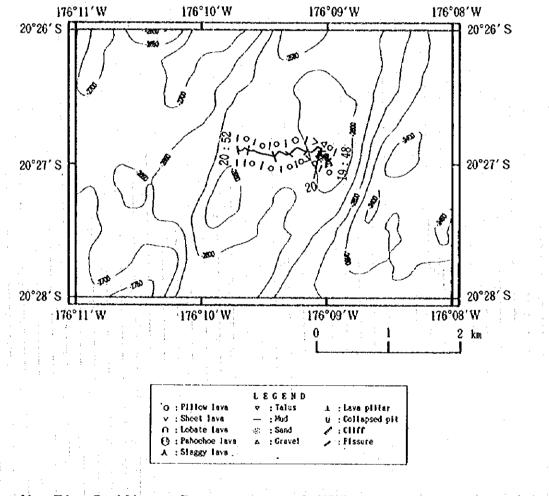
Appendix Fig.5 (1) Route-maps of FDC observation (95SFDC01)





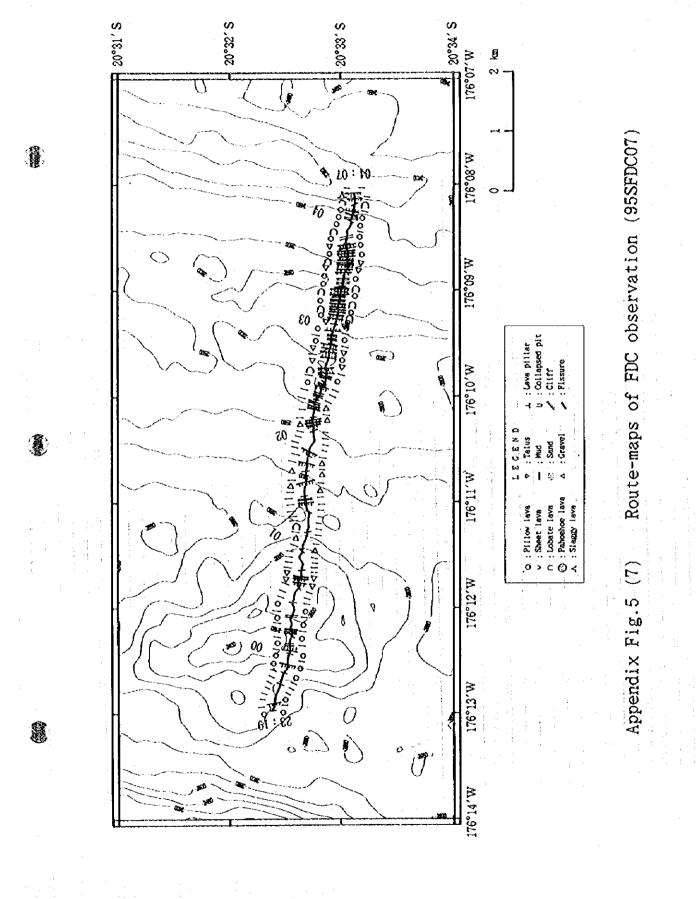


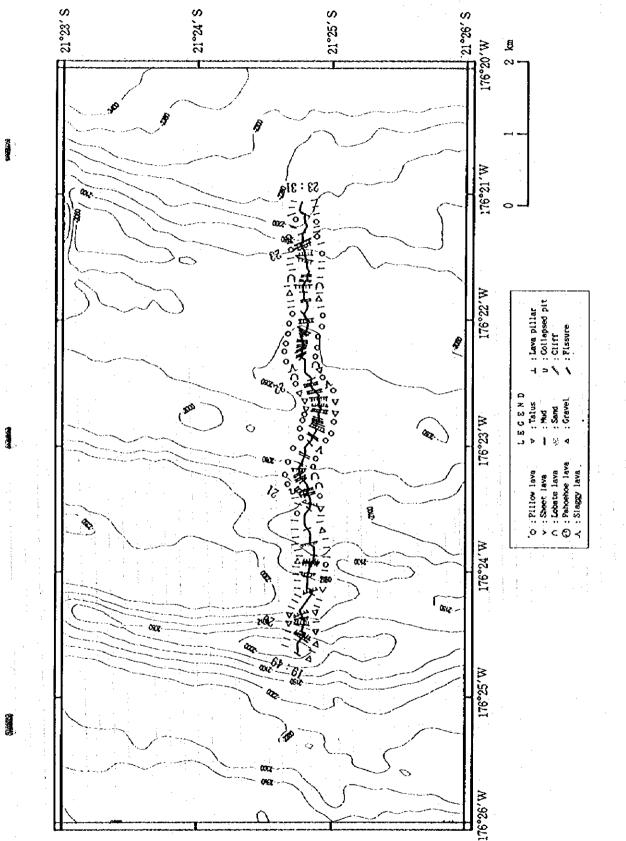




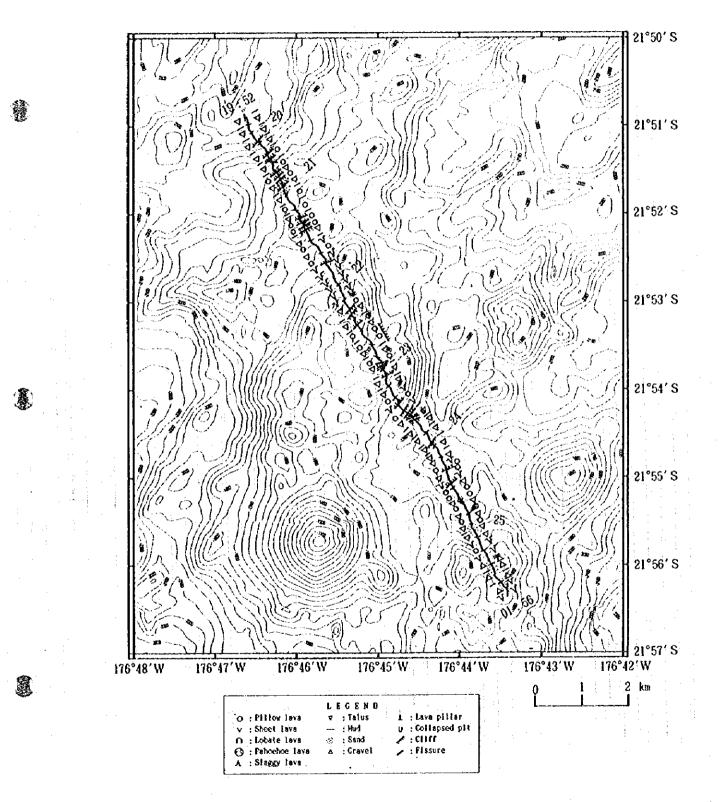
Route-maps of FDC observation (95SFDC06)

Appendix Fig.5 (6)

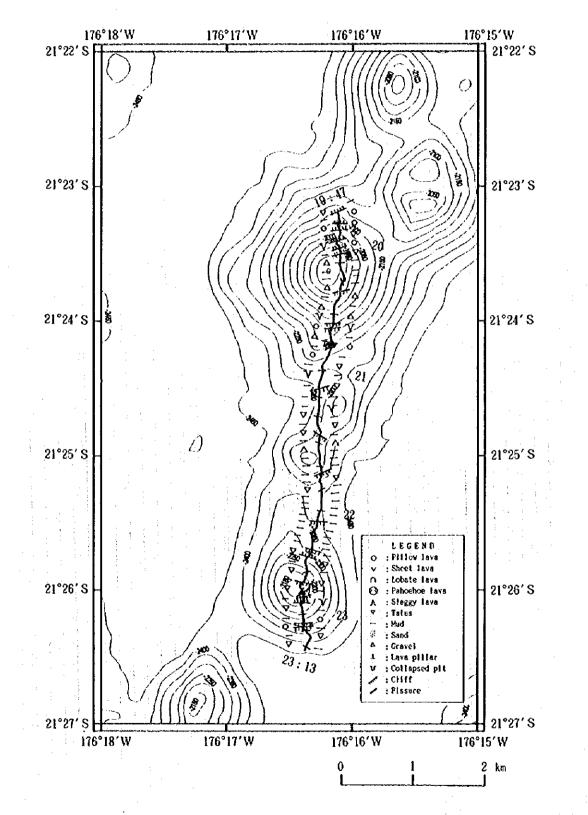




Route-maps of FDC observation (95SFDC08) Appendix Fig.5 (8)

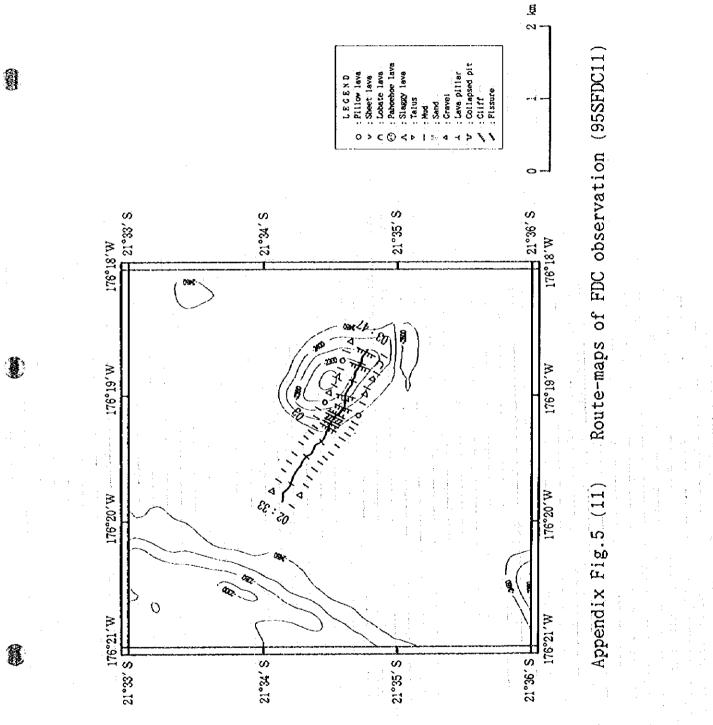


Appendix Fig.5 (9) Route-maps of FDC observation (95SFDC09)

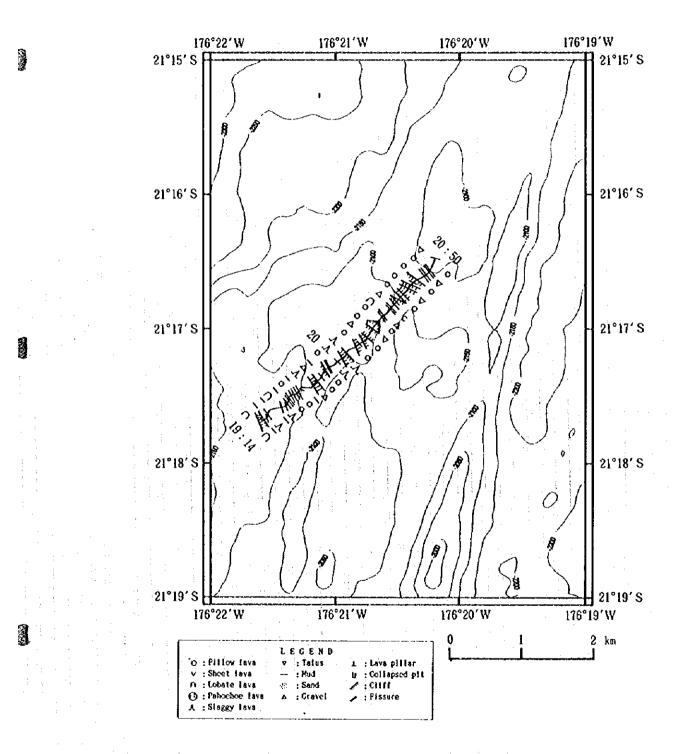


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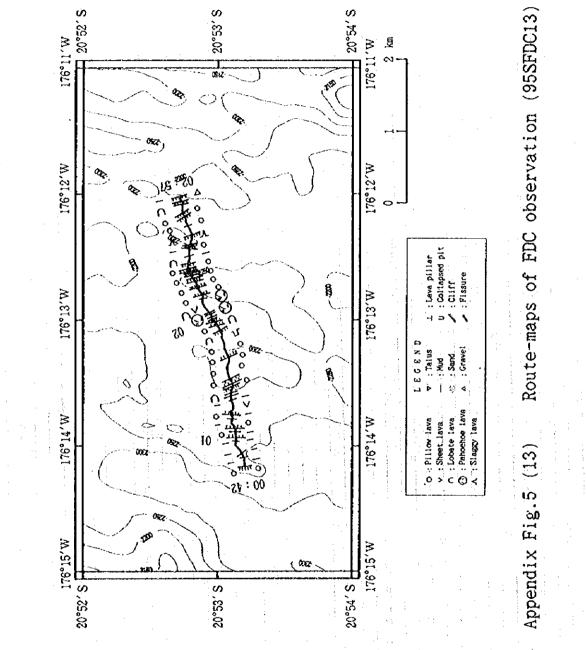
Appendix Fig.5 (10) Route-maps of FDC observation (95SFDC10)



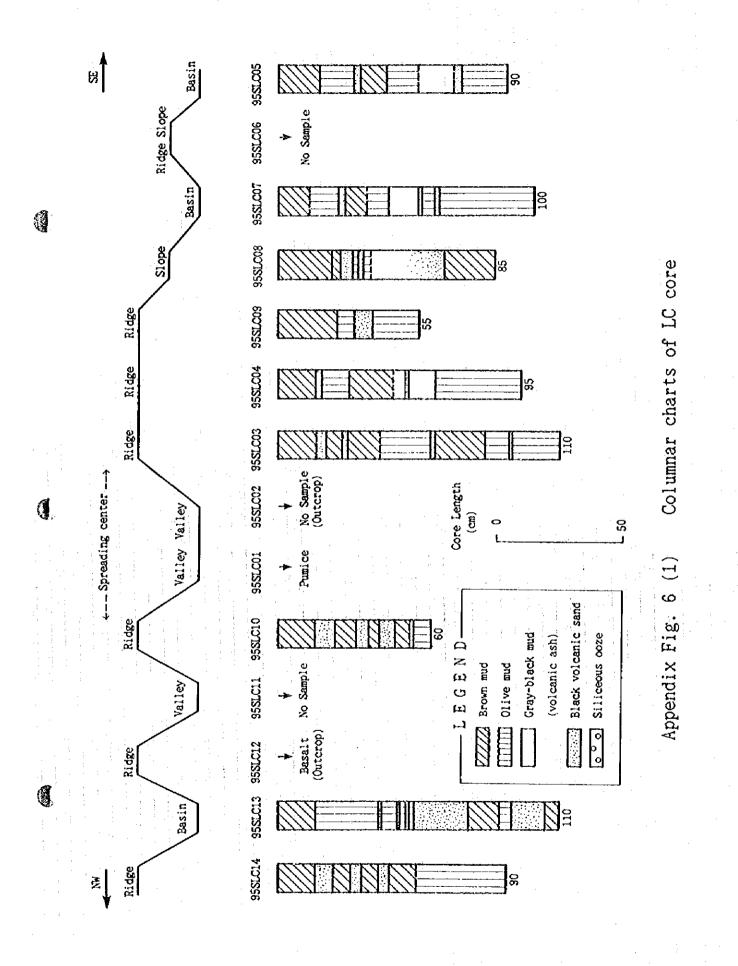
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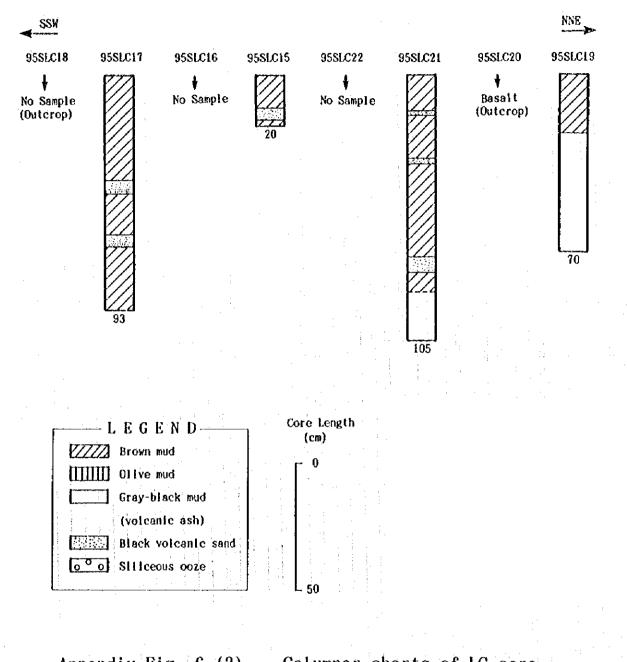


Appendix Fig.5 (12) Route-maps of FDC observation (95SFDC12)



P

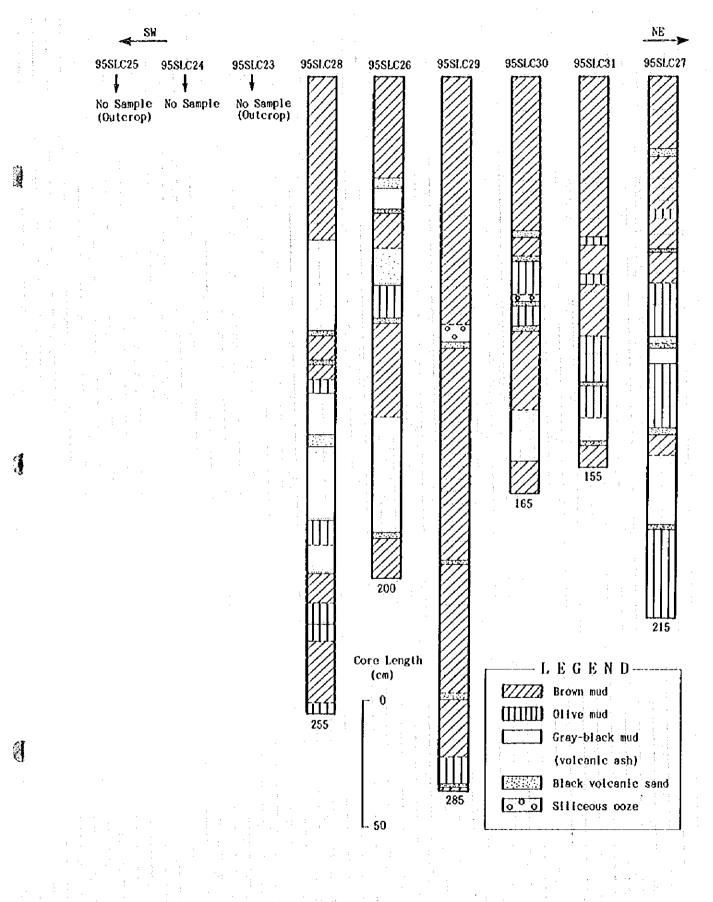




Appendix Fig. 6 (2) Columnar charts of LC core

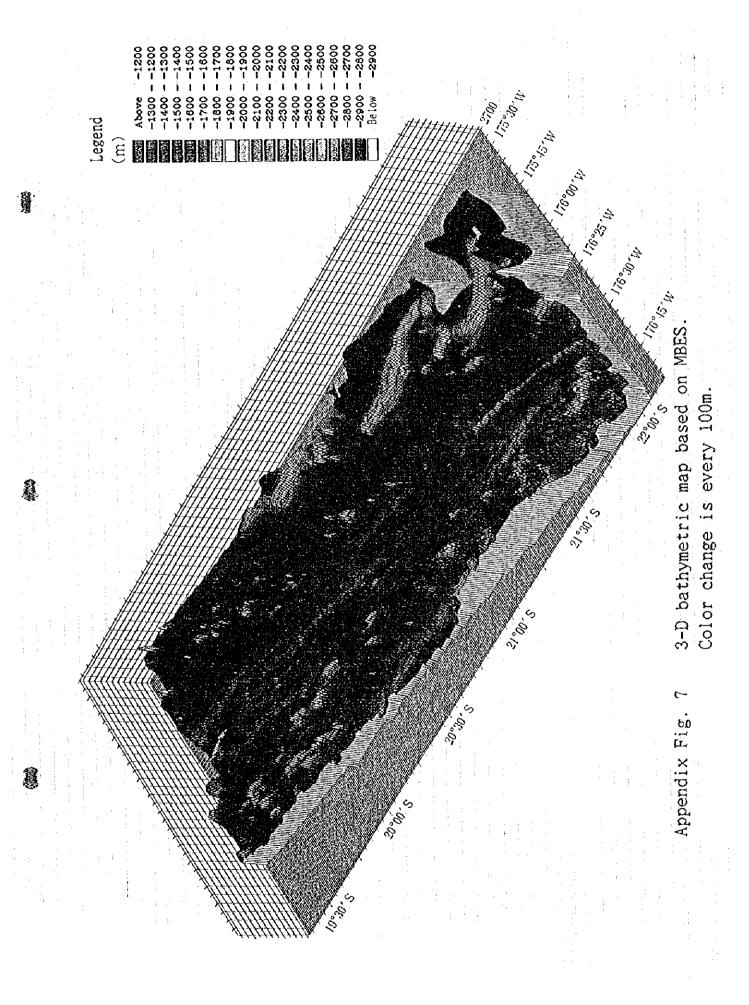
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Appendix Fig. 6 (3)

Columnar charts of LC core



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