

Chapter 4 Conclusions

The survey area, which includes the triple junction of the Central Spreading Ridge, is located in the central part of the North Fiji Basin. The topographic and magnetic surveys were conducted in the survey area, while, the hydrothermal mineralization survey and the environmental survey were conducted in the Triple Junction Area located at center of the survey area. The area covered by topographic and magnetic surveys correspond with the Area 1 of the year 1999 survey and no new information to be mentioned here is obtained by topographic and magnetic surveys. Consequently, the results of the hydrothermal mineralization survey and environmental survey are given below.

The Triple Junction Area of the hydrothermal mineralization and environmental surveys occupies central north of the Central Dome. It includes the Axial Valley at center, the Western Ridge on the west and the scarp toward the Eastern Ridge on the East.

4-1 Hydrothermal Mineralization Survey

Based on the results of the sea floor observations by FDC and BMS, the drilling targets were decided and 22 holes were drilled by BMS. In addition to the drilling, LC sampling was supplementary conducted on the days when drilling was hampered by bad weather.

Basaltic lavas, such as sheet lava, pillow lava and massive lava extensively occur in the Triple Junction Area. The sheet lava dominantly occupies the floor of the axial valley and the pillow lava tends to occur at the higher locations in the Axial Valley. The massive lava showing columnar joint is found along the fault escarpments.

The results of the seafloor observation by BMS and FDC show that the ore showings of the Triple Junction Area occur concentrated in two areas, the West Area and the East Area, separated by $173^{\circ} 55.2'E$ line, and they tend to occur on and near the boundary between sheet lava and pillow lava. The ore showings of the area consist of hydrothermal mound with inactive chimneys. Reddish brown fragments of 0.5-3m across consisting of chimney relic, sulfide ore and basalt are accumulated on the mound and at some places on the mound, sheets of massive sulfide with a rough surface are exposed, covered by reddish brown sediments with white and brownish yellow patches. The numbers of the ore showings confirmed by the seafloor observations are 11 in the West Area and 22 in the East Area. Among them, relatively large ore showing, with a mound extending more than 100m and uprising approximately 10m high from the

surrounding seafloor, was found at 4 locations in the West Area and 7 locations in the East Area.

The constituents of the hydrothermal mound were documented by the drilling conducted on and around the hydrothermal mound of the ore showings. The massive sulfide occurs on the top of the mound and the thickness of it corresponds to the height of the mound rising from the surrounding sea floor. The massive sulfide is underlain by altered hyaloclastite, which forms the alteration zone of the footwall. Although the massive sulfide is not found at the vicinity of the mound, alteration and stockwork zones occur as the marginal zone of the mineralization. The massive sulfide consisting mainly of pyrite, calcopyrite and sphalerite was collected in the Ore Showings W1, W3 and W6 of the West Area and in the Ore Showings E4, E12 and E13 of the East Area. Among these ore showings, the massive sulfide ores as thick as 5.96m and 7.62m were confirmed at the two drill holes in the Ore Showing W3. Compared to the West Area, thick massive sulfide was not collected in the East Area due to the rough surface of the mound in the East Area, many of them being located on the slope. There were also some cases that the massive sulfide was crushed and lost during the drilling operation in the East Area.

The chemical analyses of the basalt show that the basalts from the West and East Areas have different chemical characteristics; the former is tholeiitic and transitional from T-MORB to E-MORB, the latter is transitional from E-MORB to oceanic island basalt. These variations of chemical nature of the basalt from the two areas occur continuously from the West to the East Areas.

By the X-ray diffraction analyses, two alteration zones of different degree were identified surrounding the ore body of the massive sulfide. Zone I-b characterized by coexistence of quartz and either chlorite or mixed layers of chlorite/smectite occurs close to the massive sulfide and Zone I-a characterized by mordenite and smectite occurs outside of Zone I-b. Barite occurs in the ore body and in veins of the stockwork zone.

The relatively large mounds extending over an area of approximately 100m and rising 10m high from the surrounding sea floor occur in the Triple Junction Area. Chimneys of 3-5m high stand on the mound and they are surrounded by fragments of chimney and sulfide ore. After the formation of chimney at the first stage, the mound starts to build with accumulation of collapsed chimney and Zn-Au-Ag rich ore of Cu4.04%, Zn3.17%, Au1.83g/t and Ag71.20g/t is formed on the surface of the mound. This ore is formed by precipitations of marcasite, pyrite and sphalerite through mixing of hydrothermal fluid with seawater. As formation of the mound continues, Cu-rich massive sulfide of Cu6.93%, Zn0.61%, Au0.85% and Ag24.39% is formed in the core of

the mound. This ore was formed by precipitations of mainly calcopyrite and pyrite at high temperature by isolation of hydrothermal fluid from seawater. At the drill sites of 01SFBMS08 and 01SFBMS24 in the Ore Showing W3, the Zn-Au-Ag rich ore was not confirmed and the Cu-rich ore seems to be exposed on the surface. From the both drill holes, the thickness of the Cu-rich ore is 6.0m to 7.5m. In the East Area, on the other hand, fragments of chimney and massive sulfide of the mound with only 80cm thick were collected. A part of Zn-Au-Ag ore of the surface was collected and Cu-rich ore beneath this was not hit by the drilling in the East Area. Because of the locations of mounds in the East Area being distributed on slope and of rough surface of the mounds, Cu-rich ore could not be hit by drilling.

The survey suggests that more than seven ore showings, with ore reserves of more or less 70,000t at the grade of Cu6.93%, Zn0.61%, Au0.85% and Ag24.39%, are expected to exist in the Triple Junction Area. Although the scale of the ore body is small compared to on land copper mine, Cu grade is high considering the Cu grades of on land mine. The Cu grades of open pit mine and underground mine are, respectively more or less 1% and 3-4%. Further, a possibility still remains finding more ore showings in the Triple Junction Area by detail survey in future. Since there is some ambiguity in location of ore showing in the survey, a detail survey with more accurate location is awaited.

4-2 Environmental Survey

The environmental survey was conducted as a baseline study of the area to predict the magnitude of mining impacts on the deep-sea environment.

Abnormal distributions of potential water temperature, concentrations of methane, light transmission and the biomass of bacterioplankton were observed lower than 100 m above the seafloor and they strongly suggest the existence of plume derived from hydrothermal vent. On the other hand, the remarkable high concentration of inorganic carbon was observed deeper than 5cm in the sediment at the site of 01SFM05. From this result, it was inferred that calcium carbonate derived from hot water was precipitated in the sediments.

Judging from total points of view, hydrothermal vent was confirmed in this site, and the effects of it extent to this area. However there were also unexplainable results, i.e. the data of light transmission was not correspond to that of suspended solid, there was no obvious difference in abundance of benthic organisms between the stations of much inorganic carbon and less inorganic carbon. It suggests the necessity of more detail survey in the future.

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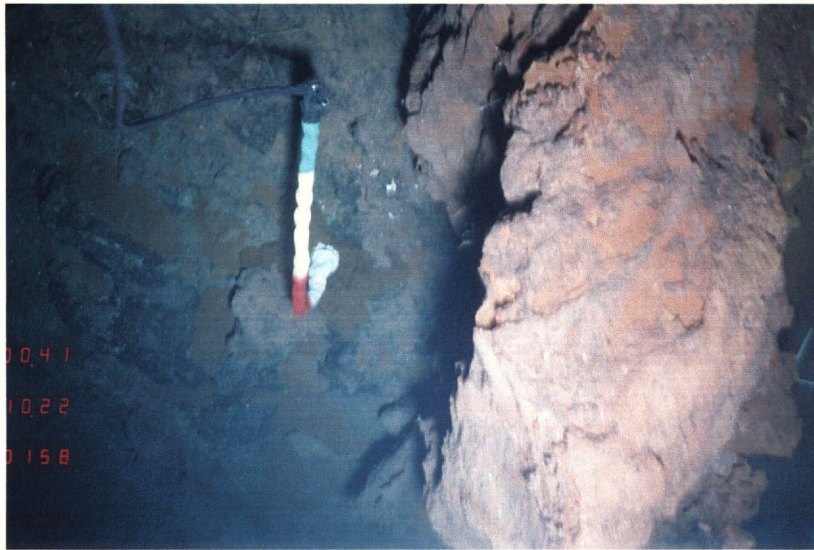
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{Appendix}

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Appendix 1 Photographs of Ore Showings



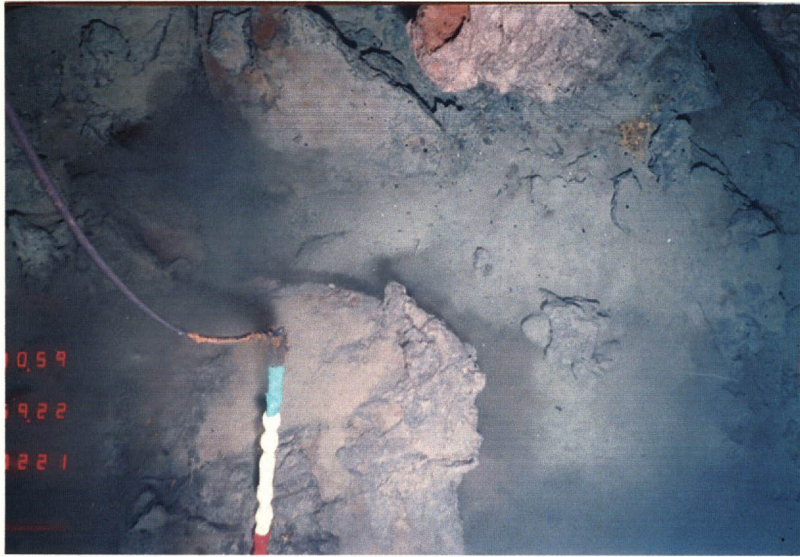
Ore Showing No. : W1



Ore Showing No. : W4



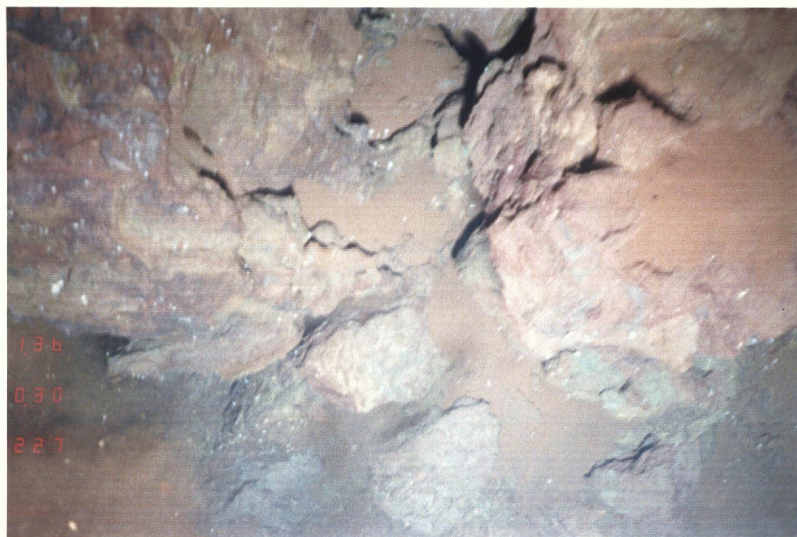
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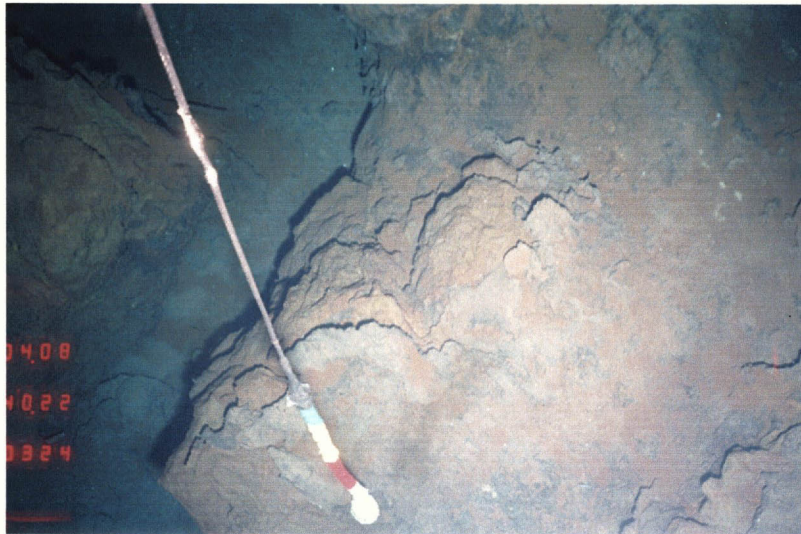
Ore Showing : W6



Ore Showing : E1



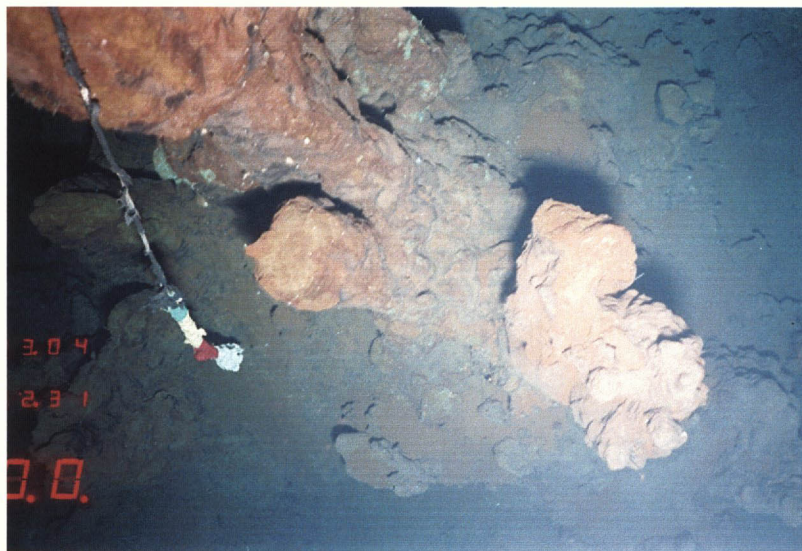
Ore Showing : E4



Ore Showing : E4



Ore Showing : E8



Ore Showing : E11

Appendix 2 Column of LC and MC

Sampling Site	01SFMC01 (West Part)
Latitude	16° 57.5053' S
Longitude	173° 55.0994' E
Depth	1,980 m
Core Length	0 cm
Core Weight	- kg

cm	Sample		Color	Description	Lab. Test
10				No Sample	
20					

Column of 01SFMC01

Sampling Site	01SFMC02 (West Part)
Latitude	16° 57.5184' S
Longitude	173° 55.1005' E
Depth	1,980 m
Core Length	0 cm
Core Weight	- kg

cm	Sample		Color	Description	Lab. Test
10				No sample	
20					


Column of 01SFMC02

Sampling Site	01SFMC03 (West Part)
Latitude	16° 57.5286' S
Longitude	173° 55.1029' E
Depth	1,980 m
Core Length	0 cm
Core Weight	- kg

cm	Sample	Color	Description	Lab. Test
10			No sample.	
20				


Column of 01SFMC03

Sampling Site	01SFLC07 (West Part)
Latitude	16° 57.5782 S
Longitude	173° 55.0956' E
Depth	1,983 m
Core Length	0 cm
Core Weight	0.1 kg

cm	Sample	Color	Description	Lab. Test
10			Few fragments of massive sulfides, 0.5 to 4cm across. Chalcopyrite-pyrite-rarely sphalerite.	
20				

Column of 01SFLC07

Sampling Site	01SFLC08 (West Part)
Latitude	16° 57.5770' S
Longitude	173° 55.1040' E
Depth	1,982 m
Core Length	55 cm
Core Weight	2.8 kg

cm	Sample	Color	Description	Lab. Test
0			0~35cm : Fragments of black glass (ϕ 1-2cm) , rarely basalt, conchidal fracture	
10				
20				
30				
40			35~55cm : Fragments of basalt (ϕ 3-5cm) with black glass, blackish gray, fine-grained, compact.	
50				
60				

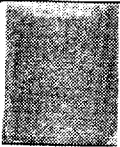
Column of 01SFLC08

Sampling List	01SFLC09 (West Part)
Latitude	16° 57.3980' S
Longitude	173° 55.0496' E
Depth	1,980 m
Core Length	95 cm
Core Weight	11.3 kg

cm	Sample	Color	Description	Lab. Test
0	Brown Clay	5YR 3/2	Brown clay 0~10cm : High water content 10cm : Black layer, thick:5mm < 20°, concentrated Mn ₂ O ₃	
10			20cm : Black layer, thickness 3mm 20~95cm : It shows brighter color with oxidized patches of reddish brown	
20			90~95cm : Consolidated part.	
30			Whole LC core, cavity (φ1cm) is scattered.	
40		10YR 4/4		
50				
60				
70				
80				
90				
100				


Column of 01SFLC09

Sampling Site	01SFMC04 (West Part)
Latitude	16° 57.3957' S
Longitude	173° 55.0495' E
Depth	1,978 m
Core Length	10 cm
Core Weight	- kg

cm	Sample	Color	Description	Lab. Test
10	 Brown Clay	5YR 3/2	Brown Clay.	
20				



Column of 01SFMC04

Sampling Site	01SFLC10 (East Part)
Latitude	16° 57.5768' S
Longitude	173° 55.2335' E
Depth	1,989 m
Core Length	0 cm
Core Weight	0.05 kg

cm	Sample	Color	Description	Lab. Test
10			Basalt fragments of 1-4cm across with brownish color by oxidation, glassy, fine grained, compact,	
20				

Column of 01SFLC10

Sampling site	01SFLC11 (West Part)
Latitude	16° 57.6540' S
Longitude	173° 55.0201' E
Depth	1,981 m
Core Length	10 cm
Core Weight	1.10 kg

cm	Sample	Color	Description	Lab. Test
10			Fragment of basalt (ϕ 10cm) & black glass (ϕ 0.5~1cm) Basalt:blackish gray, fine, compact, the surface of it is covered by black glass of few cm thick.	
20				

Column of 01SFLC11

Sampling Site	01SFLC12 (West Part)
Latitude	16° 57.5692' S
Longitude	173° 54.5972' E
Depth	1,895 m
Core Length	110 cm
Core weight	12.9 kg

cm	Sample	Color	Description	Lab. Test
0~40	Brown Clay	5YR 3/3	0~40cm : Brown clay, Calcareous, mixed with foraminifer.	
40~45	Volcanic Ash		40~45cm : Including much volcanic ash.	
45~55	Pinkish gray calcareous clay	7.5YR 7/2	45~55 cm : Pinkish gray, calcareous clay, much foraminifers part.	
55~110	Grayish Brown clay	10YR 5/2	55~110 cm : Grayish brown clay, little foraminifers part.	

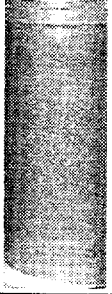
Column of 01SFLC12 1/2

Sampling Site	01SFLC12 (West Part)
Latitude	16° 57.5692' S
Longitude	173° 54.5972' E
Depth	1,895 m
Core Length	110 cm
Core Weight	12.9 kg

cm	Sample	Color	Description	Lab. Test
70	Grayish Brown clay	10YR 5/2	55~110 cm: Grayish brown clay, little foraminifers part.	
80			85~110cm: Black glass, Weathered fragment of basalt (ϕ 1~2cm) .	
90				
100				
110				
120				


Column of 01SFLC12 2/2

Sampling Site	01SFMC05 (West Part)
Latitude	16° 57.5690' S
Longitude	173° 54.5937' E
Depth	1,895 m
Core Length	20 cm
Core Weight	- kg

cm	Sample	Color	Description	Lab. Test
10 20			Brown clay including calcareous material.	


Column of 01SFMC05

Sampling Site	01SFLC13 (West Part)
Latitude	16° 57.6610' S
Longitude	173° 55.0496' E
Depth	1,980 m
Core Length	0 cm
Core Weight	0.05 kg

cm	Sample	Color	Description	Lab. Test
10 20			2~0.5cm: Volcanic Breccia, glassy, black, compact.	

Column of 01SFLC13

Sampling Site	01SFLC14 (West Part)
Latitude	16° 57.9039' S
Longitude	173° 55.0056' E
Depth	1,990 m
Core Length	15 cm
Core Weight	0.5 kg

cm	Sample	Color	Description	Lab. Test
10	 Black Glass		Fragment of black glass (φ 0.5-6cm), black glass, compact	
20				

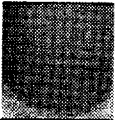
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Sampling Site	01SFLC15 (West Part)
Latitude	16° 57.6339' S
Longitude	173° 55.0153' E
Depth	1,981 m
Core Length	95 cm
Core Weight	12.25 kg

cm	Sample	Color	Description	Lab. Test
0-10	Brown Clay	5YR 3/2	Brown clay with 2mm thickness Mn oxides	
0-10			0~10cm : Banded Brown Clay including black Layer. Little of grain of sand. No reaction to HCl.	
10-75	Light Reddish Clay	10YR 6/3	10~75cm : Pale Brown, Much water content in percentage of total weight. Little of grain of sand. No reaction to HCl.	
75-95	Black Glass	Black	75~95cm : Fragment of black glass (φ2~5cm)	
90-95				
100				

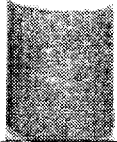
Column of 01SFLC15

Sampling Site	01SFMC06 (West Part)
Latitude	16° 57.6441' S
Longitude	173° 55.0206' E
Depth	1,981 m
Core Length	8 cm
Core Weight	- kg

cm	Sample	Color	Description	Lab. Test
	 Reddish Clay	5YR 3/2	0~8mm : Brown clay with 5mm thick Mn oxides. Sediment included the fragment of black glass (φ 6mm)	
10				
20				


Column of 01SFMC06

Sampling Site	01SFMC07 (West Part)
Latitude	16° 57.6258' S
Longitude	173° 55.0304' E
Depth	1,978 m
Core Length	10 cm
Core Weight	- kg

cm	Sample	Color	Description	Lab. Test
		5YR 3/2	Brown clay same as LC15.	
10				
20				


Column of 01SFMC07

Sampling Site	01SFLC16 (East Part)
Latitude	16° 57.7066' S
Longitude	173° 55.3375' E
Depth	1,993 m
Core Length	10 cm
Core Weight	0.35 kg

cm	Sample	Color	Description	Lab. Test
10 20			Fragment of basalt with black glass (ϕ 2-5mm), blackish, compact, fine-grained, aphyric	

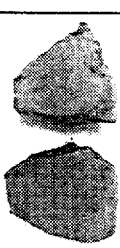
Column of 01SFLC16

Sampling Site	01SFLC17 (East Part)
Latitude	16° 57.7501' S
Longitude	173° 55.4309' E
Depth	1,988 m
Core Length	10 cm
Core Weight	0.85 kg

cm	Sample	Color	Description	Lab. Test
10 20			Massive Sulfide(ϕ 10cm) consist of Py, Cp, Sph and mac. 2 stage mineralization : 1) Py rich zone 2) Py-Cp and rarely Sph zone	AS01 PL01 CM01


Column of 01SFLC17

Sampling Site	01SFLC18 (East Part)
Latitude	16° 57.8473' S
Longitude	173° 55.2092' E
Depth	1,989 m
Core Length	5 cm
Core Weight	0.44 kg

cm	Sample	Color	Description	Lab. Test
10			Two fragments of basalt (ϕ 5cm) , blackish gray, fine-grained, apyric, vesicular, Mn oxide on surface.	
20				

Column of 01SFLC18

Sampling Site	01SFLC19 (East Part)
Latitude	16° 57.5580' S
Longitude	173° 55.3904' E
Depth	1,997 m
Core Length	0 cm
Core Weight	0.05 kg

cm	Geology	Color	Description	Laboratory
10			Fragment of basalt (ϕ 1.3mm) , blackish, fine-grained, vesicular	
20				


Column of 01SFLC19

Sampling Site	01SFLC20 (East Part)
Latitude	16° 57.8598' S
Longitude	173° 55.3068' E
Depth	1,989 m
Core Length	0 cm
Core Weight	0.01 kg

cm	Sample	Color	Description	Lab. Test
10			Fragment of black glass (ϕ 0.5mm), Quartz films with pyrite in the black glass.	
20				


Column of 01SFLC20

Sampling Site	01SFLC21 (East Part)
Latitude	16° 57.6209' S
Longitude	173° 55.6324' E
Depth	1,951 m
Core Length	25 cm
Core Weight	0.50 kg

cm	Sample	Color	Description	Lab. Test
10	 Fragments of Basalt		Mixed with Fragments of basalt, mudstone and Mn oxide with sand Basalt: Basalt with 5mm thick black glass layer, fine-grained, aphyric and slightly vesicular. Mudstone: Grayish Brown, soft mudstone, Fragments of Mn oxides: 5mm thick Mn oxides, platy Sand: pyrite and reddish oxidized grains.	
20				
30				


Column of 01SFLC21

Sampling Site	01SFLC22 (East Part)
Latitude	16° 57.8522' S
Longitude	173° 55.6436' E
Depth	1,950 m
Core Length	20 cm
Core Weight	0.65 kg

cm	Sample	Color	Description	Lab. Test
0 10 20	 Basalt		Basalt and black glass fragment (ϕ 1-7mm) Basalt : blackish gray, fine-grained, vesicular. Black glass : 5cm thick layer	


Column of 01SFLC22

Sampling Site	01SFLC23 (East Part)
Latitude	16° 57.9789' S
Longitude	173° 55.5767' E
Depth	1,977 m
Core Length	0 cm
Core Weight	0.01 kg

cm	Sample	Color	Description	Lab. Test
0 10 20			Basalt and black glass fragments. Basalt:blackish grey, fine-grained, compact.	

Column of 01SFLC23

Sampling Site	01SFLC24 (West Part)
Latitude	16° 57.7340' S
Longitude	173° 55.1598' E
Depth	1,987 m
Core Length	0 cm
Core Weight	0.01 kg

cm	Sample	Color	Description	Lab. Test
10 20			Fragments of black glass with 2mm thick Mn oxides. Pyrite grains of sand-size	

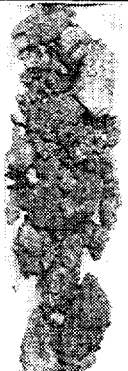
Column of 01SFLC24

Sampling Site	01SFLC25 (West Part)
Latitude	16° 57.8993' S
Longitude	173° 54.9548' E
Depth	1,993 m
Core Length	25 cm
Core Weight	0.55 kg

cm	Sample	Color	Description	Lab. Test
10 20			Fragments of black glass (ϕ 5mm) Core bit is stucked the clay with Mn oxide.	

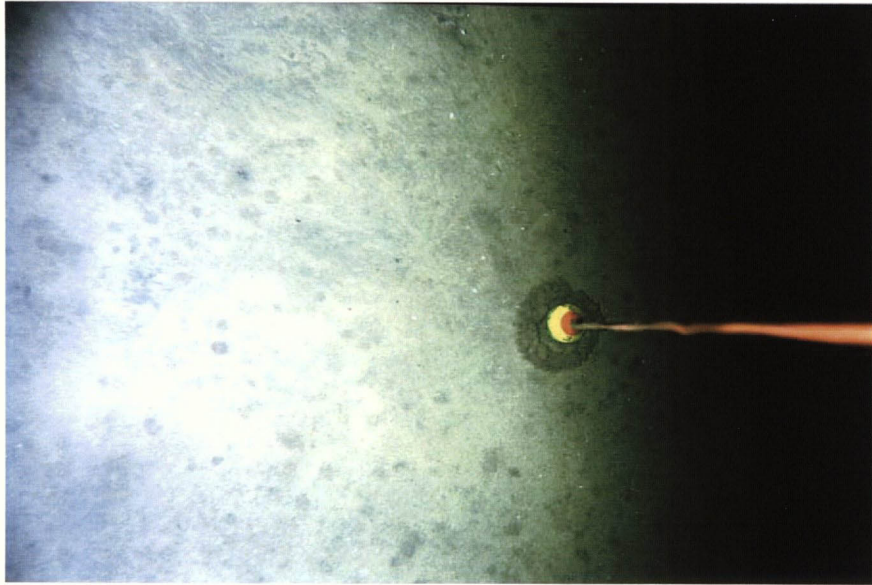
Column of 01SFLC25

Sampling Site	01SFLC26 (East Part)
Latitude	16° 57.8933' S
Longitude	173° 54.9548' E
Depth	1,993 m
Core Length	25 cm
Core Weight	0.55 kg

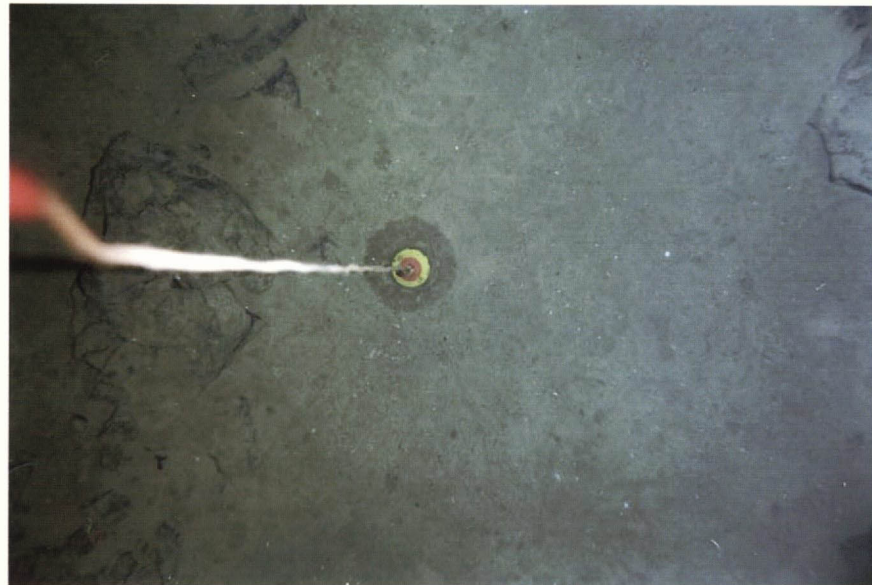
cm	Sample	Color	Description	Lab. Test
10	 Mud sediment and Mn oxide		Soft mud stones covered by 5mm thick Mn oxides. The surface of Mn oxide looks granulated texture.	
20				
30				

Column of 01SFLC26

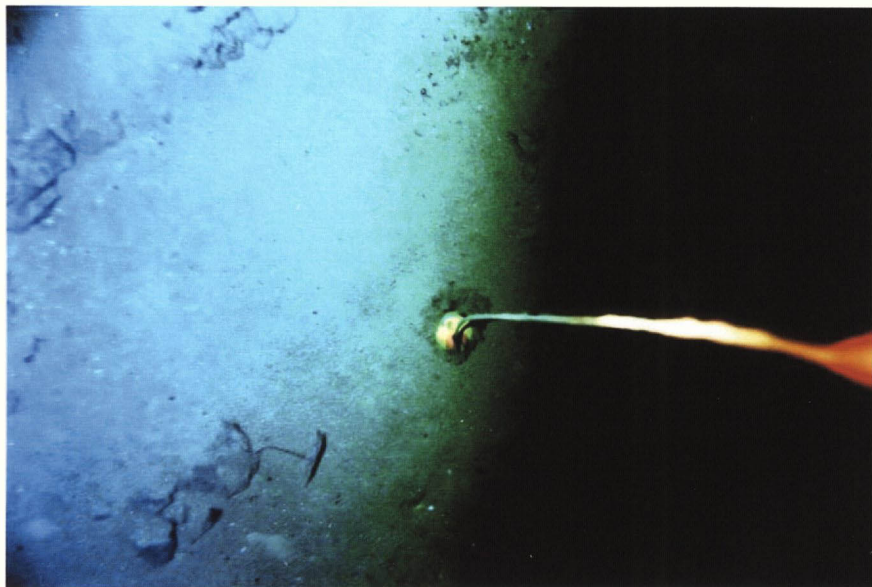
Appendix 3 Photographs of LC and MC



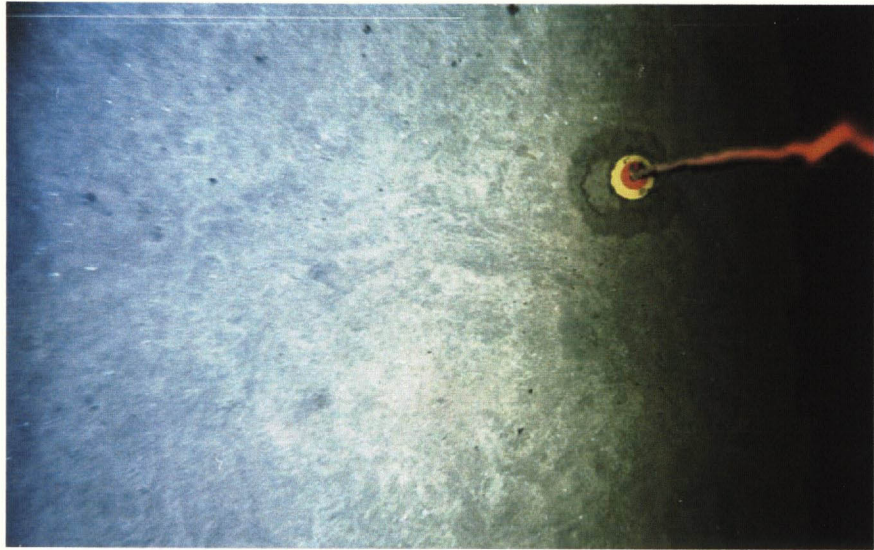
01SFLC09



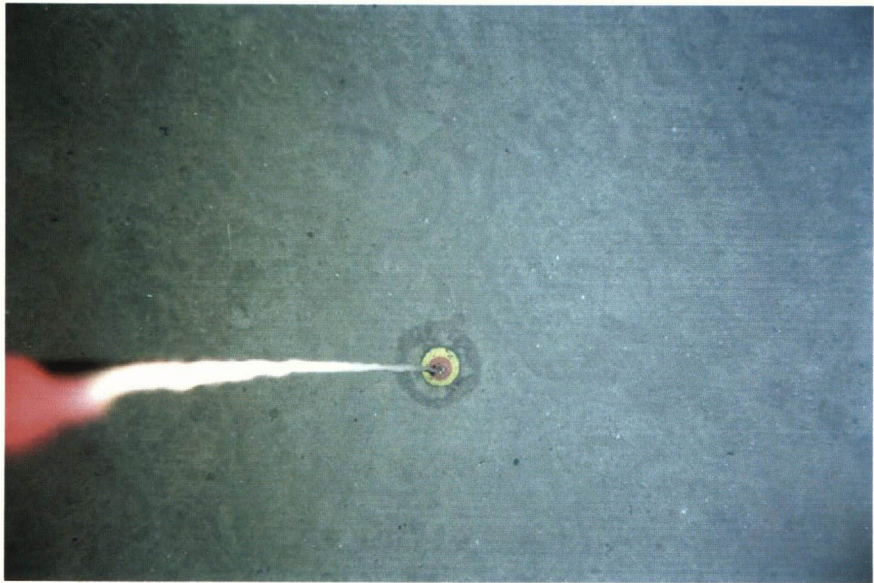
01SFMC04



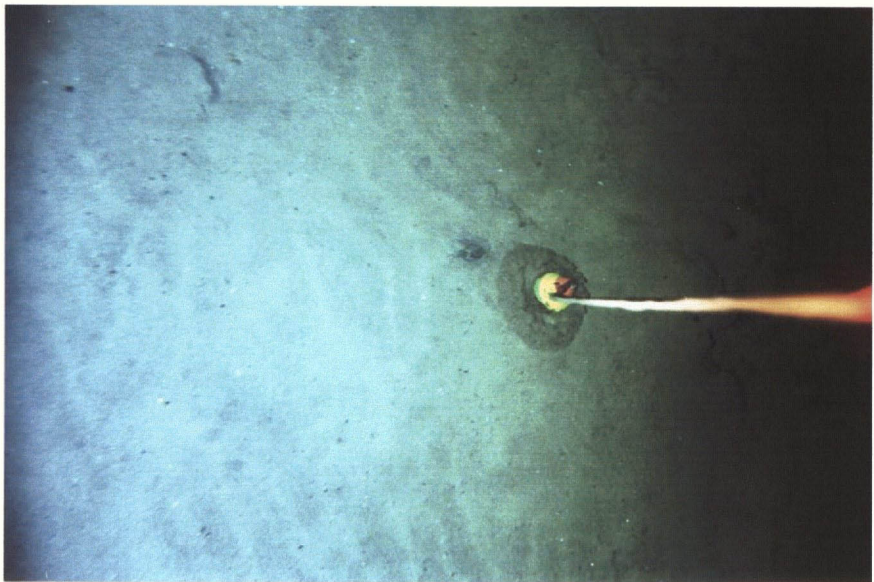
01SFLC11



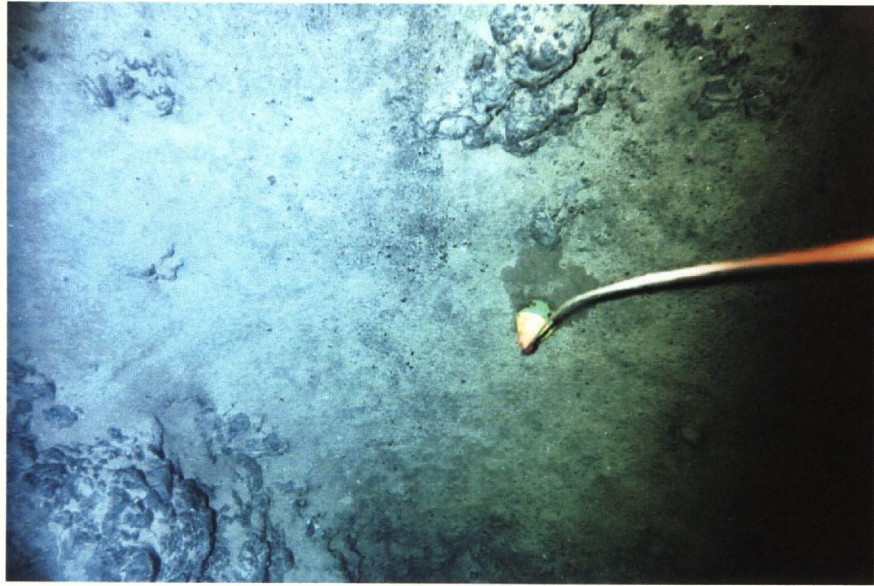
01SFLC12



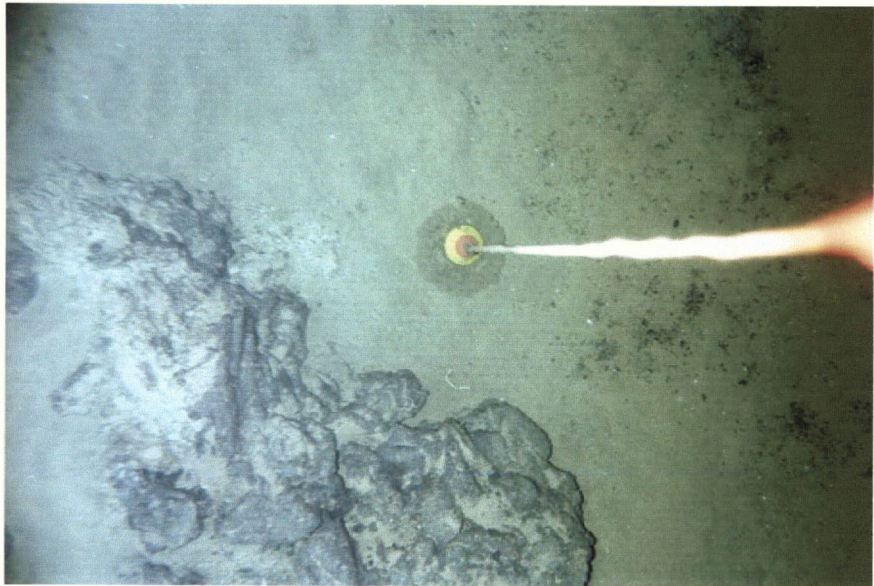
01SFMC05



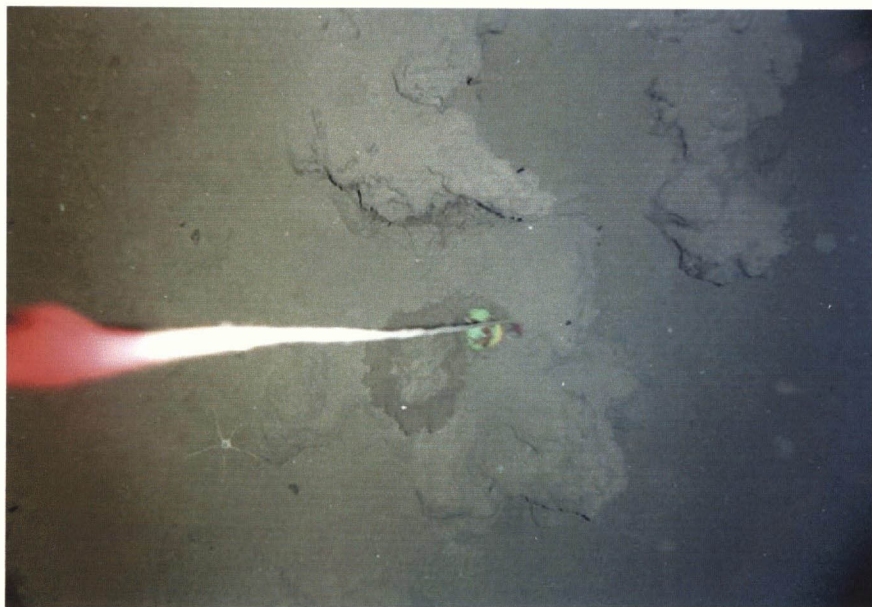
01SFLC13



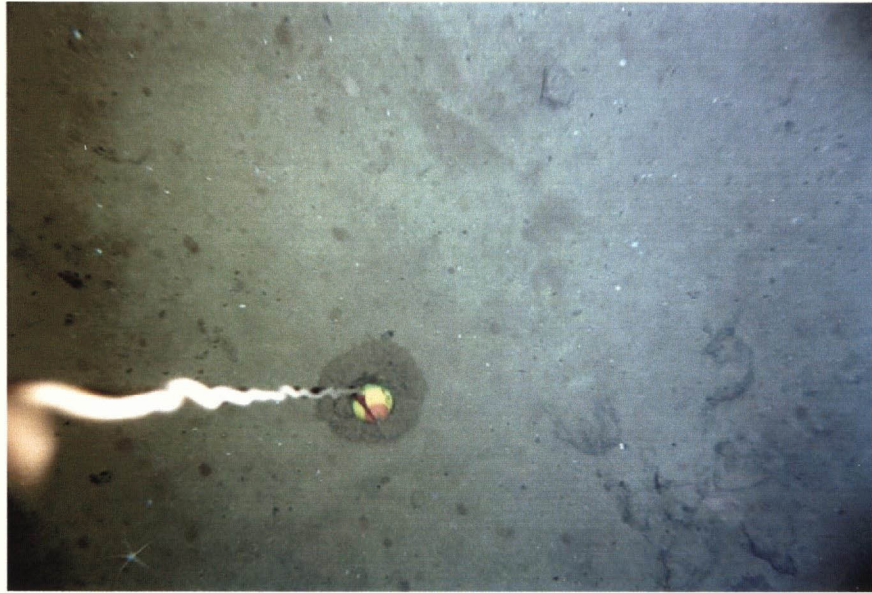
01SFLC14



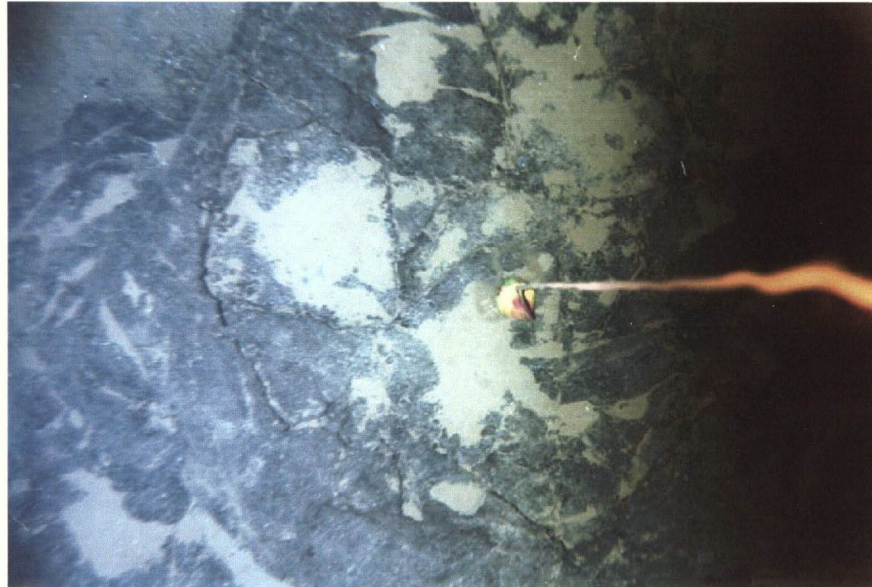
01SFLC15



01SFMC06



01SFMC07



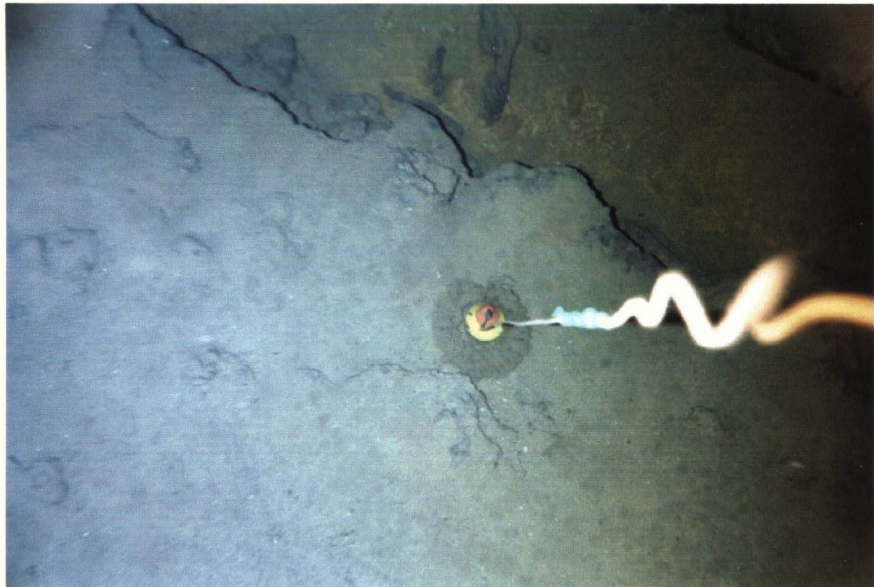
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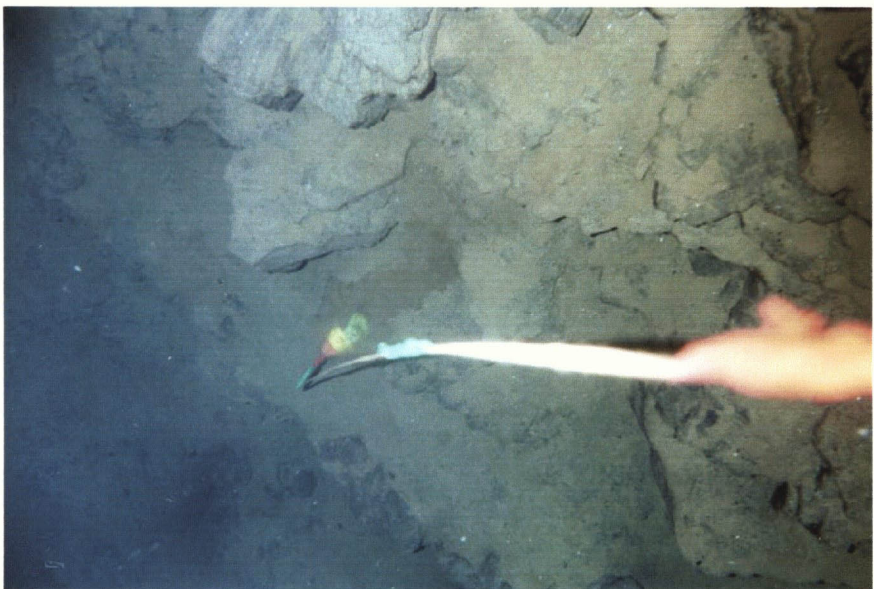
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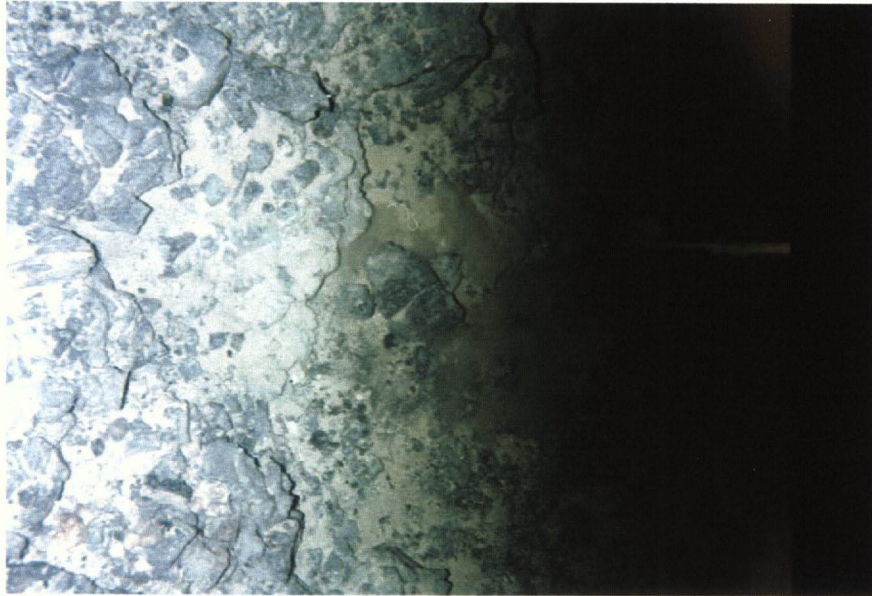
01SFLC19



01SFLC20



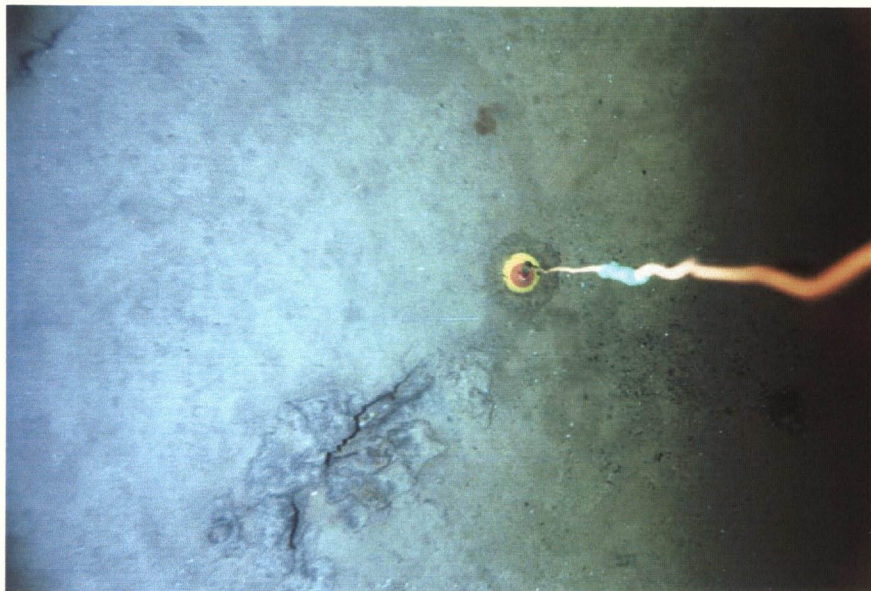
01SFLC21



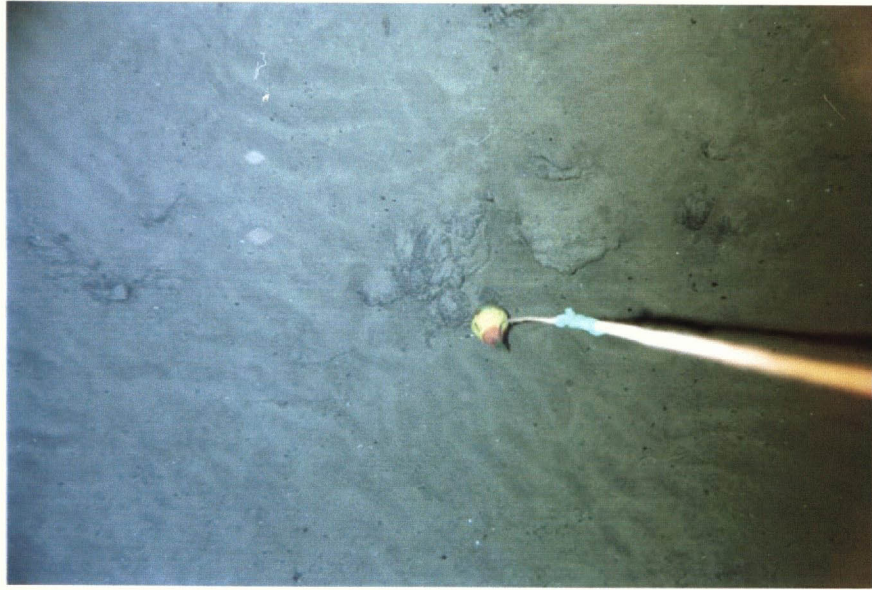
01SFLC22



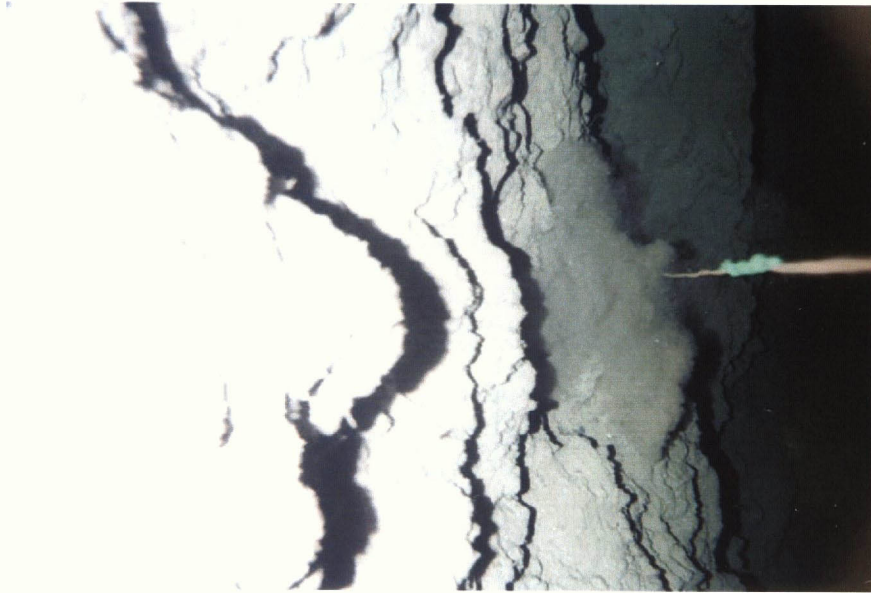
01SFLC23



01SFLC24



01SFLC25



01SFLC26