

Appendix 5 Columnar Profile LC and MC Samples


Column of LC Samples

Hole No.	02SMS01LC14
Latitude	10° 43.501' N
Longitude	161° 27.759' E
Water Depth	2.075m
Core Length	115 cm
Core Weight	11.7 kg

cm	Core	Color	Descriptions	Remarks
20	foraminiferal sand	10YR 7/4	Pale brown foraminiferal sand, slightly coarse grained, homogeneous. shallower than 55cm: brown, oxidized particles are partly included. Mn oxides particles are not observed.	FS01
				FS02
				FS03
40				
60				
80		10YR 8/3		
100				
120				
140				
160	Core			
180				
200				

02SMS11LC14

Hole No.	02SMS01LC15
Latitude	14° 17.195' N
Longitude	160° 57.014' E
Water Depth	1.542m
Core Length	155 cm
Core Weight	19.8 kg

cm	Core	Color	Descriptions	Remarks
0-20		10YR 7/4	homogenous, pale brown, medium grain size foraminiferal sand.	
20-60			0-60cm: shaples patch of few cm across consisting of fine sand occur. Mn oxides particles are attached to foraminifera fragments	
40-60				FS01
60-120				
120-140				FS02
140-160				
160-180				
180-200				


02SMS01LC15

Hole No.	02SMS11LC15
Latitude	10° 46.792' N
Longitude	161° 29.315' E
Water Depth	1.954m
Core Length	- cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10			samples are not collected, slightly coarse foraminiferal sands are attached. no damages to LC bit.	


02SMS11LC15

Hole No.	02SMS11LC16
Latitude	10° 46.998' N
Longitude	161° 29.513' E
Water Depth	1.977m
Core Length	50 cm
Core Weight	5.8 kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand	10YR 7/4	pale brown foraminiferal sand, medium grain size.	
20				
30				
40				
50				


02SMS11LC16

Hole No.	02SMS11LC17
Latitude	10° 47.100' N
Longitude	161° 29.708' E
Water Depth	1,975m
Core Length	- cm
Core Weight	0.05 kg

cm	Core	Color	Descriptions	Remarks
10			angular fragments of Mn oxides, 0.5-4cm across, surface of crust with botryoidal texture, 15mm+ thick, black, compact.	


02SMS11LC17

Hole No.	02SMS11LC18
Latitude	10° 52.493' N
Longitude	161° 22.371' E
Water Depth	1,968m
Core Length	- cm
Core Weight	0.01 kg

cm	Core	Color	Descriptions	Remarks
10			fragments of limestone, few mm to 3cm across, pale gray, consist of foraminifera fragments, micro nodules are included, one fragment of Mn oxides obtained.	FR01


02SMS11LC18

Hole No.	02SMS11LC19
Latitude	10° 52.502' N
Longitude	161° 22.314' E
Water Depth	1,974m
Core Length	90 cm
Core Weight	8.6 kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand	10YR 6/3	foraminiferal sand, medium grain size, homogenous, pale brown, consist of foraminifera fragments, some of them slightly oxidized to brown color. top of bit is partly deformed.	FS01
20				
30				
40				
50				
60				
70				FS02
80				
90				
400				


02SMS11LC19

Hole No.	02SMS11LC20
Latitude	10° 52.506' N
Longitude	161° 22.220' E
Water Depth	1,977m
Core Length	3 cm
Core Weight	0.3 kg

cm	Core	Color	Descriptions	Remarks
10			a cobble crust(8×6cm) and Mn oxides fragments of 0.5-3cm across were collected, cobble crust:botryoidal surface, 30mm thick, 3layers structure.	CM01

02SMS11LC20

Hole No.	02SMS11LC21
Latitude	10° 52.507' N
Longitude	161° 22.258' E
Water Depth	1,977m
Core Length	- cm
Core Weight	0.13 kg

cm	Core	Color	Descriptions	Remarks
10			Mn oxides fragments of 0.5-5cm across, black, compact type (Type1) and porous type(Type6).	CM01


02SMS11LC21

Hole No.	02SMS11LC22
Latitude	11° 00.829' N
Longitude	161° 29.846' E
Water Depth	1,844m
Core Length	95 cm
Core Weight	11.5 kg

cm	Core	Color	Descriptions	Remarks
10	foraminiferal sand	10YR 7/3	foraminiferal sand, pale brown, slightly coarse, grains of oxidized to brown color are included.	
20				FS01
30				
40				
50				
60				
70				
80				FS02
90				
100				

02SMS11LC22

Hole No.	02SMS12LC19
Latitude	08° 42.495' N
Longitude	163° 07.510' E
Water Depth	1,343m
Core Length	150 cm
Core Weight	15.0 kg

cm	Core	Color	Descriptions	Remarks
				FS01
		5YR 6/3	pale brown foraminiferal sand. 0-20cm : slightly coarse.	
20		5YR 8/2	20-40cm : fine grained.	
40			40-150cm : calcareous mud with foraminiferal sand.	FS02
60	foraminiferal sand		grain size decreases from top to bottom.	
80		5Y 8/1		
100				
120				FS03
140				
160				
180				
200				

02SMS12LC19

Hole No.	02SMS12LC20
Latitude	08° 42.690' N
Longitude	163° 09.815' E
Water Depth	1.302m
Core Length	- cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10			no sample collected. no damage to bit.	


02SMS12LC20

Hole No.	02SMS12LC21
Latitude	08° 43.993' N
Longitude	163° 11.611' E
Water Depth	1.245m
Core Length	- cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10			no sample collected. no damage to bit.	

02SMS12LC21

Hole No.	02SMS12LC22
Latitude	08° 44.411' N
Longitude	163° 11.208' E
Water Depth	1.234m
Core Length	7 cm
Core Weight	0.41 kg

cm	Core	Color	Descriptions	Remarks
10			bit was damaged 0-5cm : foraminiferal sand on surface. 5-? cm : crust crushed to fragments of 1-5cm across. botryoidal surface, 20mm+ thick, black and compact.	CM01

02SMS12LC22

Hole No.	02SMS12LC23
Latitude	08° 45.309' N
Longitude	163° 11.805' E
Water Depth	1,142m
Core Length	- cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10			no samle bit was not damaged.	

02SMS12LC23

Hole No.	02SMS12LC24
Latitude	08° 47.290' N
Longitude	163° 12.499' E
Water Depth	1,093m
Core Length	- cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10			no sample bit was not damaged.	


02SMS12LC24

Hole No.	02SMS12LC25
Latitude	08° 46.403' N
Longitude	163° 08.807' E
Water Depth	1,275m
Core Length	60 cm
Core Weight	6.6 kg

cm	Core	Color	Descriptions	Remarks
10	foraminiferal sand	10YR 7/4	Pale brown, foraminiferal sand. coarse grained, homogenous, oxidized grains are partly included.	
20				FS01
30				
40				
50				
60				


02SMS12LC25

Hole No.	02SMS12LC26
Latitude	08° 48.002' N
Longitude	163° 07.603' E
Water Depth	1,266m
Core Length	55 cm
Core Weight	5.0 kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand	10YR 7/4	pale brown foraminiferal sand. slightly coarse grained, homogeneous, some of the grains are oxidized to brown color.	FS01
20				FS02
30				
40				
50				
60				





02SMS12LC26

Hole No.	02SMS12LC27
Latitude	08° 50.708' N
Longitude	163° 05.810' E
Water Depth	1,308m
Core Length	50 cm
Core Weight	4.4 kg

cm	Core	Color	Descriptions	Remarks
10		10YR 7/4	sample is disturbed. pale brown foraminiferal sand, consist of coarse grains, homogeneous.	
20			deeper than 30cm: calcareous clay is included.	
30			foraminiferal sand	
40				
50				

02SMS12LC27

Hole No.	02SMS12LC28
Latitude	08° 47.304' N
Longitude	163° 12.503' E
Water Depth	1.093m
Core Length	100 cm
Core Weight	9.3 kg

cm	Core	Color	Descriptions	Remarks
10			pale brown foraminiferal sand, consists of slightly coarse sand grains of foraminifera and calcareous clay.	FS01
20				
30				
40				foraminiferal sand
50				10YR 8/2
60				
70				
80				FS02
90				
100				


02SMS12LC28

Hole No.	02SMS12LC29
Latitude	08° 45.406' N
Longitude	163° 10.505' E
Water Depth	1,208m
Core Length	- cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10			no sample bit was not damaged.	

02SMS12LC29

Hole No.	02SMS12LC30
Latitude	08° 48.749' N
Longitude	163° 10.255' E
Water Depth	1,145m
Core Length	35 cm
Core Weight	3.2 kg

cm	Core	Color	Descriptions	Remarks
10		7YR 7/4	pale brown foraminiferal sand. consist of foraminifera fragments of medium sand grains, homogeneous.	
20				
30				
40				
50				

02SMS12LC30

Hole No.	02SMS12LC31
Latitude	08° 48.008' N
Longitude	163° 07.208' E
Water Depth	1,292m
Core Length	65 cm
Core Weight	7.0 kg

cm	Core	Color	Descriptions	Remarks
20	foraminiferal sand	10YR 7/3	pale brown foraminiferal sand, consist of foraminifera fragments of medium sand grains.	
		14YR 8/4	0-15cm:brownish color with oxidized grains. bit was deformed, Mn oxides were attached to bit.	
40				
60				
80				

02SMS12LC31

Hole No.	02SMS12LC32
Latitude	08° 48.004' N
Longitude	163° 07.112' E
Water Depth	1,302m
Core Length	- cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10			bit was deformed, Mn oxides clay was attached to bit.	


02SMS12LC32

Hole No.	02SMS12LC33
Latitude	08° 50.352' N
Longitude	163° 07.759' E
Water Depth	1,257m
Core Length	105 cm
Core Weight	12.3 kg

cm	Core	Color	Descriptions	Remarks
10	foraminiferal sand	10YR 7/3	pale brown foraminiferal sand, slightly coarse grain, includes clay rich patches.	FS01
20				FS01
40		10YR 8/2		
60		10YR 7/3		
80		10YR 8/2		
90		10YR 7/3		
100				FS02


02SMS12LC33

Hole No.	02SMS12LC34
Latitude	08° 51.152' N
Longitude	163° 09.414' E
Water Depth	1,288m
Core Length	5 cm
Core Weight	0.47 kg

cm	Core	Color	Descriptions	Remarks
10	 crust		crust, crushed to fragments of 1-5cm, botryoidal surface, black, compact, Type1.	CM01


02SMS12LC34

Hole No.	02SMS12LC35
Latitude	08° 51.496' N
Longitude	163° 11.006' E
Water Depth	1,311m
Core Length	65 cm
Core Weight	5.8 kg

cm	Core	Color	Descriptions	Remarks
20	 foraminiferal sand	10YR 7/4	pale brown foraminiferal sand, medium to coarse grain size, homogeneous. 0-40cm : brownish color with oxidized grains	
40		10YR 8/2	40-65cm : pale yellow, fragments of Mn oxides few mm across are included. bit is partly deformed, black clay of Mn oxides attached.	
60				
80				


02SMS12LC35

Hole No.	02SMS12LC36
Latitude	08° 51.148' N
Longitude	163° 14.009' E
Water Depth	1,329m
Core Length	- cm
Core Weight	0.02 kg

cm	Core	Color	Descriptions	Remarks
10			fragments of Mn oxides, bit is damaged.	CM01


02SMS12LC36

Hole No.	02SMS12LC37
Latitude	08° 43.705' N
Longitude	163° 09.273' E
Water Depth	1,218m
Core Length	- cm
Core Weight	0.08 kg

cm	Core	Color	Descriptions	Remarks
10			bit is damaged, fragments of Mn oxides are attached to bit.	


02SMS12LC37

Hole No.	02SMS12LC38
Latitude	08° 42.901' N
Longitude	163° 08.509' E
Water Depth	1,329m
Core Length	- cm
Core Weight	0.01 kg

cm	Core	Color	Descriptions	Remarks
10			4 fragments of crust, 0.5-4cm across, 10mm+ thick, botryoidal surface. surface sample	CM01


02SMS12LC38

Hole No.	02SMS12LC39
Latitude	08° 42.003' N
Longitude	163° 08.406' E
Water Depth	1.374m
Core Length	- cm
Core Weight	0.03 kg

cm	Core	Color	Descriptions	Remarks
10			crushed fragments of Mn oxides, less than 1 cm across, details are unknown.	CM01


02SMS12LC39

Hole No.	02SMS12LC40
Latitude	08° 50.998' N
Longitude	163° 05.216' E
Water Depth	1.325m
Core Length	- cm
Core Weight	0.02 kg

cm	Core	Color	Descriptions	Remarks
10			bit is damaged, small angular fragments of Mn oxides, 2-20mm across.	CM01


02SMS12LC40

Hole No.	02SMS12LC41
Latitude	08° 51.694' N
Longitude	163° 03.209' E
Water Depth	1.497m
Core Length	- cm
Core Weight	0.01 kg

cm	Core	Color	Descriptions	Remarks
10			bit was damaged, small amount of Mn oxides were collected. crushed angular fragments of 1-3cm across, botryoidal surface.	CM01

02SMS12LC41

Hole No.	02SMS12LC42
Latitude	08° 52.255' N
Longitude	163° 01.511' E
Water Depth	1.783m
Core Length	- cm
Core Weight	0.07 kg

cm	Core	Color	Descriptions	Remarks
10			bit was damaged, fragments of Mn oxides, 1-6cm across. 13mm+ thick. 2 layers structure. layer1 : porous, Type1 layer2 : black, compact, type1	

02SMS12LC42

Column of MC Samples


Hole No.	02SMS01MC01
Latitude	14° 17.198' N
Longitude	160° 57.016' E
Water Depth	1,542m
Core Length	27 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	foraminiferal sand	10YR 7/4	pale brown, fine foraminiferal sand.	samples were collected for 8 tubes
20				
30				


Hole No.	02SMS01MC02
Latitude	14° 18.500' N
Longitude	160° 57.996' E
Water Depth	1,469m
Core Length	28 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	foraminiferal sand	10YR 7/4	pale brown, medium grained, foraminiferal sand.	sample were collected for 6 tubes
20				
30				


Hole No.	02SMS01MC03
Latitude	14° 20.500' N
Longitude	160° 59.254' E
Water Depth	1.221m
Core Length	26 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand	10YR 7/4	pale brown, fine foraminiferal sand. samples were collected for 7 tubes.	
20				
30				


Hole No.	02SMS01MC04
Latitude	14° 23.003' N
Longitude	161° 01.004' E
Water Depth	1.156m
Core Length	22 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand	10YR 7/3	pale brown, fine foraminiferal sand, samples were collected for 7 tubes.	
20				
30				


Hole No.	02SMS11MC01
Latitude	10° 43.500' N
Longitude	161° 27.761' E
Water Depth	2,131m
Core Length	28 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand		foraminiferal sand, samples were collected for 7 tubes	
20				
30				


Hole No.	02SMS11MC02
Latitude	10° 48.245' N
Longitude	161° 27.761' E
Water Depth	1,749m
Core Length	25 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand		foraminiferal sand. samples were collected for 8 tubes	
20				
30				

Hole No.	02SMS11MC03
Latitude	10° 53.001' N
Longitude	161° 27.763' E
Water Depth	1.549m
Core Length	29 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand		foraminiferal sand, samples were collected for 8 tubes	
20				
30				

Hole No.	02SMS11MC04
Latitude	10° 56.002' N
Longitude	161° 28.014' E
Water Depth	1.513m
Core Length	25 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand		foraminiferal sand. samples were collected for 7 tubes	
20				
30				


Hole No.	02SMS12MC01
Latitude	08° 47.301' N
Longitude	163° 12.506' E
Water Depth	1.093m
Core Length	27 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	foraminiferal sand	10YR 8/2	foraminiferal sand. samples were collected for 7 tubes.	
20				
30				

Hole No.	02SMS12MC02
Latitude	08° 48.755' N
Longitude	163° 10.257' E
Water Depth	1.146m
Core Length	27 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	foraminiferal sand		foraminiferal sand samples were collected for 5 tubes	
20				
30				

Hole No.	02SMS12MC03
Latitude	08° 50.354' N
Longitude	163° 07.757' E
Water Depth	1.257m
Core Length	29 cm
Core Weight	- kg

cm	Core	Color	Descriptions	Remarks
10	 foraminiferal sand		foraminiferal sand. samples were collected for 8 tubes	
20				
30				

Appendix 6 Results of Microscopic Observation

Results of Microscopic Observation (Pyroclastic Rock)

Sample No.	Rock Name	Alteration	Rock Fragments			Fragment			Matrix			Alteration				
			Size	Shape	Rock Name	Pl	Cpx	Ol	Op	G	Cc	Ab	Cc	Srp	Chl	Pal
02SMS01BMS02C TS01	Tuffaceous Sandstone	Medium	<8mm	Crushed	Olivine Basalt, Limestone						△			○		○
02SMS01BMS03B TS01	Hyaloclastite	Medium	<4mm	Breccia	Olivine Basalt Scoria			•								◎
02SMS11BMS01B TS01	Calcareous Sandstone	Weak	<7mm	Subangular - Subround	Olivine Basalt Scoria	•							•			○
02SMS11BMS03B TS01	Hyaloclastite - Peperite	Weak	<10mm	Crushed	Basalt Scoria	△					○					○
02SMS12BMS02C TS01	Hyaloclastite	Medium	<10mm	Crushed	Olivine Basalt Scoria						△					◎
02SMS12BMS05A TS01	Hyaloclastite	Medium	<7mm	Crushed	Olivine Basalt			•					•		△	○
02SMS12BMS06C TS01	Hyaloclastite	Medium	<7mm	Crushed	Olivine Basalt Scoria										◎	○

Minerals

Pl ; Plagioclase
 Cpx ; Clinopyroxene
 Ol ; Olivine
 Op ; Popaque Minerals
 G ; Glass
 Ab ; Albite

Cc ; Calcite
 Srp ; Serpentine
 Chl ; Chlorite
 Pal ; Paragonite

Abundance (%)

◎ ; Abundant (>80)
 ○ ; Common (10~30)
 △ ; Rare (3~10)
 • ; Trace (<3)

Results of Microscopic Observation (Volcanic Rock)

Sample No.	Rock Name	Texture	Alteration	Phenocryst			Groundmass					Alteration Minerals							
				Pl	Cpx	Ol	Op	Pl	Cpx	Ol	Op	G	Ab	Cc	Srp	Zeo	Chl	Ser	Pal
02SMS01BMS01C TS01	Olivine Basalt	amg,aph,ins	Medium			•		◎	○	△	○	○	△	•	○				
02SMS01BMS03C TS01	Olivine Basalt	amg,ins	Strong			•		◎	○		◎	△	△		△				•
02SMS12BMS04C TS01	Olivine Basalt	ing	Week	△		△		◎	○	△	○	△	△	•	○				•
02SMS12BMS07C TS01	Olivine Clinopyroxene Basalt	ins	Week	△	•	△		○	△	○	○	△	△	•	○				
02SMS12BMS07D TS01	Olivine Clinopyroxene Basalt	ins	Medium	△	•	△		◎	△	○	△	△	△		△				

Minerals

Pl ; Plagioclas
 Cpx ; Clinopyroxene
 Ol ; Olivine
 Op ; Popaque Minerals
 G ; Glass
 Ab ; Albite

Cc ; Calcite
 Srp ; Serpentine
 Zeo ; Zeolite
 Chl ; Chlorite
 Ser ; Sericite
 Pal ; Paragonite
 Idd ; Indingsite

Texture

amg ; Amygdaloidal
 aph ; Aphyric
 ing ; Intergranular
 ins ; Intersertal

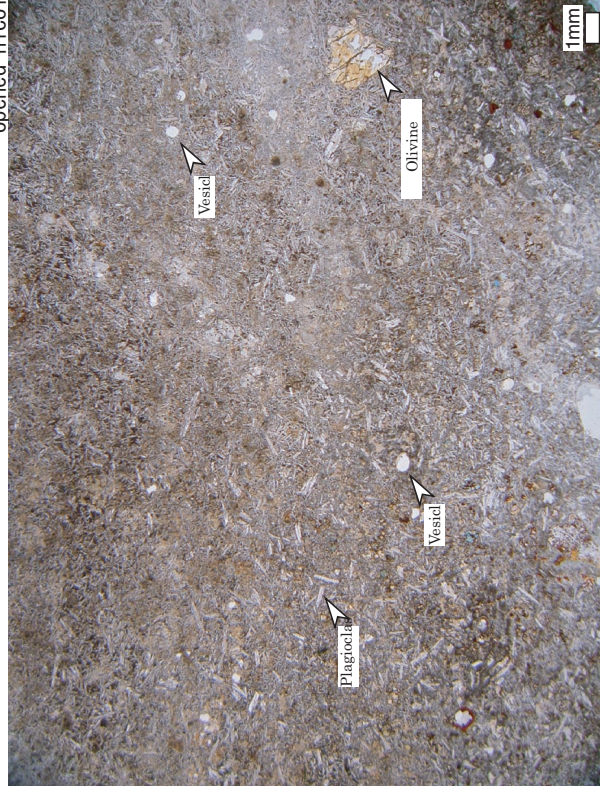
Abundance (%)

◎ ; Abundant (>30)
 ○ ; Common (10~30)
 △ ; Rare (3~10)
 • ; Trace (<3)

Appendix 7 Microscopic Photographs of Rocks Thin Section

02SMS01BMS01CTS01

opened nicol

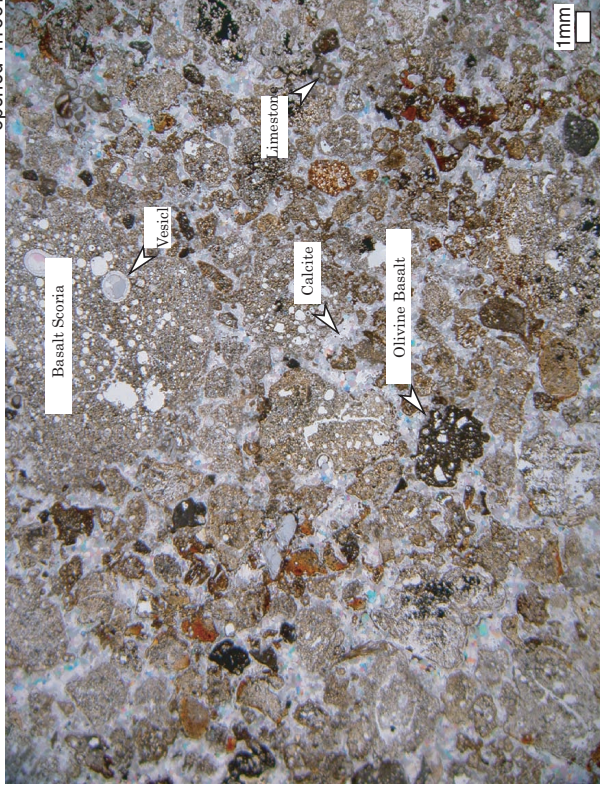


crossed nicols

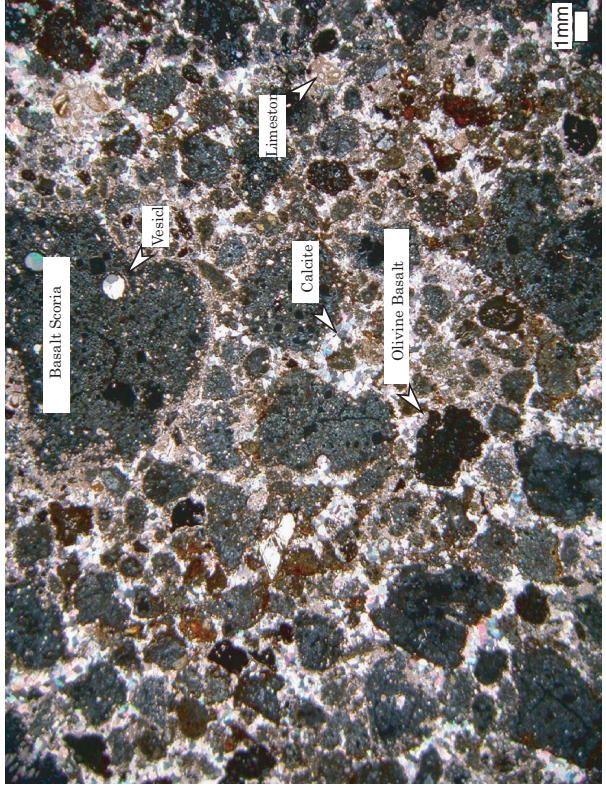


02SMS01BMS02CTS01

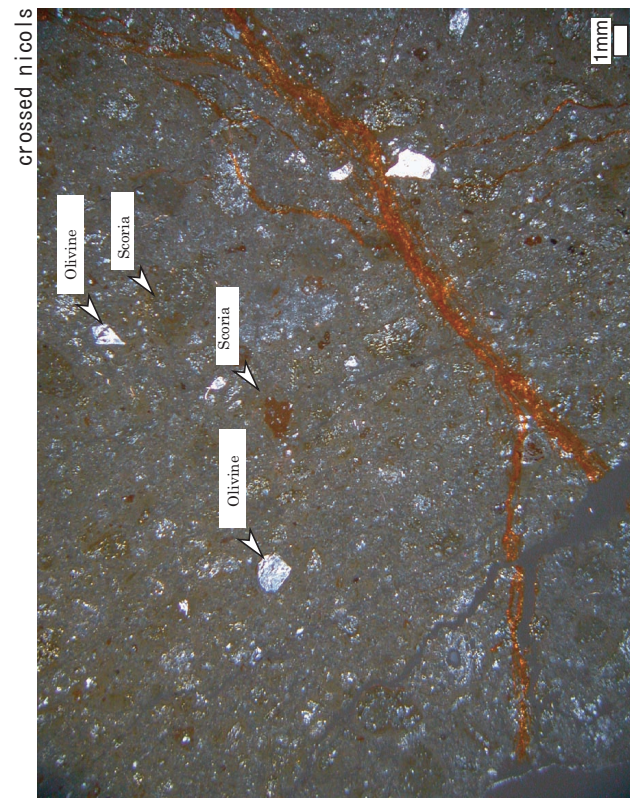
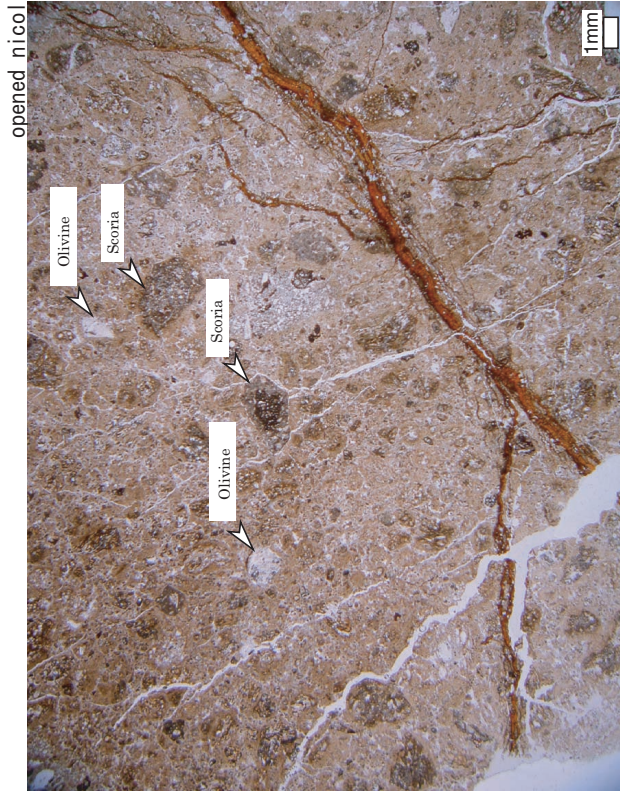
opened nicol



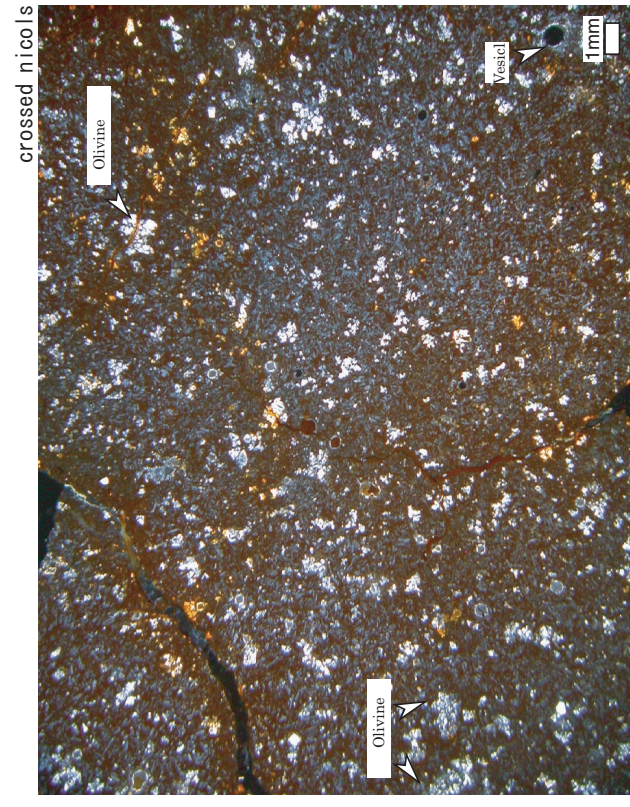
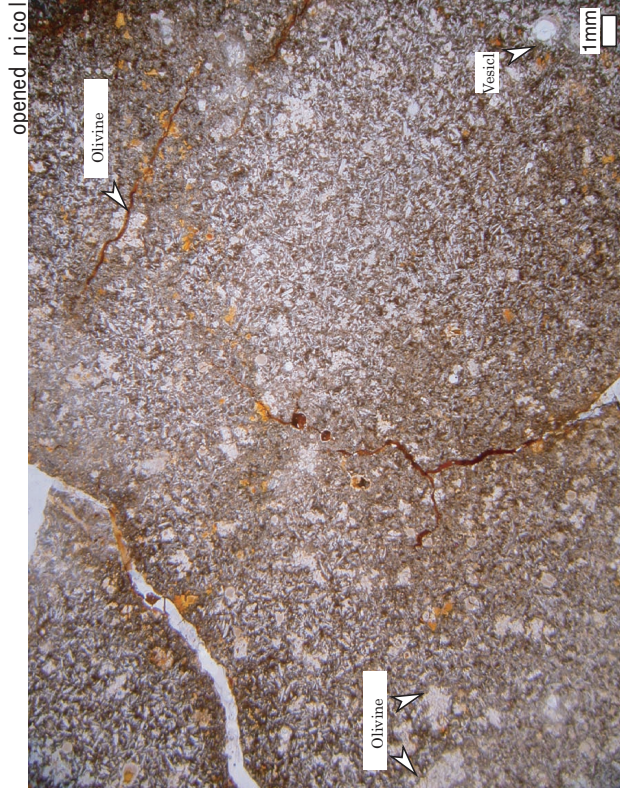
crossed nicols



02SMS01BMS03BTS01

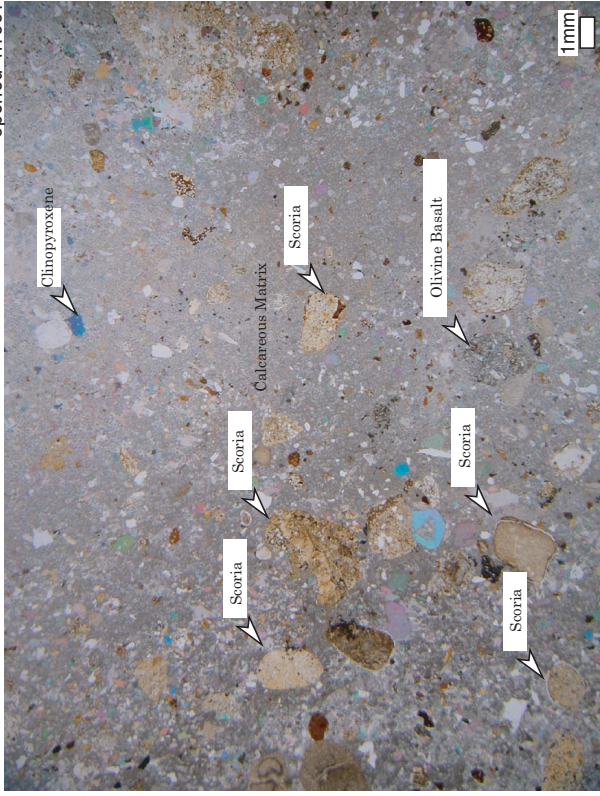


02SMS01BMS03CTS01

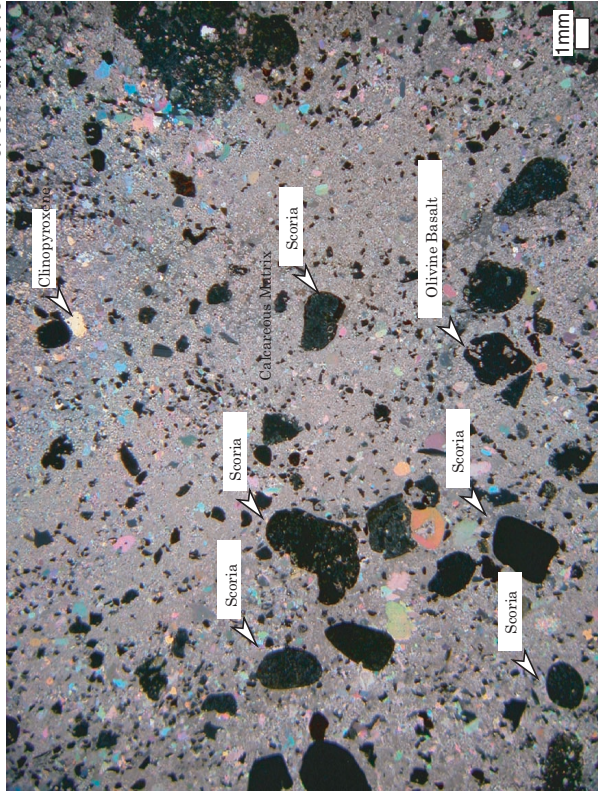


02SMS11BMS01BTS01

opened nicol

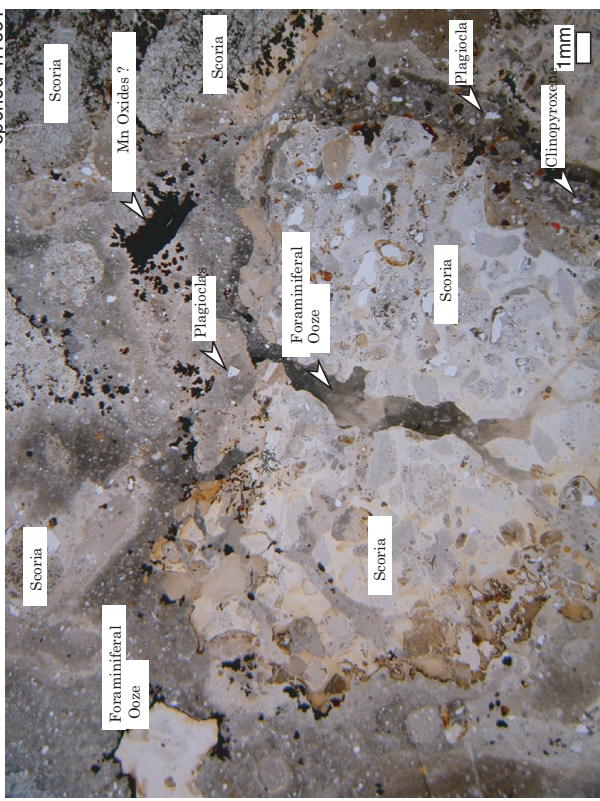


crossed nicols

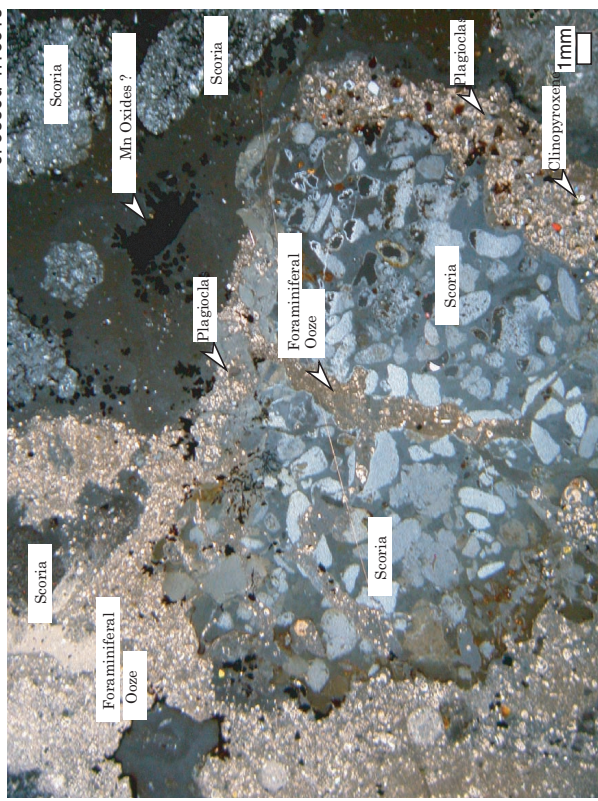


02SMS11BMS03BTS01

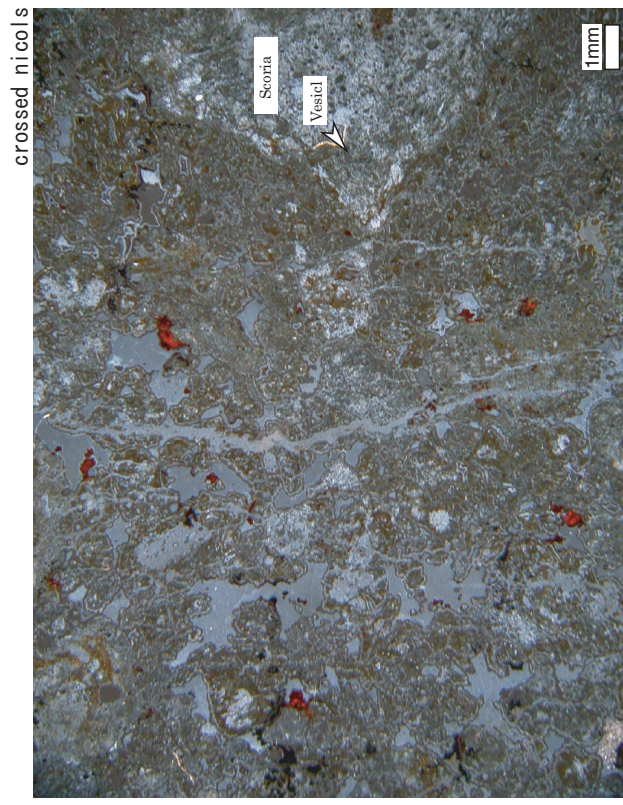
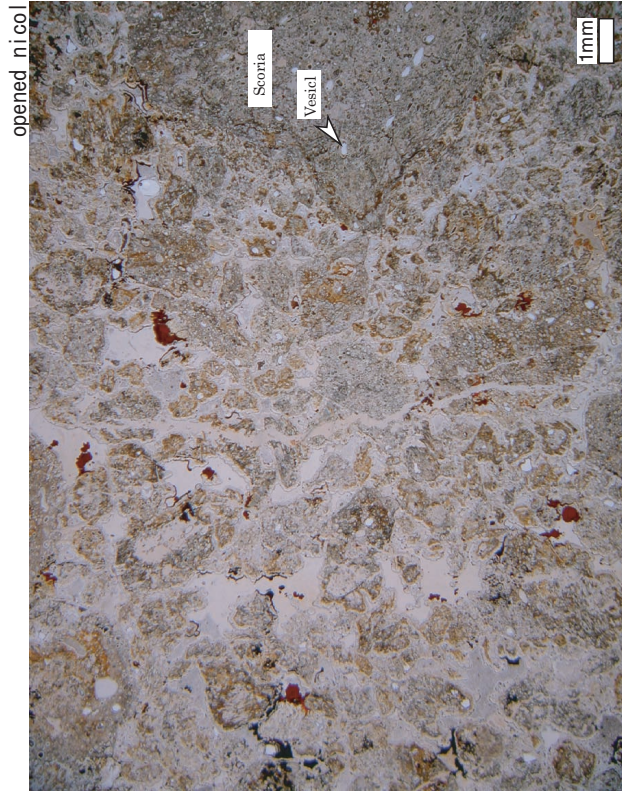
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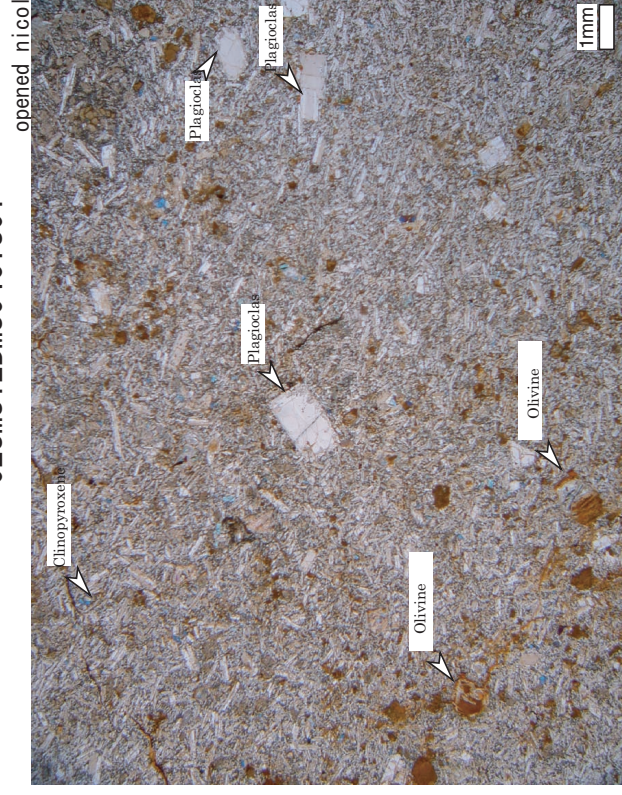
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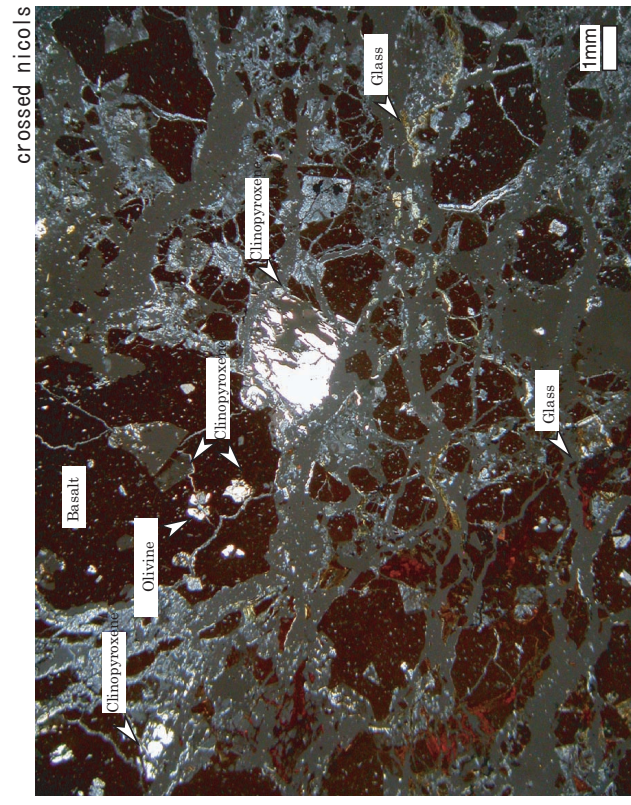
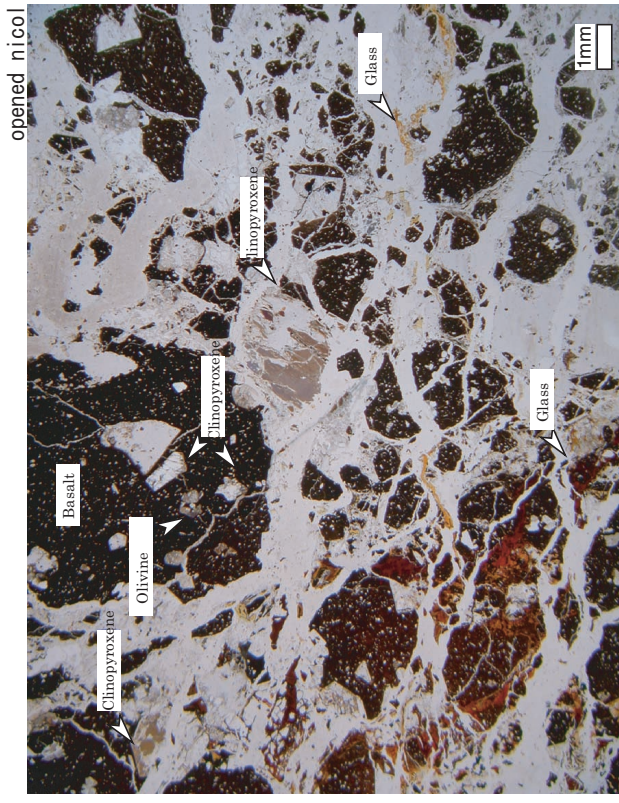
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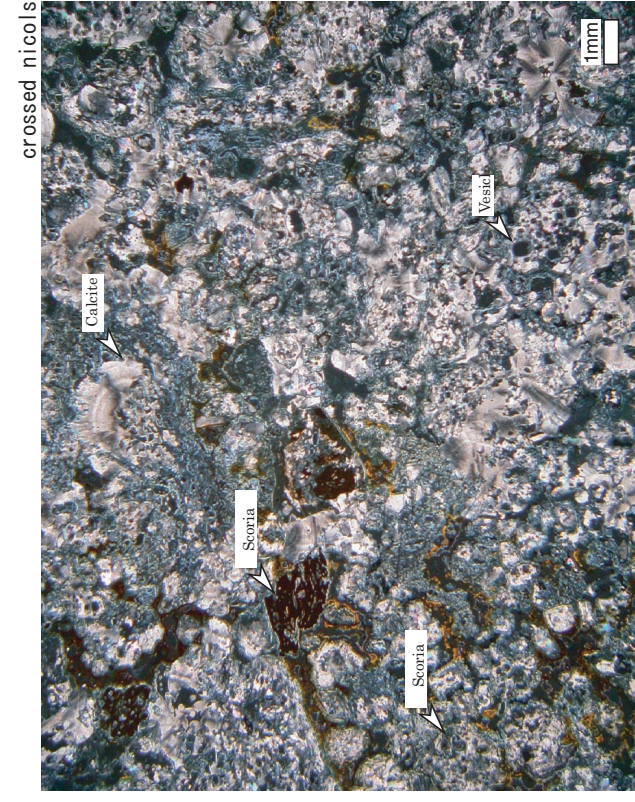
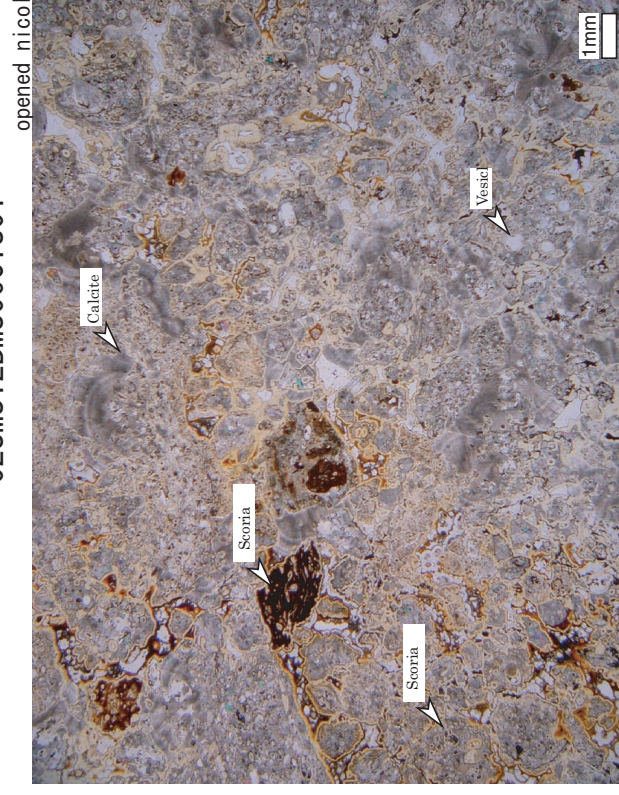
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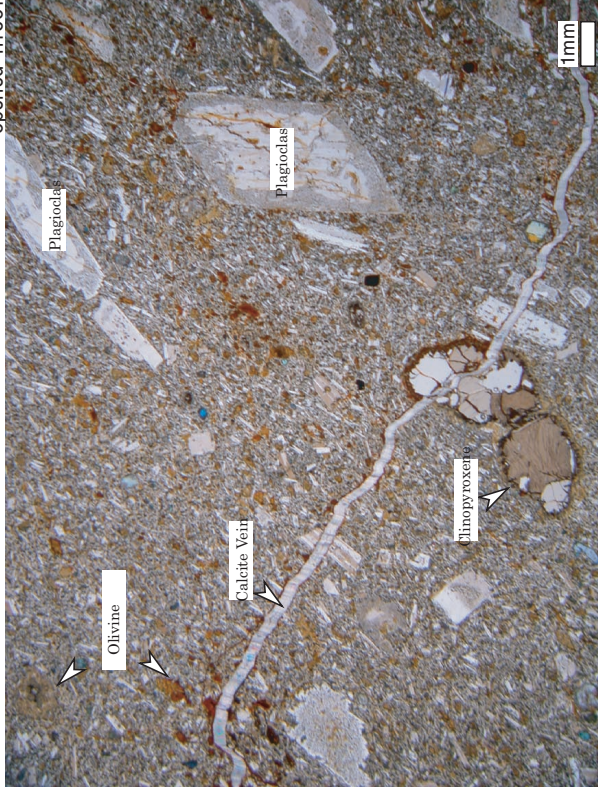


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02SMS12BMS07CTS01

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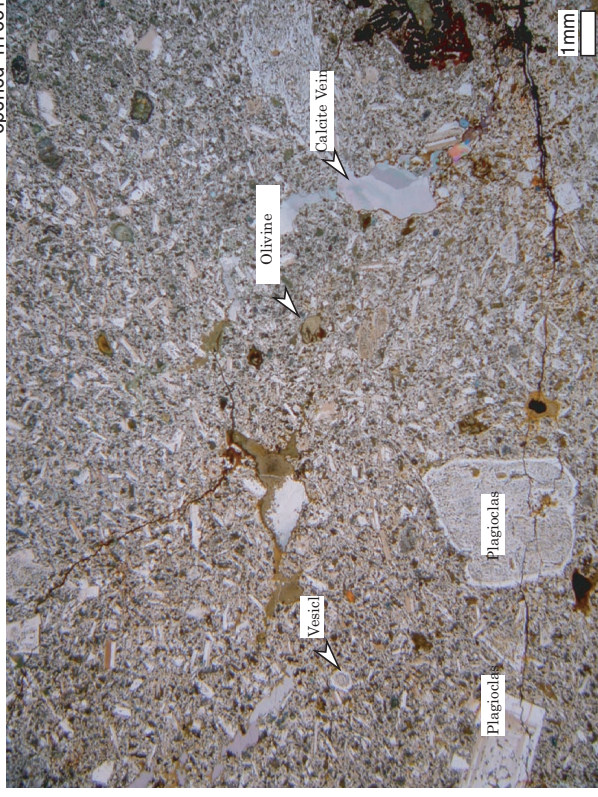


crossed nicols



02SMS12BMS07DTS01

opened ni col



crossed nicols



Appendix 8 Chemical Analysis Methods (rock, cobalt crust)

1. Chemical Analysis of Rock

Chemical analyses of five basalts samples were conducted for 36 components. Analyzed elements and detection limits are given below.

Elements and Detection Limit

Majors Elements (15)	SiO ₂ , TiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ , FeO, MnO, MgO, CaO, Na ₂ O, K ₂ O, P ₂ O ₅ , CO ₂ , H ₂ O ⁺ , H ₂ O ⁻ , LOI	Detection limit 0.01%
Trace Elements (21)	Sr, Ba, Zr, V, Y Rb, Nb La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	Detection Limit 1ppm Detection Limit 0.1ppm Detection Limit 0.01ppm

The chemical analyses were conducted by following method.

Analytical Methods

Elements	Method
SiO ₂ , TiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ , MnO, MgO, CaO, Na ₂ O, K ₂ O, P ₂ O ₅ ,	ICP
FeO	Titration
CO ₂ , H ₂ O ⁺ , H ₂ O ⁻ , LOI	LECO
Rb, Sr, Ba, Zr, V, Nb, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	ICPmass

For chondrite normalized diagram, the chemical composition of Wakita et al. (1971) was used.

Chemical Composition of Chondrite

La	0.340	Tb	0.047
Ce	0.910	Dy	0.300
Pr	0.121	Ho	0.080
Nd	0.640	Er	0.200
Sm	0.195	Tm	0.032
Eu	0.073	Yb	0.220
Gd	0.260	Lu	0.034

Wakita *et al.* (1971)

2. Chemical analysis of Cobalt Crust

Chemical analyses of 85 manganese crust samples were conducted for 36 components. Analyzed elements and detection limits are given below.

Elements and Detection Limit

Elements	Detection Limit
Co, Ni, Cu, Mn, Fe, Pb, Zn, Ti, Mo, V, Si, Al, Ca, Na, K, P, Ba, Sr, LOI, H ₂ O ⁺ , H ₂ O ⁻	0.01%
Pt, La, Ce, Pr, Nb, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	0.01ppm

Sample preparation of manganese crust was done following the method of Terashima, Usui and Imai (1995). Chemical analyses were conducted by methods given below at ALS Chemex Labs, Canada.

Analytical Methods

Elements	Method
Co, Ni, Cu, Mn, Fe, Ti, Si, Al, Ca, Na, K, P,	ICP
Pt	Fire Assay – ICP
Pb, Zn, Mo, V, Ba, Sr, La, Ce, Pr, Nb, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	ICP MASS
LOI, H ₂ O ⁺ , H ₂ O ⁻	LECO

Appendix 9 Results of Chemical Analysis of Rocks

Results of Chemical Analysis of Rocks

	02SMS01		02SMS12		02SMS12	
	BMS01C CA01	BMS03C CA01	BMS04C CA01	BMS07C CA01	BMS07D CA01	
	Olivine Basalt	Olivine Basalt	Olivine Basalt	Olivine, Clinopyroxene Basalt	Olivine, Clinopyroxene Basalt	
SiO ₂	%	47.41	34.89	49.14	50.75	50.81
TiO ₂	%	1.93	1.60	2.74	1.66	1.65
Al ₂ O ₃	%	16.85	12.94	15.39	16.58	16.36
Fe ₂ O ₃	%	10.32	9.62	6.67	7.11	6.12
FeO	%	0.55	0.55	3.04	1.40	1.88
MnO	%	0.10	0.06	0.13	0.14	0.10
MgO	%	3.54	2.05	5.49	4.53	4.69
CaO	%	6.83	17.39	8.56	6.16	7.58
Na ₂ O	%	4.06	3.08	3.76	4.18	4.25
K ₂ O	%	1.28	1.33	1.31	2.64	2.26
P ₂ O ₅	%	1.05	8.73	0.43	0.60	0.51
CO ₂	%	0.11	1.39	0.07	0.07	1.06
H ₂ O ⁺	%	1.99	2.18	1.08	1.78	1.35
H ₂ O ⁻	%	2.35	1.83	0.84	1.07	0.92
LOI	%	5.05	6.65	2.47	3.25	3.66
TOTAL	%	98.97	98.89	99.13	98.99	99.87
FeO*	%	9.84	9.84	9.04	7.80	7.39
Mg#		0.265	0.172	0.378	0.367	0.388
Rb	ppm	30.6	35.7	29.1	72.7	64.4
Sr	ppm	340	693	538	733	709
Ba	ppm	187	141	350	856	798
Zr	ppm	100	99	145	244	236
V	ppm	154	205	221	95	103
Nb	ppm	27.2	24.6	35.9	67.5	65.3
Y	ppm	29.2	123.0	22.8	22.8	22.2
La	ppm	19.05	70.63	23.90	57.56	52.88
Ce	ppm	29.06	38.04	49.89	101.90	95.44
Pr	ppm	3.97	6.92	6.18	10.60	9.93
Nd	ppm	17.95	31.24	27.38	38.78	36.41
Sm	ppm	4.37	6.49	6.42	6.47	6.16
Eu	ppm	1.76	2.30	2.48	2.36	2.26
Gd	ppm	4.91	8.74	5.89	5.07	4.90
Tb	ppm	0.92	1.42	1.00	0.85	0.87
Dy	ppm	4.63	7.93	4.71	4.41	4.39
Ho	ppm	0.84	1.78	0.77	0.76	0.73
Er	ppm	2.34	5.37	2.02	2.08	2.02
Tm	ppm	0.31	0.80	0.24	0.27	0.27
Yb	ppm	1.86	4.32	1.48	1.63	1.68
Lu	ppm	0.26	0.69	0.19	0.24	0.22

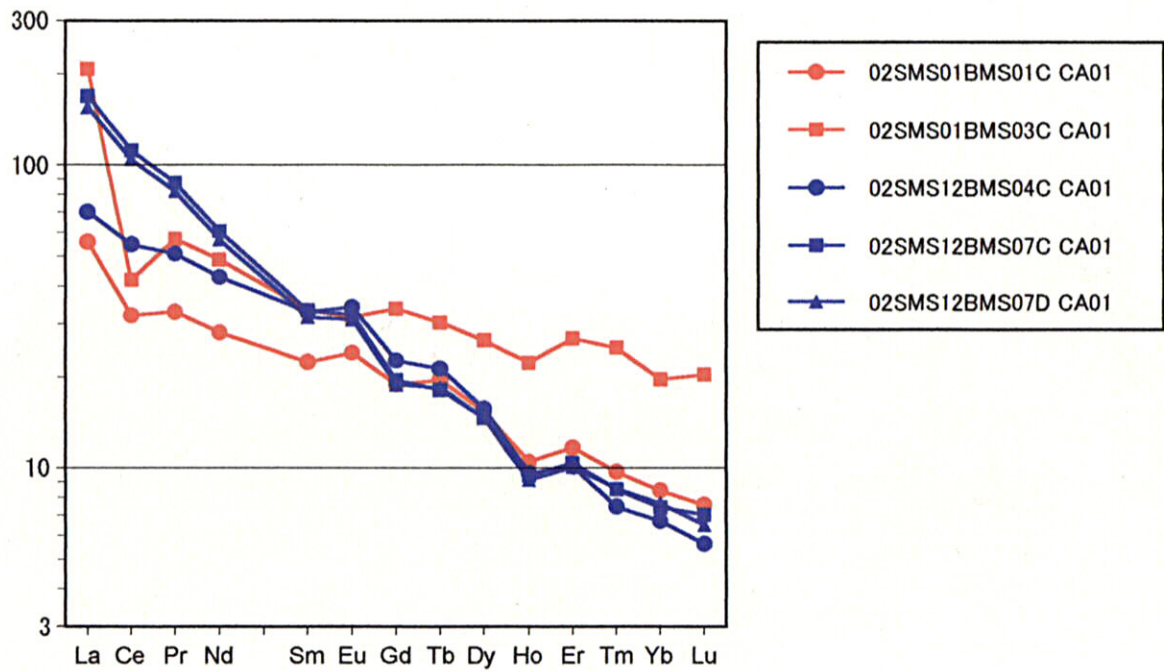
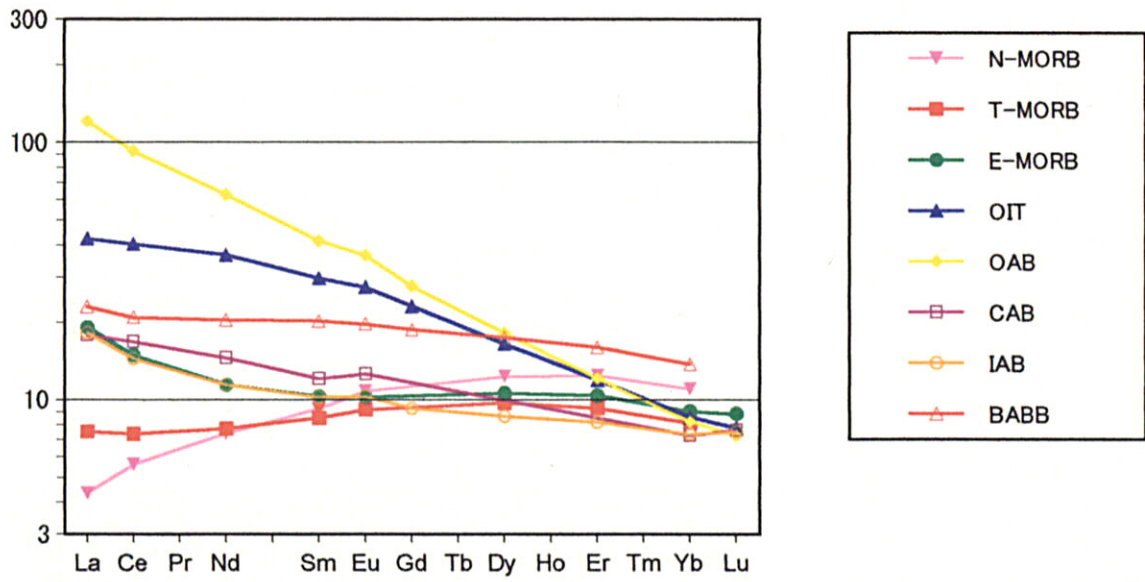


Figure1 Chondrite Normalized Patterns of REE

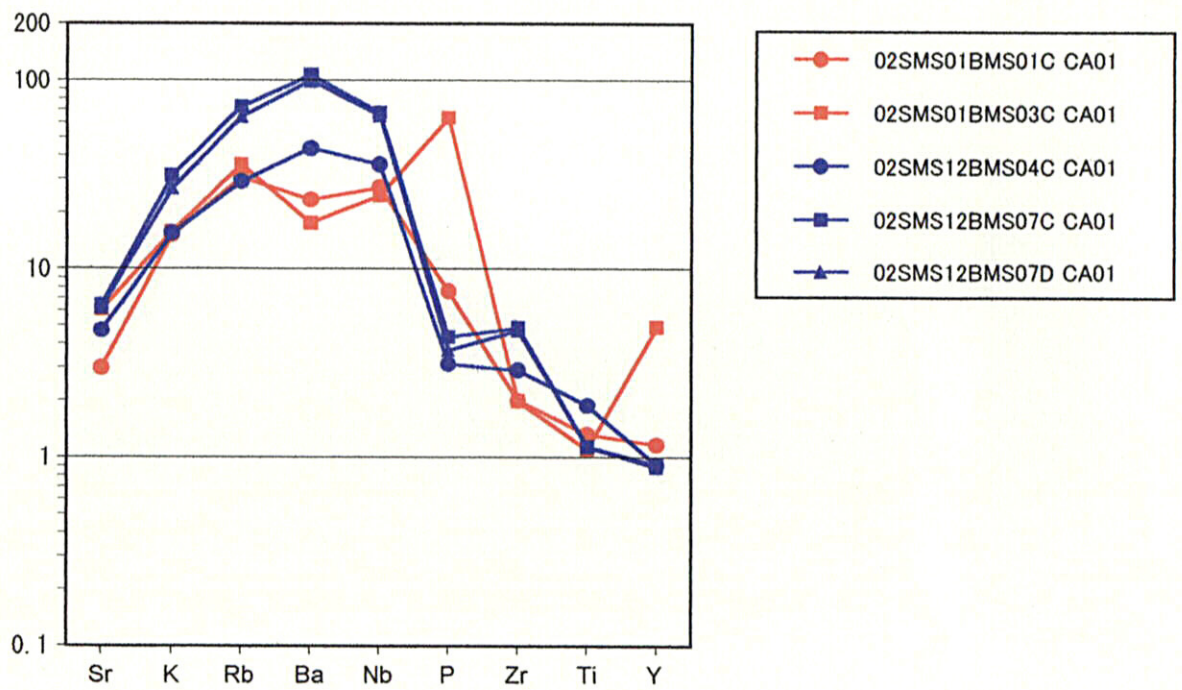
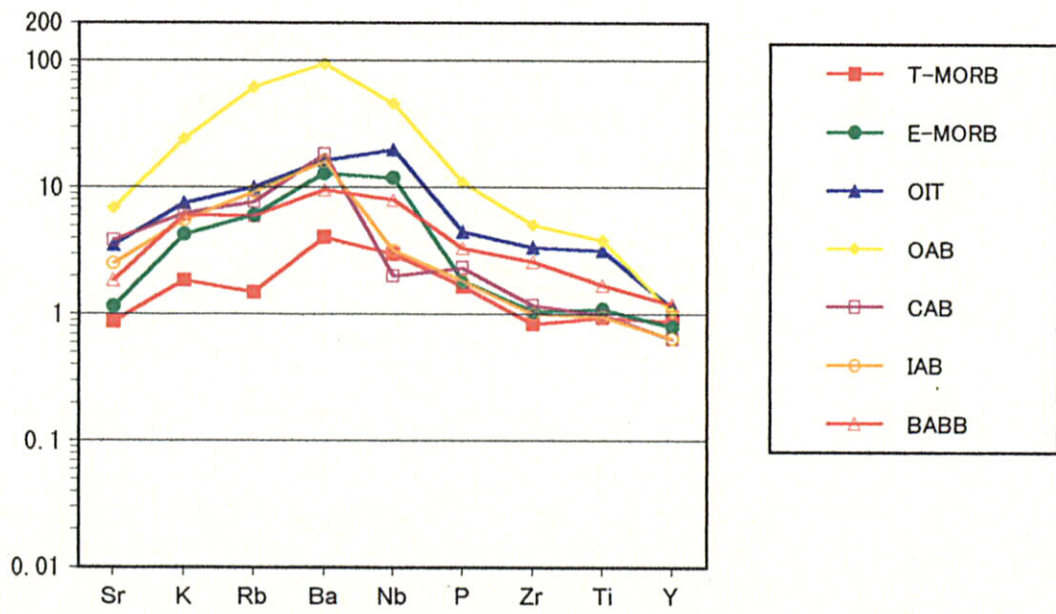


Figure2 Spiderdiagram

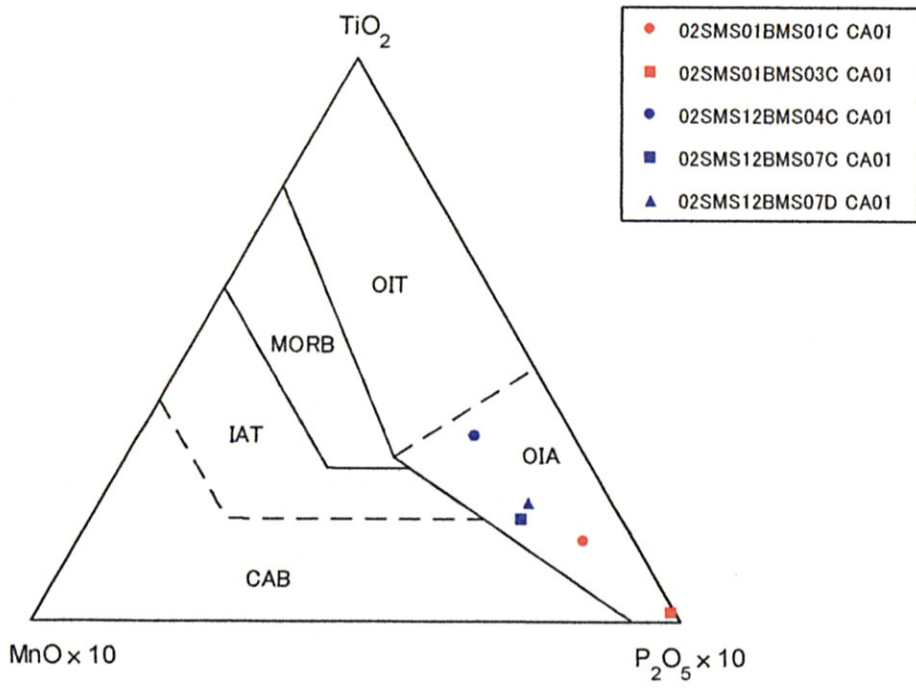


Figure3 TiO₂-MnO-P₂O₅

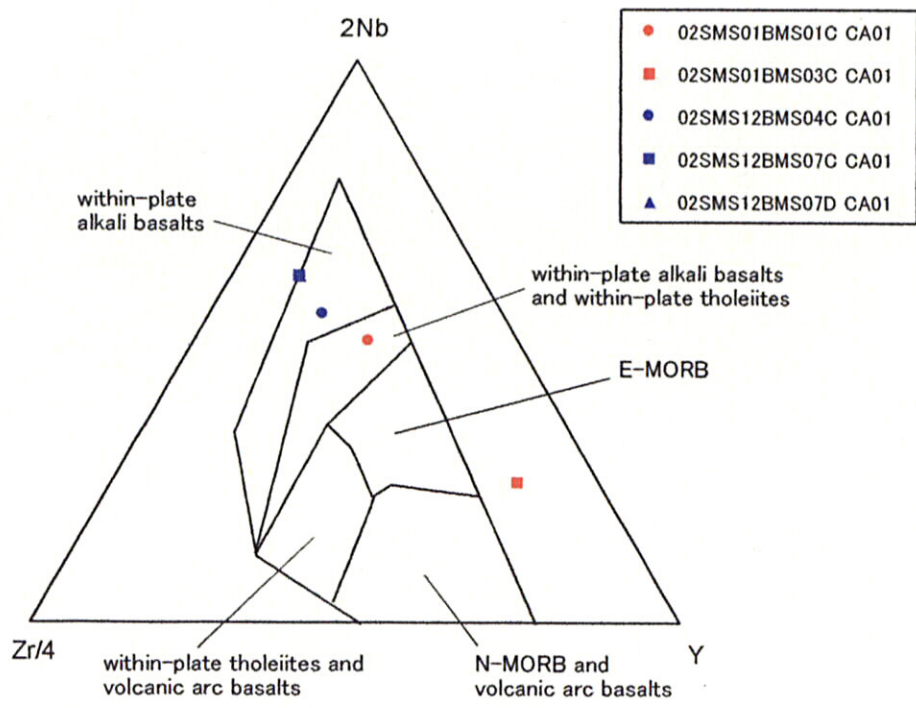


Figure 4 Nb-Zr-Y

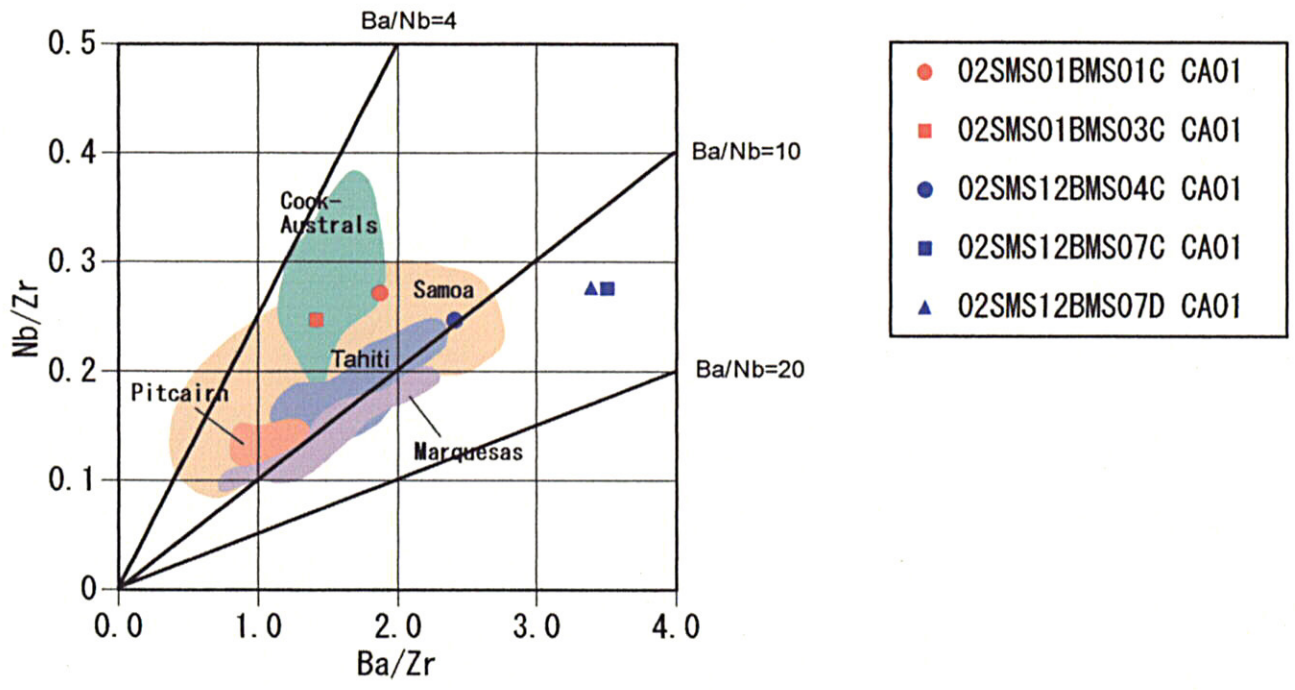


Figure 6 Nb/Zr - Ba/Zr

Appendix 10 Fossil Test

Table 1 Occurrences of Fossils in Unconsolidated Sediments

Seamount		Site	Sample No.	Depth (m)	Sampling Depth (cm)	Type of Samples	Abundance of Planktonic Foraminifera	Preservation of Planktonic Foraminifera	Abundance of Benthic Foraminifera	Preservation of Benthic Foraminifera	Fragments of Foraminifera	Fragments of Volcanic Rocks	Echinoidea	Geological Age
MS01	02SMS01	LC15	FS01	1542	35-40	Foraminiferal Sand	A	G	R	M	F			Late~Middle Pleistocene (0.12~0.65M)
			FS02		125-130	Foraminiferal Sand	A	G	R	M	A			Early Pleistocene (0.65~1.6Ma)
	02SMS11	LC14	FS01	2075	10-15	Foraminiferal Sand	A	G	R	M				Early Pleistocene (1.6~2.0Ma)
MS11			FS02		55-60	Foraminiferal Sand	A	G	R	M				Early Pleistocene (1.6~2.0Ma)
			FS03		110-115	Foraminiferal Sand	A	G	R	M				Early Pleistocene (1.6~2.0Ma)
		LC19	FS01	1974	15-20	Foraminiferal Sand	A	G	R	M				Early Pleistocene (1.6~1.77Ma)
MS12			FS02		70-75	Foraminiferal Sand	A	G	R	M				E. Pleist.~ Late Pliocene (1.77~2.0Ma)
	02MSM12	LC19	FS01	1343	0-5	Foraminiferal Sand	A	G	R	M		R	R	Late Pleistocene (~0.12Ma)
			FS02		40-45	Foraminiferal Sand	A	G	R	M				Pliocene (3.09~3.12Ma)
			FS03		125-130	Foraminiferal Sand	A	G	R	M				Pliocene (3.09~3.12Ma)
			LC33	FS01	1257	15-20	Foraminiferal Sand	A	G	R	M			
			FS02		100-105	Foraminiferal Sand	A	G	R	M				Middle Pleistocene (0.22~0.65Ma)

A: Abundant, C: Common, F: Few, R: Rare, X: Present, G: Good, M: Moderate

Table 3 Calcareous Nannoplankton of Unconsolidated Sediments

Sample No.	02SMS01LC15FS01	02SMS01LC15FS02	02SMS11LC14FS01	02SMS11LC14FS02	02SMS11LC14FS03	02SMS11LC19FS01	02SMS11LC19FS02	02SMS12LC19FS01	02SMS12LC19FS02	02SMS12LC19FS03	02SMS12LC33FS01	02SMS12LC33FS02
<i>Calcidiscus leptoporus</i>	4	6	8	+	+	1		6	3	1	3	3
<i>Calcidiscus macintyreii</i>									3	+		
<i>Ceratolithus cristatus</i>	1	1	1		+	1		1			1	+
<i>Cyclolithella annula</i>	1	+		1	1	2	1	4	2	1	1	1
<i>Discoaster asymmetricus</i>									+	+		
<i>Discoaster brouweri</i>									1	2		
<i>Discoaster pentaradiatus</i>									4	2		
<i>Discoaster surculus</i>									+	+		
<i>Discoaster tamalis</i>									+	+		
<i>Discolithina japonica</i>						1	+	1			+	+
<i>Discolithina</i> spp.	+	+		+					+			
<i>Discosphaera tubifera</i>	1		1					1			+	
<i>Emiliania huxleyi</i>	3		8	3		39	41	17			44	3
<i>Gephyrocapsa caribbeanica</i>		4	1	2	4							
<i>Gephyrocapsa oceanica</i>	27	6	8	20	39	4	6	5			8	39
<i>Gephyrocapsa parallela</i>	10	3	14	14	11	8	2	10			9	12
<i>Gephyrocapsa</i> spp. (small)	17	15	15	19	32	6	7	5	1	1	4	14
<i>Helicosphaera carteri</i>	10	4	5	3	4	3	4	5	+	2	1	2
<i>Helicosphaera hyalina</i>				+		+						
<i>Helicosphaera inversa</i>				1	+							+
<i>Helicosphaera sellii</i>									+	+		
<i>Helicosphaera wallichi</i>											1	+
<i>Oolithotus antillarum</i>	1	1		1					+	+		+
<i>Pseudoemiliana lacunosa</i>		26			+				7	4		
<i>Reticulofenestra ampla</i>									7	5		
<i>Reticulofenestra</i> spp. (small)		3	2	6		2			70	80	1	3
<i>Rhabdosphaera clavigera</i>	3	7	4	1	+	3	1	1			1	4
<i>Rhabdosphaera stylifera</i>				+		1		1			+	+
<i>Scapholithus fossilis</i>	1	+		2	1	+	+	2			2	+
<i>Syracosphaera pulchra</i>	4	5	8	9	1	7	3	5	1	1	2	+
<i>Umbellosphaera irregularis</i>	6	1	7	3		8	11	3			1	+
<i>Umbilicosphaera sibogae</i>	11	18	18	15	7	14	24	33	1	1	21	19
Total no. (%)	100	100	100	100	100	100	100	100	100	100	100	100
<i>Florisphaera</i> no. vs 200 nannofossils	193	524	148	302	86	502	340	696	16	0	166	56
age	Ple.~Hol.	Pleistocene	Ple.~Hol.	Pleistocene	Pleistocene	Ple.~Hol.	Ple.~Hol.	Ple.~Hol.	late Pliocene	late Pliocene	Ple.~Hol.	Pleistocene
calcareous nannofossil zone (Martini, 1971)	NN21	NN19	NN21	NN21	NN19	NN21	NN21	NN21	NN16	NN16	NN21	NN21
nannofossil datum (Sato & Kameo, 1996)	0~1	4~5	0~1	1~2	3~4	0~1	0~1	0~1	19~21	19~21	0~1	1~2
age (Ma; Sato et al., 1999)	0~0.16	0.51~0.85	0~0.16	0.16~0.25	0.41~0.51	0~0.16	0~0.16	0~0.16	2.78~3.85	2.78~3.85	0~0.16	0.16~0.25

Table 4 Occurrence of Fossils in Rock

Seamount	Drill Point	Sample No.	Depth (m)	Sampling Depth (cm)	Topography	Rock Type	Neritic fossils	Planktonic Foraminifera	Benthic Foraminifera	Ostracoda	Solenopora	Sponge Spicule	Echinoida	Mollusca	Bryozoa	Volcanic Rock	Planktonic Foraminifera	Geological Age
MS01	BMS01B	FR01	1385	5-20	summit	cal. Conglo	A	X	X	X						C	aggregation	middle Eocene(P12-14)
	BMS03A	FR01	1286	8-25	summit	cal. Conglo	A	X	X					F		C	aggregation	middle Eocene(P12-14)
	BMS05C	FR01	1586	15-26	summit	cal. Conglo	A	X	X							C	aggregation, fragments	middle Eocene(P12-14)
MS11	BMS01D	FR01	1971	0-8	summit	limestone	A				X						aggregation, fragments	late Eocene
	BMS01D	FR02	1971	15-18	summit	limestone							X	X	X		-	Cretaceous
	BMS03A	FR01	2750	32-47	U. slope	limestone							X	F	X		-	Cretaceous
	BMS03C	FR01	2549	30-43	U. slope	limestone	C	R	R	X			X	F		X	fragment	Cretaceous
	BMS03C	FR02	2549	43-50	U. slope	limestone	C	R	R				X	X		C		Cretaceous
	BMS04B	FR01	1928	2nd barrel 10-15	summit	limestone	C	R	F				X	X		X	fragment	Paleogene ?
	BMS04B	FR02	1928	2nd barrel 80-100	summit	limestone	C	R	R				X	X		X	fragment	Paleogene ?
MS12	BMS01A	FR01	1371	15-40	summit	reefal limestone					F		X	F	X		fragment	Cretaceous?
	BMS01C	FR01	1380	30-70	summit	reefal limestone			R					F			fragment	Cretaceous?

A: Abundant, C: Common, F: Few, R: Rare, X: Present
 U. slope: upper slope, cal. Conglo: calcareous conglomerate

Table 5 List of Foraminifera in Rock

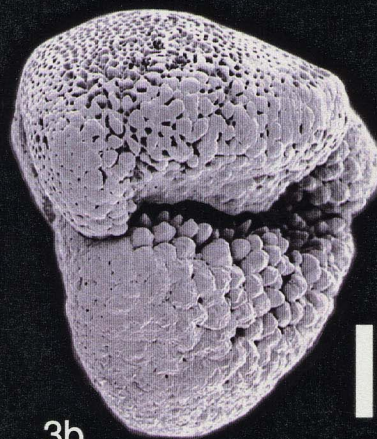
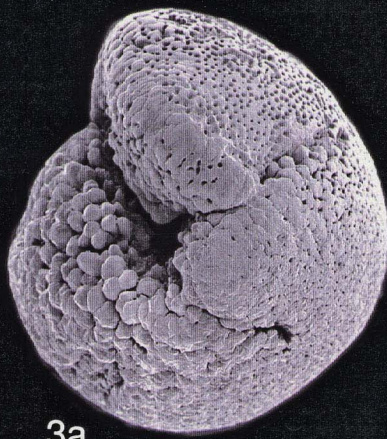
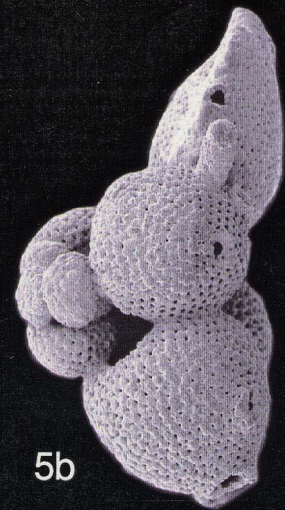
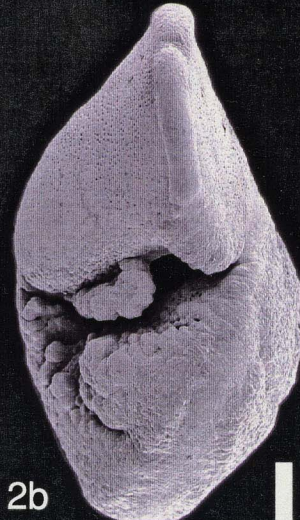
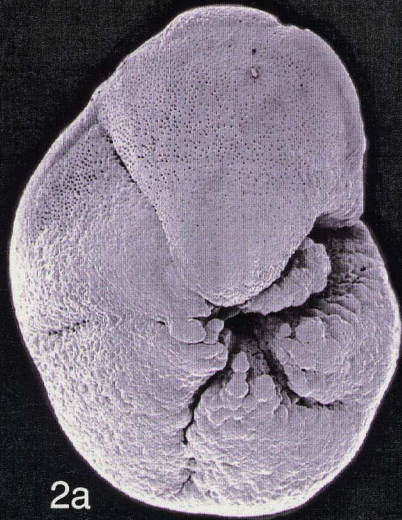
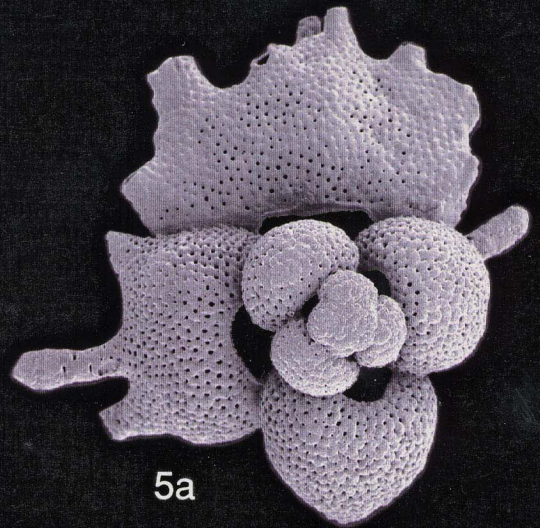
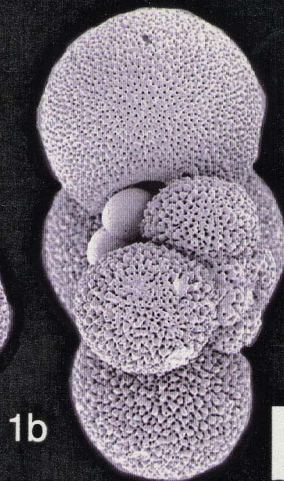
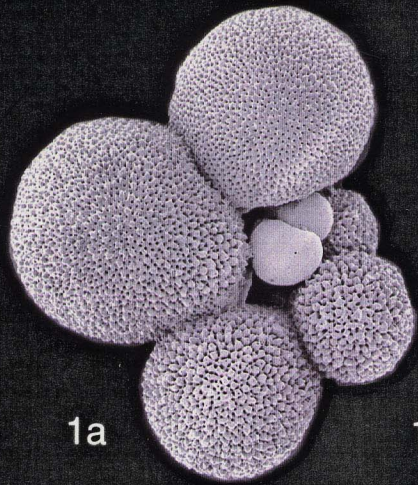
Seamount	Drill Point	Sample No.	Depth (m)	Sampling Depth (cm)	Rock Type	Acarina spp.	Acarina bullbrooki	Acarina spp.	Globigerinatheka spp.	Morozovella spp.	Morozovella spinulosa	Subbotina spp.	Truncorotaloides rhori	Truncorotaloides praetopilensis	Truncorotaloides topilensis	Turborotalia cerroazulensis	low-trochospiral forms	trochospiral forms	Geological Age
MS01	BMS01B	FR01	1385	5-20	calcareous conglomerate	R						R	C	C	C				middle Eocene (P12-14)
	BMS03A	FR01-a	1286	8-25	calcareous conglomerate	R			F	R		F	C	C	C				middle Eocene (P12-14)
	BMS03A	FR01-b	1286	8-25	calcareous conglomerate	R			F	R		R	C	C	F				middle Eocene (P12-14)
	BMS05C	FR01	1586	15-26	calcareous conglomerate						R		F	C	F	R			middle Eocene (P12-14)
MS11	BMS01D	FR01	1971	0-8	limestone				R			C					X		late Eocene ?
	BMS03C	FR01	2549	30-43	limestone												X		Cretaceous ?
	BMS03C	FR02	2549	43-50	limestone												X		Cretaceous ?
	BMS04B	FR01	1928	2nd 10-15	limestone												X		unknown
	BMS04B	FR02	1928	2nd 80-100	limestone													X	unknown

A: Abundant, C: Common, F: Few, R: Rare, X: Present

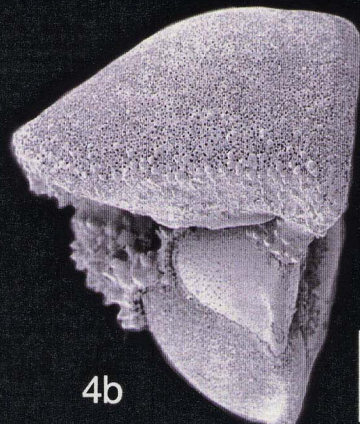
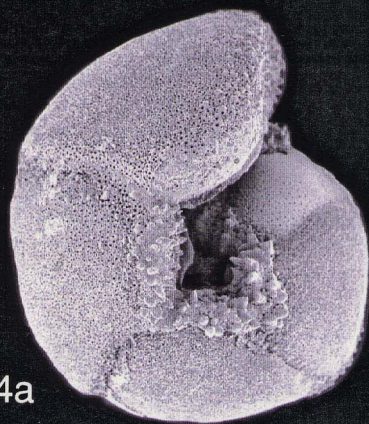
Figure 1 Electron Microscope Photograph of Planktonic Foraminifera of Unconsolidated Sediments

Scale bars: 200 μ m

1. *Bolliella calida calida* (Parker). Umbilical view, Sample from 02SMS012-LC33-FS01.
2. *Globorotalia tumida* (Brady). Spiral view, Sample from 02SMS012-LC15-FS02.
3. *Globorotalia tosaensis* Takayanagi and Saito. Umbilical view, Sample from 02SMS012-LC15-FS02.
4. *Globorotalia truncatulinoides* (d'Orbigny). Umbilical view, Sample from 02SMS012-LC15-FS02.
5. *Globigerinoides fistulosus* (Schubert). Spiral view, Sample from 02SMS011-LC14-FS03.



scale bar = 100 μ m



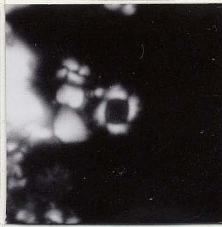
**Figure 2 Microscopic Photographs of Calcareous Nannoplankton in
Unconsolidated Sediments**

1. *Emiliana huxleyi* (Lohmann) Hay & Mohler, sample 02SMS12LC33FS01
2. *Pseudoemiliana lacunosa* (Kamptner) Gartner, sample 02SMS12LC19FS02
- 3, 4. *Gephyrocapsa parallela* Hay & Beaudry, sample 02SMS11LC14FS01
5. *Gephyrocapsa oceanica* Kamptner, sample 02SMS11LC14FS01
6. *Calcidiscus macintyreii* (Bukry & Bramlette) Loeblich & Tappan, sample
02SMS12LC19FS02
7. *Umbellosphaera irregularis* Paasche, sample 02SMS11LC14FS01
8. *Oolithotus antillarum* (Cohen) Reinhardt, sample 02SMS12LC19FS02
9. *Umbilicosphaera sibogae* (Weaber-van Bosse) Gaarder, sample
02SMS11LC14FS01
10. *Helicosphaera carteri* (Wallich) Kamptner, sample 02SMS11LC14FS01
11. *Helicosphaera inversa* Gartner, sample 02SMS11LC14FS02
12. *Rhabdosphaera clavigera* Murray & Blackman, sample 02SMS11LC14FS01
13. *Discosphaera tubifera* (Murray & Blackman) Ostenfeld, sample
02SMS12LC19FS01
14. *Syracosphaera pulchra* Lohmann, sample 02SMS12LC19FS02
15. *Scapholithus fossilis* Deflandre, sample 02SMS12LC19FS01
16. *Discoaster brouweri* Tan, sample 02SMS12LC19FS02
17. *Discoaster asymmetricus* Gartner, sample 02SMS12LC19FS02
18. *Discoaster pentaradiatus* Tan, sample 02SMS12LC19FS02
19. *Discoaster surculus* Martini & Bramlette, sample 02SMS12LC19FS02
20. *Discoaster tamalis* Kamptner, sample 02SMS12LC19FS02

Plate



1



2



3



4



5



6



7



8



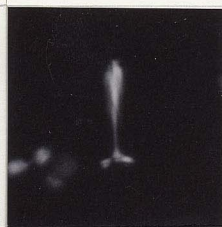
9



10



11



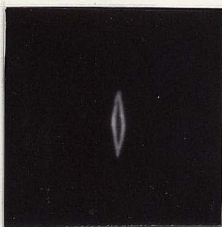
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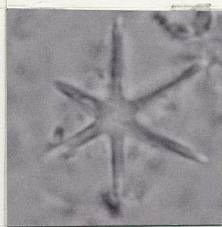
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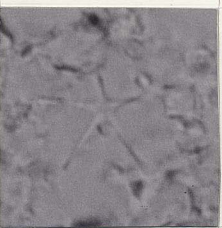
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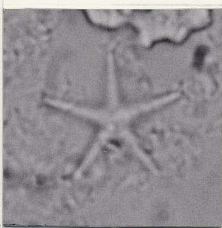
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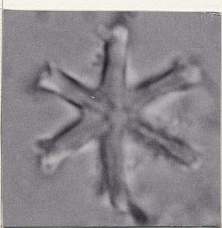
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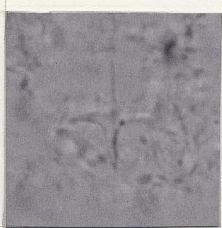
17



18



19



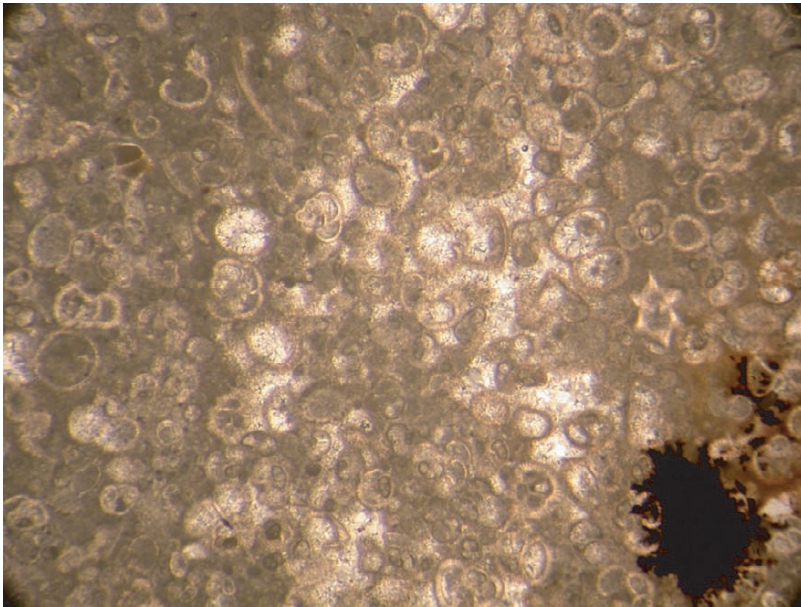
20

5 μ m

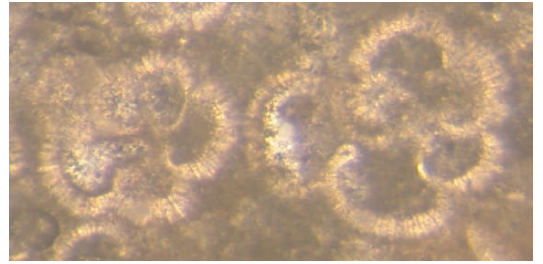
Figure 3

Microscopic Photographs of Planktonic Foraminifera of Rock Samples

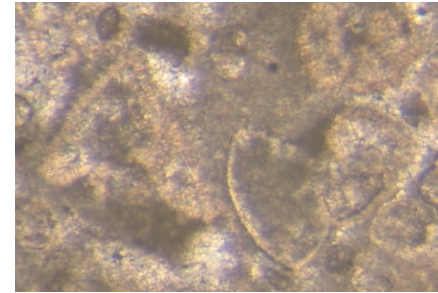
(1) MS01 Seamount 02SMS01-BMS01B-FR01



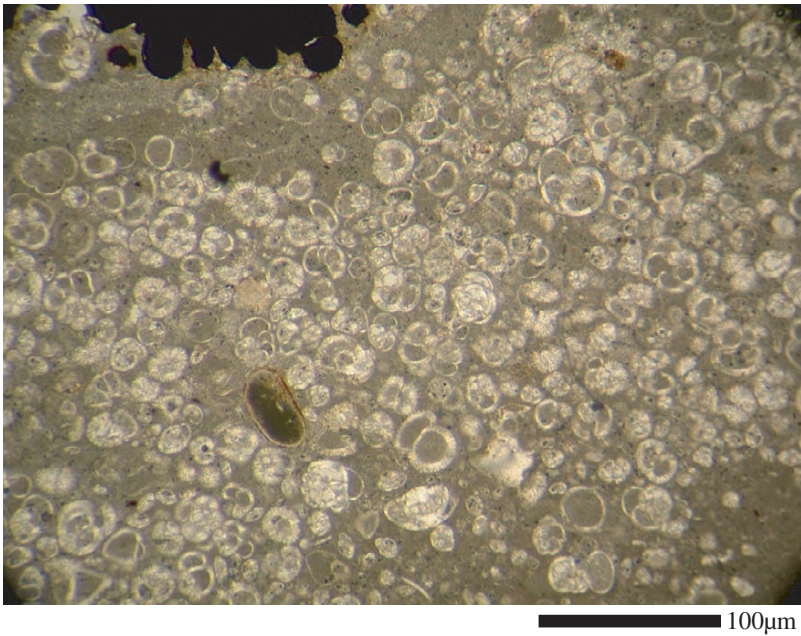
Truncorotaloides rohri



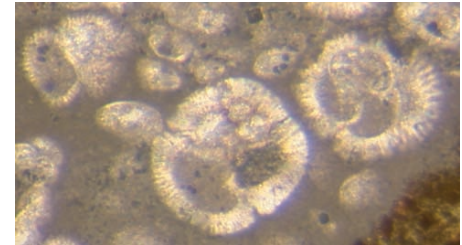
Truncorotaloides topilensis



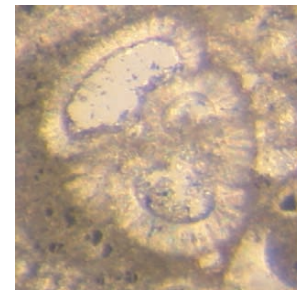
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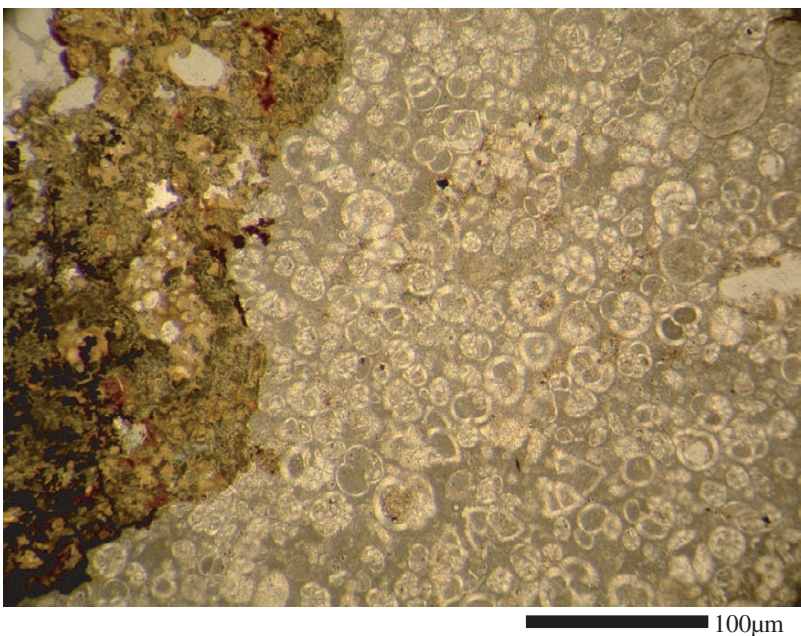
Globigerinatheka spp.



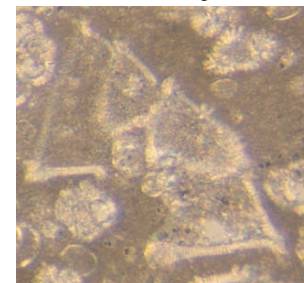
Truncorotaloides topilensis



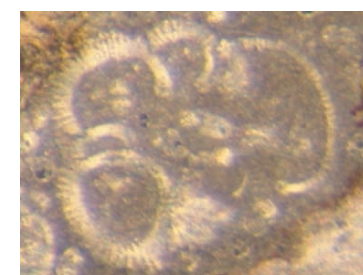
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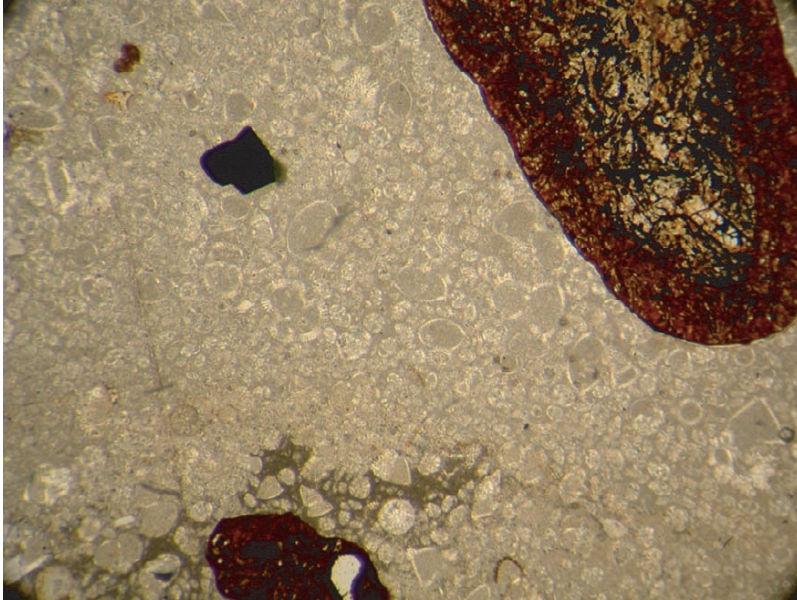
Truncorotaloides topilensis



Truncorotaloides rohri

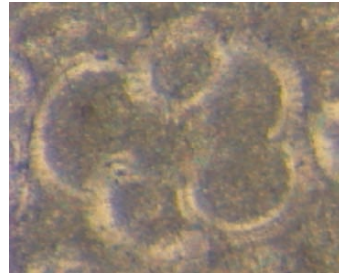


(4) MS01 Seamount 02SMS01-BMS05C-FR01

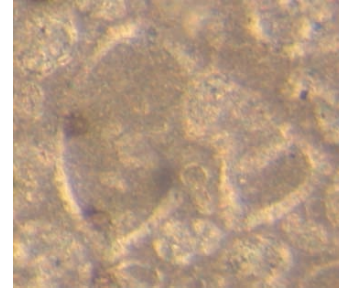


100µm

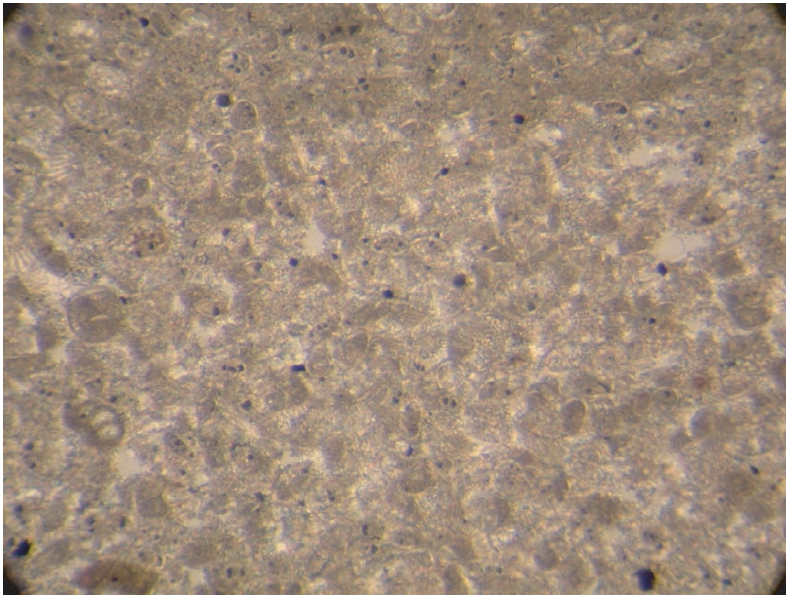
Truncorotaloides rohri



Truncorotaloides topilensis

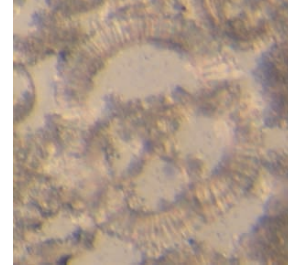


(5) MS11 Seamount 02SMS11-BMS01D-FR01

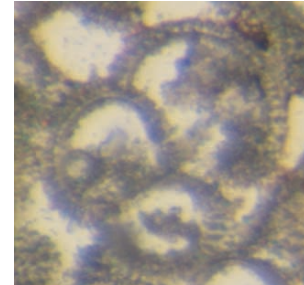


100µm

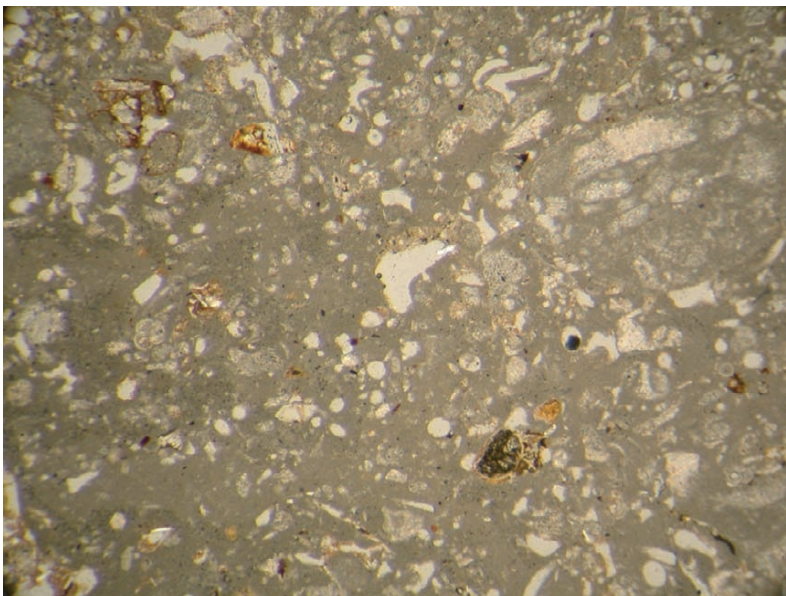
Globigerinatheka spp.



Subbotina spp.

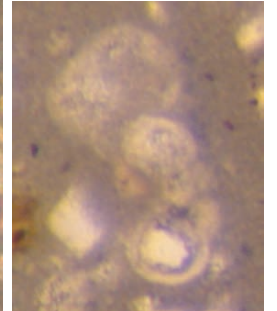
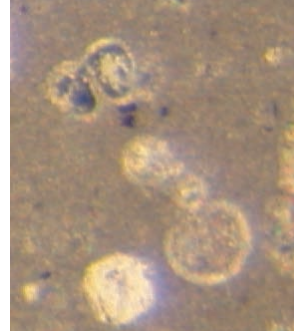


(6) MS11 Seamount 02SMS11-BMS03C-FR01



100µm

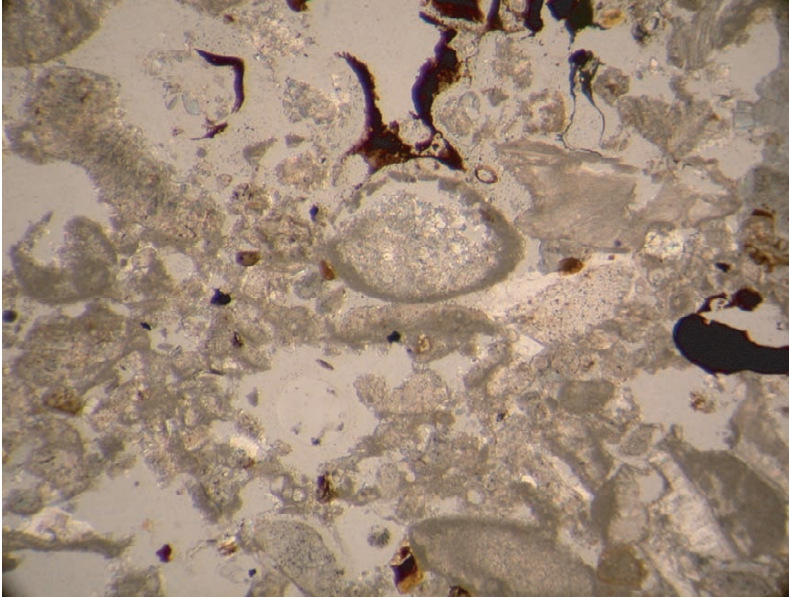
Hedbergella ? spp.



Benthic foraminifera

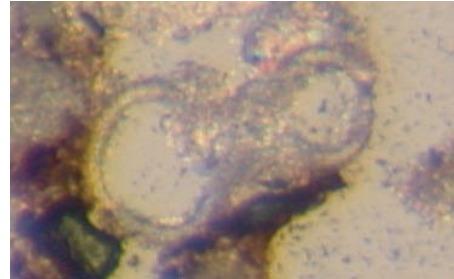
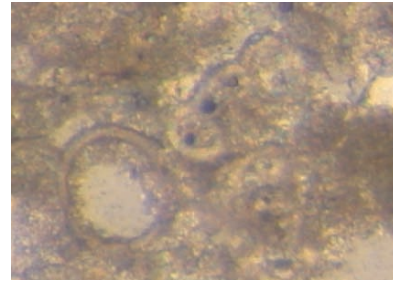


(7) MS11 Seamount 02SMS11-BMS03C-FR02

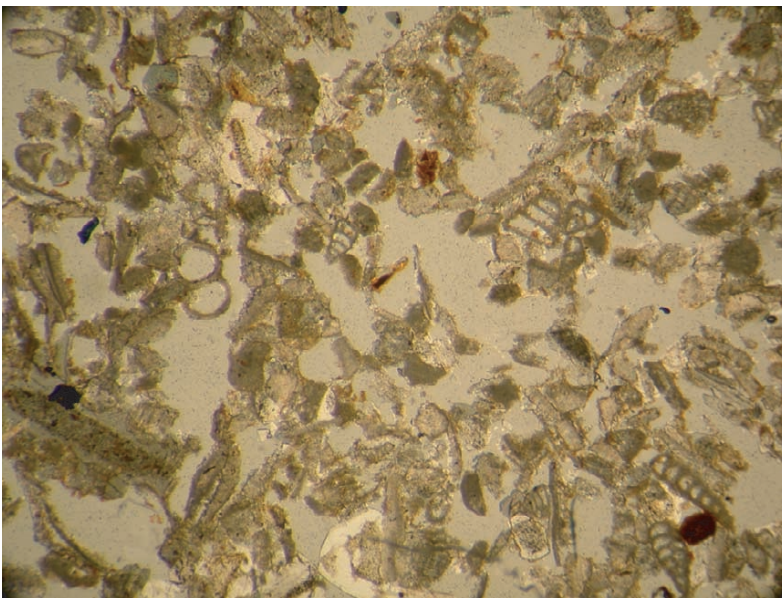


100µm

Hedbergella ? spp.

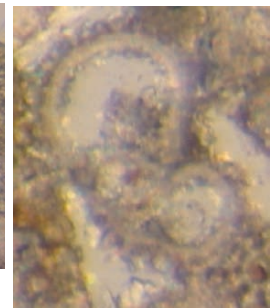
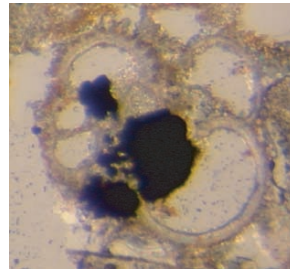


(8) MS11 Seamount 02SMS11-BMS04B-FR01

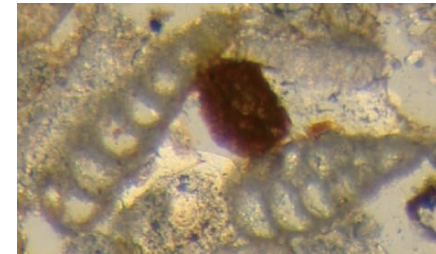


100µm

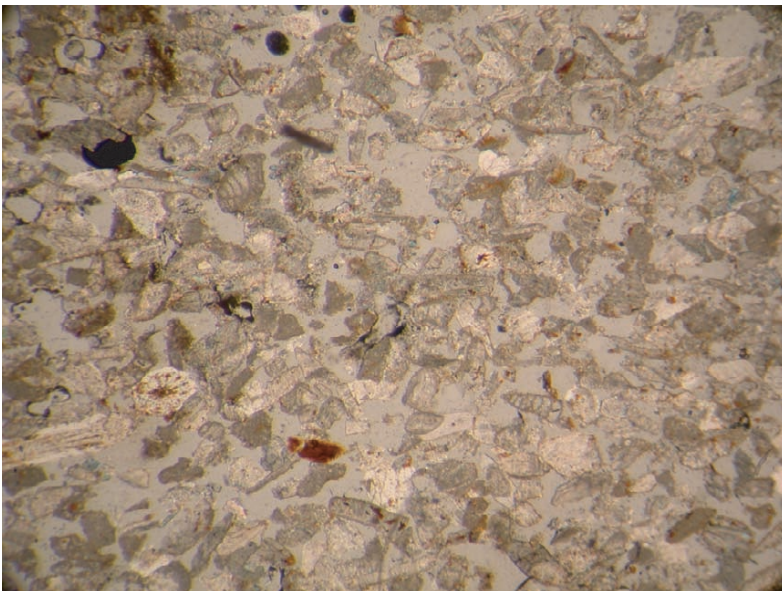
Hedbergella ? spp.



Benthic foraminifera

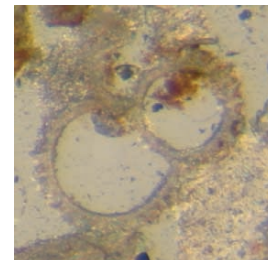


(9) MS11 Seamount 02SMS11-BMS04B-FR02



100µm

Hedbergella ? spp.



Benthic foraminifera

